



## ***Pseudogramma polyacantha* complex (Serranidae, tribe Grammistini): DNA barcoding results lead to the discovery of three cryptic species, including two new species from French Polynesia**

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### **Abstract**

The *Pseudogramma polyacantha* species complex was found to harbor cryptic taxonomic diversity with three similar, but genetically divergent, species previously hidden in the complex. The true *Pseudogramma polyacantha* occurs from French Polynesia to South Africa and has modally 19 (many with 20) segmented dorsal-fin rays, modally 16 segmented anal-fin rays, a relatively short lateral line, no dermal flap or small tentacle dorsally on eye, and extensive scalation on the interorbital, suborbital and dentary. *Pseudogramma brederi* (previously synonymized with *P. polyacantha*) is recognized as a valid species occurring from Hawaii to Mauritius and having modally 21 segmented dorsal-fin rays, modally 17 segmented anal-fin rays, a relatively long lateral line, no dermal flap or small tentacle dorsally on eye, and relatively well-developed scalation on the interorbital, suborbital and dentary. *Pseudogramma galzini* **n. sp.** is described as a new species known only from French Polynesia and having modally 22 segmented dorsal-fin rays, modally 17 segmented anal-fin rays, a relatively long lateral line, no dermal flap or small tentacle dorsally on eye, and limited scalation on the interorbital, suborbital and dentary. *Pseudogramma paucilepis* **n. sp.** is described as a new species known only from French Polynesia and having 20 segmented dorsal-fin rays, modally 16 segmented anal-fin rays, a relatively long lateral line, no dermal flap or small tentacle dorsally on eye, and relatively reduced scalation on the interorbital, suborbital and dentary. A mtDNA COI analysis including all available *Pseudogramma* sequences shows well-supported genetic divergence between the two new species and among congeners.

**Key words:** Podge, Epinephelinae, *Pseudogramma paucilepis* **n. sp.**, *Pseudogramma galzini* **n. sp.**

### **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 based on samples collected during the survey (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 endemic species of the Marquesas (Delrieu-Trottin *et al.* 2015). Our preliminary analysis of the results to date indicates the presence of over 140 probable new species of marine shore fishes based on the results of mtDNA COI barcoding combined with morphological examination of the preserved voucher specimens.

Genetic and morphological analysis of specimens identified as *Pseudogramma polyacantha* led to the discovery of a complex comprising four distinct cryptic (morphologically as well as ecologically) species occurring in French Polynesia. *Pseudogramma polyacantha* (Bleeker, 1856) is redescribed, *P. brederi* (Hildebrand in Longley & Hildebrand, 1940) is removed from synonymy and recognized as a distinct species, and two new

species with mostly sympatric geographic distributions are described based on specimens collected from the Austral Islands and the Gambier Archipelago. Additional records of *P. xantha* Randall, Baldwin & Williams, 2002, are discussed.

In a revision of the Pseudogrammina, Randall and Baldwin (1997) recognized 10 species in the genus *Pseudogramma*. In 2002, *Pseudogramma xantha* was described as a valid South Pacific species. The additional three species recognized herein result in 14 valid species now recognized in *Pseudogramma*.

There has been confusion regarding the gender (neuter or feminine) of the generic name *Pseudogramma*. As discussed by Williams and Howe (2003) for *Helcogramma*, these names are based on the Greek noun *gramme*, a feminine noun meaning line, not the neuter Latin noun *gramma* meaning letter. The Greek *gramme* is Latinized to the feminine *gramma*. The name *Pseudogramma* is therefore feminine and all adjectival species names must be feminine.

## Materials and methods

Methods of measuring and counting specimen characters and the presentation format for the descriptions generally follow Randall and Baldwin (1997) to facilitate comparisons. Nomenclature for the classification of *Pseudogramma* follows Baldwin and Johnson (1993) recognizing the tribe Gammistini in the subfamily Epinephelinae. Additionally, length of the lateral line is measured from the insertion of the first tubed scale to the end of the posteriormost lateral-line scale. Characters associated with the anterior extent of scalation on the head are presented as the anterior limit relative to the nearest appropriate cephalic sensory pore(s) (Figs. 1, 2). Types are deposited in the National Museum of Natural History, Smithsonian Institution (USNM). USNM collection records are available online ([http://vertebrates.si.edu/fishes/fishes\\_collections.html](http://vertebrates.si.edu/fishes/fishes_collections.html)). Abbreviations used: standard length (SL), head length (HL), lateral line (LL), nasal pores (N), infraorbital pores (IO), interorbital pores (InO), supraorbital pores (SO), and dentary pores (D). The extent of scalation on the head is given in relation to the anteriormost sensory pore the scales reach in the appropriate pore series.

Procedures used for our mtDNA analysis using cytochrome C oxidase subunit I (COI) follow Williams *et al.* (2012) and Delrieu-Trottin *et al.* (2014). Two different tree-building methods were used to construct branching diagrams. Neighbor-joining (NJ) analysis based on the K2P model of sequence evolution was conducted using the software package MEGA 5 (Tamura *et al.* 2011). The ML analysis was run using the Geneious implementation of PHYML (Drummond *et al.* 2010, Guindon & Gascuel 2003). The appropriate model of nucleotide substitution was determined using jModeltest version 3.07 (Posada 2008). Confidence in topologies was evaluated by a bootstrap analysis with 1000 replicates (Felsenstein 1985). GenBank accession numbers for the COI-5P sequences are included in parentheses following the tissue number for each type lot of the new species. Gene sequences were ranked following Chakrabarty *et al.* (2013) and these rankings follow the GenBank accession numbers.

### *Pseudogramma polyacantha* (Bleeker, 1856)

Palespot Podge

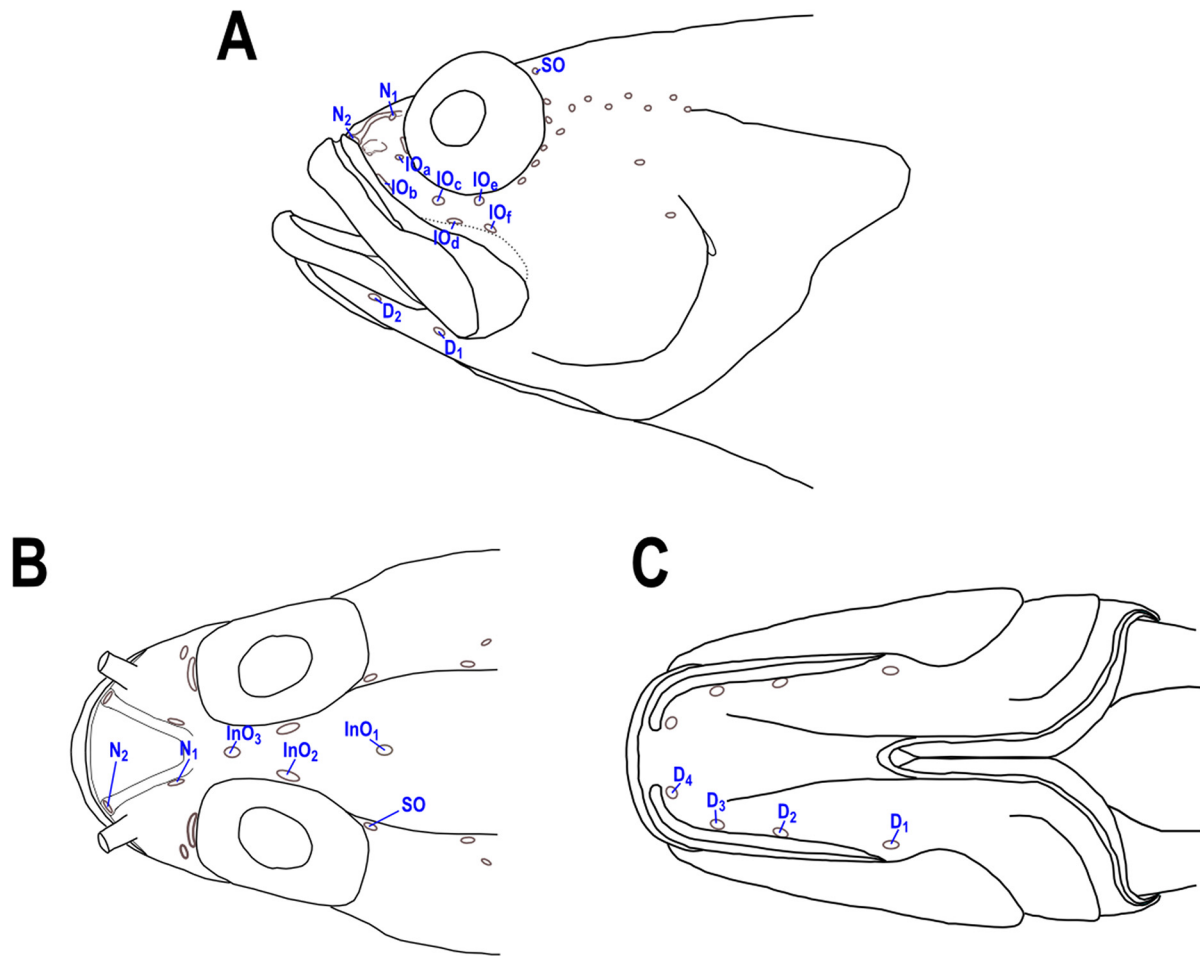
Figure 3, Table 1

*Pseudochromis polyacanthus* Bleeker, 1856: 375 (type locality Ternate, Indonesia).

*Gnathypops samoensis* Fowler & Silvester, 1922: 118, fig. 1 (type locality Aua Village, Tutuila, American Samoa).

**Diagnosis.** A species of *Pseudogramma* with modally 19 (many with 20) segmented dorsal-fin rays, modally 16 segmented anal-fin rays, LL relatively short (1.82–2.78 in SL, mean=2.14), extensive scalation on the interorbital, suborbital and dentary (Fig. 2D); head length 2.3–2.8 in SL, peduncle depth 3.1–4.6 in HL.

**Description.** Dorsal rays VII, 19–20 (mean=19.42); anal rays III, 15–17 (mean=15.80); pectoral rays 14–16 (mean=15.23); LL scales usually 27–33 (2 specimens each with 23 and 25), LL length short, 1.82–2.78 (mean=2.14) in SL; usually no fully developed second LL (some tubed scales rarely present posteriorly); longitudinal scale series 46–56; gill rakers 5–6 + 10–12; vertebrae 10 + 16 (rarely 10 + 15).

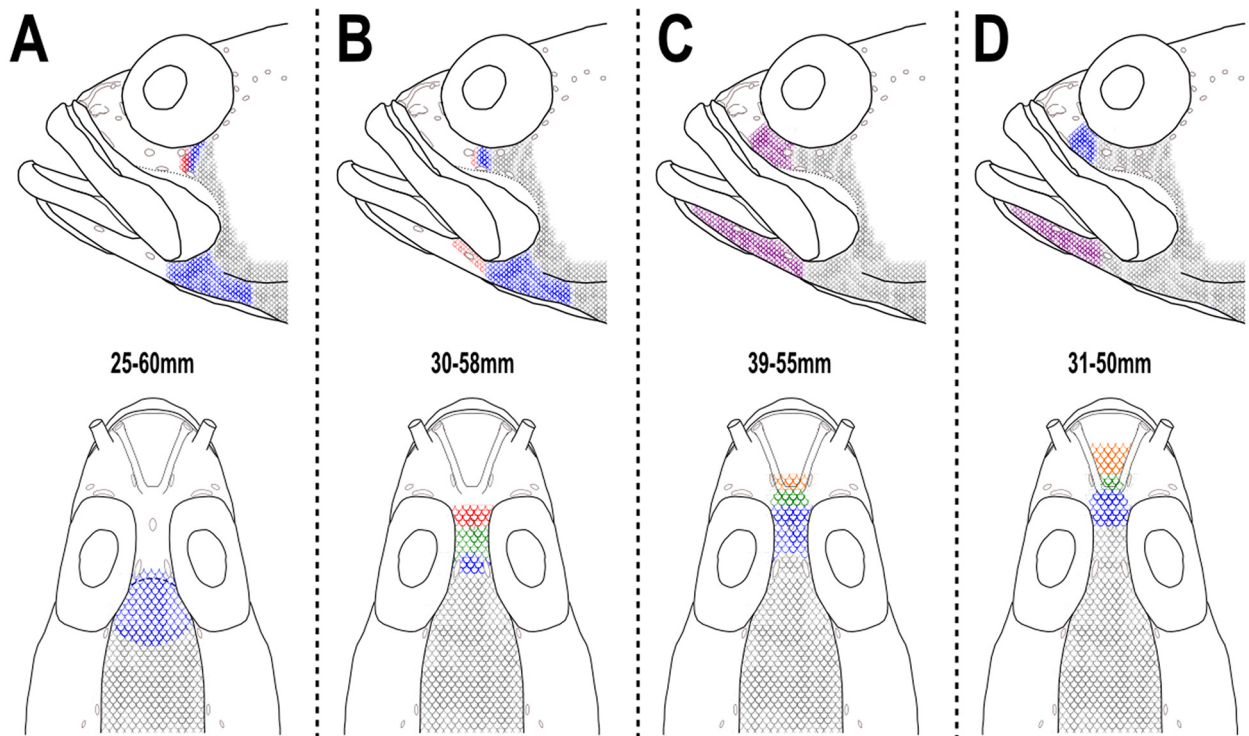


**FIGURE 1.** Cephalic sensory pores of *Pseudogramma*. Pore symbols: nasal pores (N); interorbital pores (InO), supraorbital pores (SO); infraorbital pores (IO); and dentary pores (D).

Body depth 3.03–4.17 in SL (mean=3.70); HL 2.33–2.78 (mean=2.57) in SL; snout 4.8–6.0 in HL; caudal-peduncle length 2.9–5.6 in HL; peduncle depth 3.1–4.6 in HL. Fifth or sixth dorsal spines longest, 2.9–5.3 (mean=3.7) in HL; longest dorsal segmented ray 2.6–4.6 (mean=3.5) in HL; posterior dorsal and anal rays nearly reaching, just reaching or extending slightly posterior to a vertical at caudal-fin base, second anal spine 3.5–5.5 (mean=4.5) in HL; longest anal soft ray 2.6–5.2 (mean=3.5) in HL; caudal fin short and rounded, 1.8–2.9 (mean=2.2) in HL; pectoral fins barely reaching origin of or slightly posterior to anal-fin origin (but not to the segmented rays), 1.3–2.0 in HL. Interorbital width 8.3–20.0 (mean=14.3) in HL.

Mouth large, the maxilla extending posteriorly to a vertical at rear edge of orbit; maxilla 1.85–2.33 (mean=2.08) in HL; a band of villiform teeth in jaws; upper jaw with a small canine tooth in outer row on each side at front of jaw; villiform teeth on palatines in 3–5 rows in adults, the band distinctly longer than side of V-shaped patch of teeth on vomer.

No dermal flap or small tentacle dorsally on eye. Cephalic sensory pores as shown in Fig. 1, supraorbital and some infraorbital pores variably present on head and may be absent or covered by scales when present. Tubular anterior nostril near edge of snout at base of upper lip, the tube not long, when depressed onto snout reaching between one-third the distance to and almost to posterior nostril. A sharp spine projecting downward (30–70° to horizontal axis of body, mean=50°) on posterior edge of preopercle at level of upper base of pectoral fin; upper surface of preopercular spine V-shaped with a central furrow. Three flat spines on opercle nearly in vertical alignment, the middle spine closer to lower than upper spine (preopercular and opercular spines usually covered with scales).

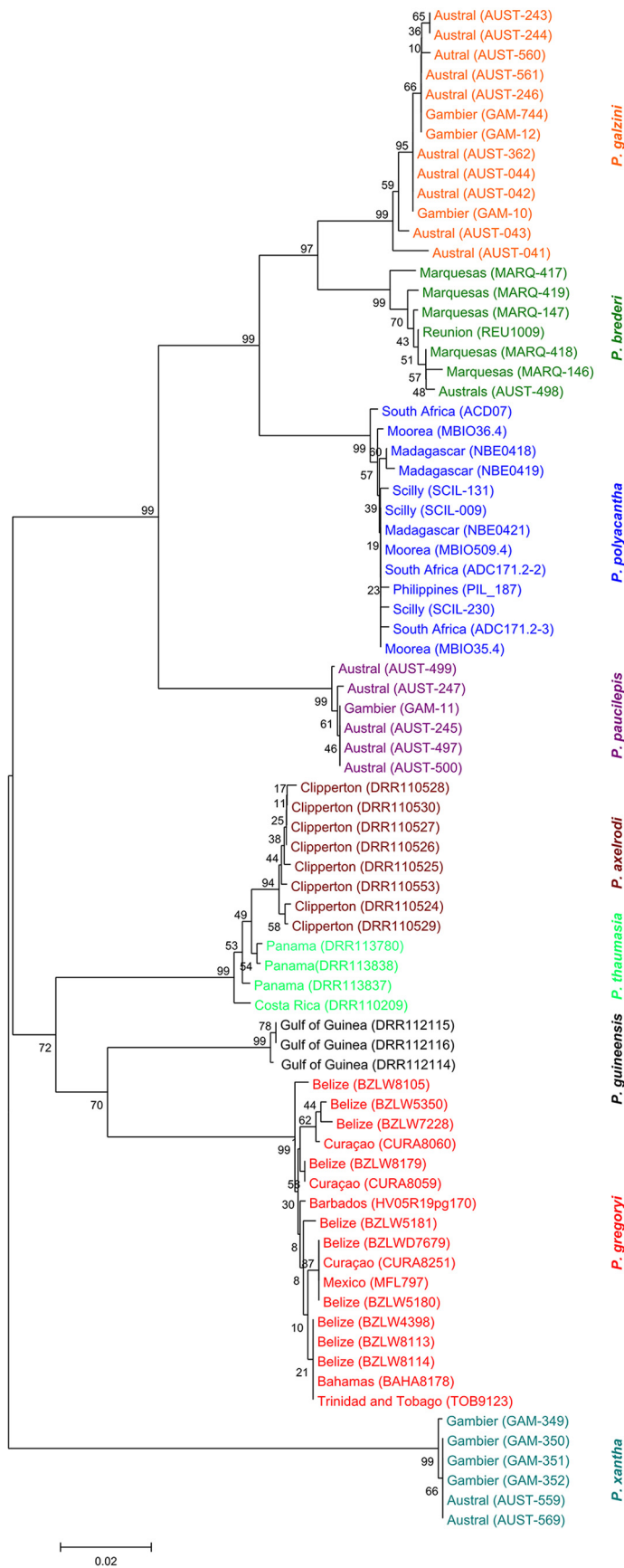


**FIGURE 2.** Scalation patterns on the head of members of the *Pseudogramma polyacantha* complex showing changes with increasing specimen length. A) Reduced scalation—*P. paucilepis* n. sp. B) Scalation extending slightly farther anteriorly—*P. galzini* n. sp. C) Moderately developed scalation—*P. brederi*. D) Well-developed scalation—*P. polyacantha*. Colors represent the following: purple: variable scale development at all sizes; grey: specimens shorter than 40 mm SL; blue: specimens longer than 40 mm SL; green: specimens longer than 45 mm SL; orange: specimens longer than 50 mm SL; red: specimens longer than 55 mm SL.



**FIGURE 3.** *Pseudogramma polyacantha*, USNM 436212, 41 mm SL, Philippines. Photo: J.T. Williams.

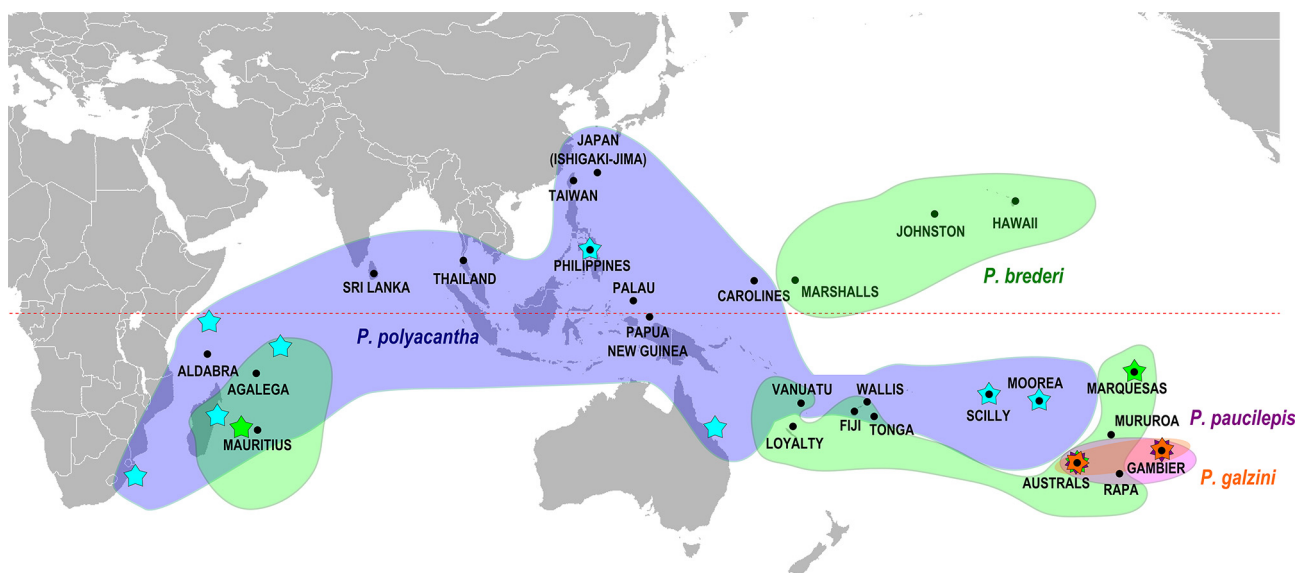
Scalation on the head well developed (Fig. 2D). Interorbital scalation extending anteriorly to at least anterior border of orbits in smallest specimens (below 40mm SL), reaching third interorbital pore ( $InO_3$ ) and extending well onto snout in longer specimens where scales reach level of anterior nostrils. Cheek scales extending anteriorly to infraorbital pore  $IO_C$  in small specimens and reaching infraorbital pore  $IO_B$  in large specimens. Dentary scalation extending anteriorly at least to first dentary pore ( $D_1$ ), some specimens with dentary completely scaled.



**FIGURE 4.** Neighbor-Joining tree based on K2P model of sequence evolution (with 1,000 bootstrap replicates) for available members of the genus *Pseudogramma*. The scale bar at left represents a 2% sequence divergence.

*Color pattern.* Based on photos of freshly dead specimens from Philippines, Palau, Scilly Atoll, and Moorea. Head brown with pale streak extending ventroposteriorly from ventral border of orbit, across preopercle toward upper end of pectoral-fin base; large black spot on opercle bordered by pale ring; anterior nostril a short brown tube with pale stripe laterally; iris brown with narrow irregular ring of yellow or orange bordering pupil; ventral border of orbit black. Body with mottled checkerboard pattern of alternating dark brown and tan spots. Fins dusky brown, caudal fin with pale bar on base bordered posteriorly by half-moon shaped brown crescent. Color in alcohol essentially the same as fresh color, but lacking yellow and orange colors.

**Remarks.** *Pseudogramma polyacantha* was distinguished from congeners by Randall & Baldwin (1997) by possessing a combination of characters: single LL, no dermal flap on upper part of eye, pectoral rays 14–17, and eye-sized black spot on opercle. *Pseudogramma polyacantha* was previously thought to be a single, geographically widespread species ranging from South Africa to Ducie Island, Pitcairn Archipelago (Randall & Baldwin 1997). A comparison of our mtDNA data combined with sequences available on BOLD reveal well-supported genetic divergences for four distinct lineages within the *P. polyacantha* species complex (Fig. 4). Subsequent morphological examination of voucher specimens from each of the four lineages revealed distinguishing morphological characters (see diagnoses) for each of the lineages and support the recognition of four species in the complex. *Pseudogramma polyacantha* remains a widespread species that is geographically distributed from Moorea and Scilly Atoll, French Polynesia, in the Central Pacific, westward through the Philippine and Indo-Malay region and Japan to Sri Lanka, Mauritius and the Cargados Carajos Shoals in the Western Indian Ocean (Fig. 5).



**FIGURE 5.** Geographical distribution of the members of the *Pseudogramma polyacantha* species complex. *Pseudogramma polyacantha*—lavender shading, blue stars; *P. brederi*—green shading, green stars; *P. galzini* n. sp.—orange shading orange stars; *P. paucilepis* n. sp.—pink shading Purple stars. Black dots represent locations of specimens examined; stars indicate specimens with COI sequence available on BOLD.

**Material examined.** MOOREA ISLAND: USNM 391081, 9 specimens, 34.8–42.7 mm. SCILLY ATOLL: USNM 434898, tissue number: SCIL-009, 39.5 mm; USNM 435020, tissue number: SCIL-131, 47.8 mm; USNM 435119, tissue number: SCIL-230, 41.8 mm; USNM 434905, tissue number: SCIL-016, 39.2 mm; USNM 435175, tissue number: SCIL-286, 43.4 mm. MARSHALL ISLANDS: USNM 259344, 45.1 mm; USNM 140724, 8 specimens, 30.4–45.8 mm. WALLIS ISLAND: USNM 370572, 2 specimens, 31.1–35.7 mm. FIJI: USNM 244015, 4 specimens, 37.6–50.1 mm. CAROLINES ISLAND: USNM 223587, 38.4 mm; USNM 224410, 34.4 mm. VANUATU: USNM 259056, 2 specimens, 41.1–41.2 mm; USNM 356220, 37.5 mm; USNM 363193, 35.7 mm; USNM 363493; USNM 356185, 2 specimens, 31.1, 33.8 mm. PAPUA NEW GUINEA: USNM 245348, 2 specimens, 34.8–35.1 mm; USNM 245350, 2 specimens, 42.2–46.3 mm. PALAU: USNM 423517, 2 specimens, 31.4–40.8 mm. PHILIPPINES: USNM 258950, 15 specimens examined of 50, 35.1–48.8 mm; USNM 436212, 41 mm SL. TAIWAN: USNM 361843, 46.1 mm. JAPAN: USNM 352686, 4 specimens, 31.7–42.8 mm. THAILAND: USNM 290536, 4 specimens, 37.1–43.5 mm. SRI LANKA: USNM 361839, 31.2 mm ; USNM 361838, 39.1 mm.

MAURITIUS ISLAND: USNM 259060–2, 42.6 mm. AGALEGA ISLANDS: USNM 259061, 9 specimens, 29.5–40.2 mm. ALDABRA: USNM 361841, 5 specimens, 31.0–36.4 mm.

**TABLE 1.** Frequency distribution of dorsal and anal rays for the four species in the *Pseudogramma polyacantha* species complex.

	Dorsal Soft Rays				Anal soft Rays			
	19	20	21	22	15	16	17	18
<i>P. paucilepis</i> n. sp.								
Australs		5				4	1	
Gambier		1				1		
TOTAL		6				5	1	
<i>P. galzini</i> n. sp.								
Australs		1	5	4		2	5	2
Gambier				2			2	
TOTAL		1	5	6		2	7	2
<i>P. brederi</i>								
Marshall		1	7	1		2	7	
Johnston		6	8	3		7	8	2
Hawaii			1			1		
Marquesas			10			7	7	
Mururoa			5				5	
Australs		1	1				2	
Vanuatu		1	1				2	
Loyalty		1	1			1	1	
Tonga		2	7			2	7	
Fiji			1				1	
Agalega		3				2	1	
Mauritius		1	1				2	
TOTAL		16	43	4		22	43	2
<i>P. polyacantha</i>								
Aldabra	3	2				4	1	
Agalega	1	4			1	3	1	
Sri Lanka	1	1			2			
Thailand	4				3	1		
Japan	2	1			1	2	1	
Taiwan	1					1		
Philippines	8	7			1	14		
Palau	1	1				2		
Papua-NG	3	1				2		
Carolines	1	1				2		
Vanuatu	4	3				5	2	
New Hebrides		2				2		
Fiji	3	3				6		
Wallis		2				2		
Moorea	4	5			2	4		
Scilly	5				1	4		
TOTAL	41	33			11	54	5	

***Pseudogramma brederi* (Hildebrand in Longley & Hildebrand, 1940)**

Confused Podge

(Figure 6; Table 1)

*Rhegma brederi* Hildebrand in Longley & Hildebrand, 1940:244, Fig. 11 (Exact type locality unknown, but apparently from the Hawaiian Islands; erroneously listed as being from the Tortugas as discussed by Randall & Baldwin 1997).

*Pseudorhegma diagramma* Schultz, 1966: 193 (type locality, Hawaii).

*Pseudogramma polyacantha hawaiiensis* Randall and Baldwin, 1997: 42 (Holotype: BPBM 28742; type locality: Ke'ei, Hawaii).

**Diagnosis.** A species of *Pseudogramma* with modally 21 segmented dorsal-fin rays, modally 17 segmented anal-fin rays, a relatively long LL (1.6–1.9, mean= 1.8) in SL, relatively well-developed scalation on the interorbital, suborbital and dentary (Fig. 2C); head length 2.4–2.7 in SL, peduncle depth 3.2–4.0 in HL.

**Description.** Dorsal rays VII, 20–21 (rarely 22); anal rays III, 16–18 (rarely 18); pectoral rays 15–17; LL scales usually 34–39 (3 specimens with 31), LL length long, 1.6–1.9 (mean=1.8) in SL; usually no fully developed second LL (some tubed scales rarely present posteriorly); longitudinal scale series 47–52; gill rakers 5–6 + 11–12; vertebrae 10 + 16.

Body depth 3.2–4.0 in SL (mean=3.57); HL 2.4–2.7 (mean=2.5) in SL; snout 5.3–6.3 in HL; caudal-peduncle length 4.0–5.9 in head; peduncle depth 3.2–4.0 in HL. Fifth or sixth dorsal spines longest, 3.3–4.8 (mean= 4.0) in HL; longest dorsal segmented ray 3.6–4.5 (mean=4.0) in HL; posterior dorsal and anal rays nearly reaching, just reaching or extending slightly posterior to vertical at caudal-fin base, second anal spine 4.2–5.6 (mean= 4.8) in HL; longest anal soft ray 3.2–4.3 (mean= 3.8) in HL; caudal fin short and rounded 2.0–2.8 (mean= 2.4) in HL; pectoral fins barely reaching or reaching slightly posterior to anal-fin origin (but not to segmented rays), 1.5–2.0 in HL. Interorbital width 8.3–20.0 (mean= 12.5) in HL.

Mouth large, the maxilla extending posteriorly to a vertical at rear edge of orbit; maxilla 2.0–2.3 (mean= 2.1) in HL; a band of villiform teeth in jaws; upper jaw with a small canine tooth in outer row on each side at front of jaw; villiform teeth on palatines in 3–5 rows in adults, the band distinctly longer than side of V-shaped patch of teeth on vomer.

No dermal flap or small tentacle dorsally on eye. Cephalic sensory pores as shown in Fig. 1, supraorbital and some infraorbital pores variably present on head and may be absent or covered by scales when present. Tubular anterior nostril near edge of snout at base of upper lip, the tube not long, reaching one-third the distance to and almost to posterior nostril when depressed onto snout. A sharp spine projecting downward (30–60° to horizontal axis of body, mean= 50°) on posterior edge of preopercle at level of upper base of pectoral fin; upper surface of preopercular spine V-shaped with a central furrow. Three flat spines on opercle nearly in vertical alignment, middle spine closer to lower than upper spine (preopercular and opercular spines usually covered with scales).



**FIGURE 6.** *Pseudogramma brederi* USNM 409417, 45 mm SL, Marquesas. Photo: J.T. Williams.



Scalation on the head moderately developed (Fig. 2C). Interorbital scalation extending anteriorly to at least anterior border of orbits (pore InO<sub>2</sub>) in smallest specimens (below 40 mm), extending onto snout in larger specimens where scales reach level of posterior nostrils and N<sub>1</sub> pore (Fig. 2C). Cheek scalation extending anteriorly to infraorbital pore IO<sub>C</sub> or IO<sub>B</sub>. Dentary scales extending anteriorly at least to first dentary pore (D<sub>1</sub>), some specimens with dentary completely scaled.

**Color pattern.** Based on photos of freshly dead specimens from Marquesas, Mururoa and Australs (Fig. 6). Head brown with pale streak extending ventroposteriorly from ventral border of orbit, across preopercle toward upper end of pectoral-fin base; large black spot on opercle bordered by pale ring; anterior nostril short brown tube with pale stripe laterally; branchiostegal membranes sometimes with pale reddish cast; iris of eye brown with narrow irregular ring of yellow or orange bordering pupil; ventral border of orbit black. Body with mottled checkerboard pattern of alternating dark brown and tan spots. Fins dusky brown or reddish brown, caudal fin with narrow pale bar on base bordered posteriorly by half-moon shaped brown crescent. Color in alcohol essentially the same as fresh color, but without reddish tones.

**Remarks.** We name this the Confused Podge to reflect the confusion surrounding its type locality when the species was first described as an Atlantic species. Our analysis of mtDNA data reveal the presence of *Pseudogramma brederi* at the Marquesas and Austral Islands and there is a BOLD sequence from a Reunion Island specimen that clusters in the same lineage (Fig.4), which is supported by our examination of preserved museum specimens of this species from the Agalega Islands and Mauritius, Western Indian Ocean. We have found additional specimens of *P. brederi* at Taiwan, Ogasawara Islands (based on Randall *et al.* 1997: plate 6B, previously identified as *P. polyacantha*), Johnston Island, Hawaii, Rapa, Fiji, Tonga, Loyalty Islands and Vanuatu. *Pseudogramma brederi* displays an interesting distribution pattern in the Pacific Ocean that, with the exception of the Marquesas, is antitropical (Fig. 5), with populations found north of 20 degrees N and south of about 19–20 degrees S latitude. Although the Marquesas are located in the tropics, Marquesan waters are influenced by upwelling that simulates a more subtropical environment. In addition, the species is currently known to have an east-west disjunct geographic distribution with a Central Pacific population from Ogasawara, Johnston, Hawaii, Marquesas, Australs, Tonga and Vanuatu and a southwestern Indian Ocean population currently known only from Agalega Islands, Mauritius and Reunion. We believe it is likely to be more widely distributed in appropriate subtropical habitats.

**Material examined.** TAIWAN: USNM 361831, 48.3 mm SL. HAWAII: USNM 160672, holotype of *Pseudogramma diagramma*, 67.5 mm SL. JOHNSTON ISLAND: USNM 140729, 18 specimens, 31.3–65.8 mm. MARQUESAS ISLANDS: USNM 409419, tissue number: MARQ-414, 53.4 mm; USNM 409417, tissue number: MARQ-417, 42.8 mm; USNM 409418, tissue number: MARQ-418, 55.0 mm; USNM 409146, tissue number: MARQ-146, 39.1 mm; USNM 409147, tissue number: MARQ-147, 54.5 mm; USNM 411305, 3 specimens, 46.6–52.0 mm; USNM 411461, 3 specimens, 33.8–45.1 mm. MURUROA, TUAMOTU ARCHIPELAGO: USNM 419833, 5 specimens, 37.6–52.0 mm. RAPA: USNM 379703, AUSTRAL ISLANDS: USNM 422967, tissue number: AUST-498, 49.3 mm. TONGA ISLANDS: USNM 334318, 51 mm; USNM 329736, 8 specimens, 34.1–52.6 mm. FIJI, southern Islands: USNM 287812, 3 specimens, 14.8–53.6 mm; USNM 258327, 3 specimens, 29.9–39.8 mm. VANUATU: USNM 356623, 47.3 mm; USNM 347531, 44.1 mm. AGALEGA ISLANDS, North Island: USNM 259061, 3: 37–44 mm. AGALEGA ISLANDS, CARGADOS CARAJOS SHOALS: USNM 259060, 2, 41.4, 53.7 mm. MAURITIUS: USNM 366584, 8 specimens, 12.9–39.9 mm.

### ***Pseudogramma paucilepis* new species**

Weakscaled Podge

Figure 7, Table 1.

Holotype: USNM 423375, 45.7 mm, female, tissue number: AUST-245 (GenBank-KU905724; genseq-1), Austral Islands, Tubuai south end, outer reef slope with dense coral, 18–22 m, rotenone, J.T. Williams, E. Delrieu-Trottin and P. Sasal, 14 April 2013.

Paratypes: USNM 422972, tissue number: AUST-499 (GenBank-KU905727; genseq-2), 42.9 mm, Austral Islands, Rimatara, outer reef slope channel to drop off with dead coral structure but little live coral, 21–29 m; USNM 422983, tissue number AUST-500 (GenBank-KU905726; genseq-2), 60.3 mm, Austral Islands, Rimatara,

outer reef slope channel to drop off with dead coral structure but little live coral, 21–29 m; USNM 422917, tissue number AUST-247 (GenBank-KU905725; genseq-2), 17.5 mm, same locality as holotype; USNM 422942, tissue number AUST-497 (GenBank-KU905723; genseq-2), 24.3 mm, Austral Islands, Rimatara, outer reef slope channel to drop off with dead coral structure but little live coral, 21–29 m; USNM 400657, tissue number GAM 011 (GenBank-KU905722; genseq-2), 26.5 mm, Gambier Islands, Kouaku Island, small surge channel in outer reef, 15–20 m.

**Diagnosis.** A species of *Pseudogramma* with 20 segmented dorsal-fin rays, modally 16 segmented anal-fin rays, LL relatively long 1.8–2.3 (mean= 2.0) in SL, relatively reduced scalation on interorbital, suborbital and dentary (Fig. 2A); HL 2.3–2.4 in SL, peduncle depth 4.2–5.0 in HL.



**FIGURE 7.** *Pseudogramma paucilepis* new species, holotype, USNM 423375, 45.7 mm SL, female, Austral Islands. Photo: J.T. Williams.

**Description.** Dorsal rays VII, 20; anal rays III, 16–17 (one specimen with 17); pectoral rays 15–16 (mean=15.33); LL scales 24–38 for specimens ranging from 25 to 60 mm, count increases with increasing size, LL length 1.8–2.3 (mean= 2.0) in SL; no fully developed second LL; longitudinal scale series 52–54; gill rakers 5–6 + 11–12; vertebrae 10 + 16.

Body depth 3.2–3.7 in SL (mean=3.5); HL 2.3–2.4 (mean=2.3) in SL; snout 5.0–5.9 in head; caudal-peduncle length 4.0–6.7 in head; peduncle depth 4.2–5.0 in HL. Fifth or sixth dorsal spines longest, 3.6–4.4 (mean= 3.9) in head; longest dorsal soft ray 3.3–5.0 (mean=4.0) in head; posterior dorsal and anal rays nearly reaching, just reaching, or extending slightly posterior to a vertical at caudal-fin base, second anal spine 3.7–5.6 (mean= 4.6) in head; longest anal soft ray 3.5–4.6 (mean= 3.9) in head; caudal fin short and rounded, 2.3–3.2 (mean= 2.7); pectoral fins barely reaching origin or to anal spines (but not to segmented rays), 1.7–2.1 in head. Interorbital width 16.7–20.0 (mean= 17.2) in HL.

Mouth large, the maxilla extending posterior to vertical at rear edge of orbit; upper-jaw length 2.1–2.3 (mean= 2.2) in head; a band of villiform teeth in jaws; upper jaw with a small canine tooth in outer row on each side at front of jaw; villiform teeth on palatines in 3–5 rows in adults, the band distinctly longer than side of V-shaped patch of teeth on vomer.

No dermal flap or small tentacle dorsally on eye. Cephalic sensory pores as shown in Fig. 1, supraorbital and some infraorbital pores variably present on head and may be absent or covered by scales when present. Tubular anterior nostril near edge of snout at base of upper lip, the tube not long, reaching one-third the distance to and almost to posterior nostril when depressed onto snout. A sharp spine projecting downward (45–60° to horizontal axis of body, mean= 56°) on posterior edge of preopercle at level of upper base of pectoral fin; upper surface of preopercular spine V-shaped with a central furrow. Three flat spines on opercle nearly in vertical alignment, middle spine closer to lower than upper spine (preopercular and opercular spines usually covered with scales).

Scalation on the head poorly developed (Fig. 2A). Interorbital scalation not extending anteriorly beyond middle of eye, with smallest specimens (below 40mm) having scales reaching only supraorbital and first interorbital pores (SO and InO<sub>1</sub>), longest specimens with scales reaching second interorbital pores (InO<sub>2</sub>). Cheek scalation not extending anteriorly beyond mid-orbit with smallest specimens having scalation reaching only IO<sub>f</sub>.

infraorbital pore, with largest specimens having scalation reaching IO<sub>E</sub> infraorbital pore. Dentary naked in small specimens, large specimens with scales reaching posterior edge of premaxilla.

**Color pattern.** Based on photos of freshly dead specimens from Gambier and the Australs (Fig. 7). Head brown, with pale streak extending ventroposteriorly from ventral border of orbit, across preopercle toward upper end of pectoral-fin base; large black spot on opercle sometimes bordered by pale ring; anterior nostril short brown tube with pale stripe laterally; cheek and branchiostegal membranes sometimes with faint pinkish cast; iris of eye brown with narrow irregular ring of yellow or orange bordering pupil; ventral border of orbit black. Body with mottled checkerboard pattern of alternating dark brown and tan spots. Fins dusky brown or yellowish brown, caudal fin with narrow pale bar on base bordered posteriorly by half-moon shaped yellowish brown crescent. Color in alcohol essentially the same as fresh color, but without yellowish tones.

**Etymology.** The species epithet is a combination of the Latin *paucus*, meaning few, and the feminine Greek noun *lepis*, meaning scale. The name *paucilepis* is treated as a noun in apposition. We name this the Weakscaled Podge in reference to its weakly scaled snout and suborbital.

**Remarks.** We have examined specimens and obtained genetic sequences of *Pseudogramma paucilepis* **n. sp.** from the Gambier Archipelago and Austral Islands. Our genetic analysis places *P. paucilepis* **n. sp.** closest to *P. polyacantha* (about 8.8% divergence). It has only been found on outer reef slopes between depths of 15–29 m. Specimens of *P. paucilepis* **n. sp.** have been found to occur sympatrically with *P. brederi* at the Austral Islands and with *P. galzini* **n. sp.** at Gambier and the Austral Islands. As is typical of specimens of the genus *Pseudogramma*, specimens have not been observed alive and have only been collected using the ichthyocide rotenone, which is the only effective collecting method for this species and other species with cryptic habits. It is currently known only from the subtropical Pacific south of 20 degrees S latitude (Fig. 5), but it is likely that it will be found to be more broadly distributed geographically, at least within the subtropical South Pacific Ocean.

### ***Pseudogramma galzini* new species**

Galzin Podge

Fig. 8; Table 1.

Holotype: USNM 402553, female, 31.2 mm, tissue number: GAM 010 (GenBank-KU905717; genseq-1), Gambier Archipelago, Kouaku Island, on SE side of archipelago, small surge channel in outer reef, 15–20 m, rotenone, J.T. Williams, S. Planes, M. Kulbicki, P. Sasal, E. Delrieu-Trottin, 29 September 2010.

Paratypes: USNM 400461, 17.3 mm, tissue number: GAM 012 (GenBank-KU905721; genseq-2), collected with holotype; USNM 404675, tissue number: GAM 744 (GenBank-KU905716; genseq-2), 47.5 mm, Gambier Islands, Teauaone Islet, due north of Mangareva, coral channel in surge zone near breakers on barrier reef, rock surge channel, 1–5 m; USNM 423326, tissue number: AUST-041 (GenBank-KU905709; genseq-2), 39.2 mm, Austral Islands, Raivavae, just outside harbor entrance on outer reef slope with rock and some coral and white sand in channel, 10–15 m; USNM 423328, tissue number: AUST-042 (GenBank-KU905715; genseq-2), 48.8 mm, Austral Islands, Raivavae, just outside harbor entrance on outer reef slope with rock and some coral and white sand in channel, 10–15 m; USNM 423302, tissue number: AUST-043 (GenBank-KU905714; genseq-2), 36.5 mm, Austral Islands, Raivavae, just outside harbor entrance on outer reef slope with rock and some coral and white sand in channel, 10–15 m; USNM 423370, tissue number: AUST-243 (GenBank-KU905712; genseq-2), 55.4 mm, Austral Islands, Tubuai, outer reef slope with dense coral, 18–22 m; USNM 423365, tissue number: AUST-244 (GenBank-KU905711; genseq-2), 46.2 mm, Austral Islands, Tubuai, outer reef slope with dense coral, 18–22 m; USNM 424068, tissue number: AUST-246 (GenBank-KU905710; genseq-2), 46.2 mm, Austral Islands, Tubuai, outer reef slope with dense coral, 18–22 m; USNM 423411, tissue number: AUST-362 (GenBank-KU905720; genseq-2), 57.4 mm, Austral Islands, Tubuai, just outside entrance to harbor on small patch reef with rock and minimal coral on a rock and sand flat, 3–5 m; USNM 423272, tissue number: AUST-560 (GenBank-KU905719; genseq-2), 61.4 mm, Austral Islands, Maria Atoll, outer reef slope at drop off with dense live coral in channel with sand and rubble at bottom of channel, 18–30 m; USNM 423284, tissue number: AUST-561 (GenBank-KU905718; genseq-2), 44.5 mm, Austral Islands, Maria Atoll, outer reef slope at drop off with dense live coral in channel with sand and rubble at bottom of channel, 18–30 m; USNM 423305, tissue number: AUST-044 (GenBank-KU905713; genseq-2), 32.0 mm, Austral Islands, Raivavae, just outside harbor entrance on outer reef slope with rock and some coral and white sand in channel, 10–15 m.

Additional non-type material examined: USNM 379703, 55.1 mm SL, Rapa Island, east side, Field number JTW 2002–44, 8–14 m depth.

**Diagnosis.** A species of *Pseudogramma* usually with 21 or 22 segmented dorsal-fin rays, modally 17 segmented anal-fin rays, LL relatively long 1.6–1.9 (mean=1.8) in SL, relatively well-developed scalation on the interorbital, suborbital and dentary (Fig. 2B); head length 2.4–2.6 in SL, peduncle depth 3.3–4.0 in HL.



**FIGURE 8.** *Pseudogramma galzini* new species, holotype, 402553, 31.2 mm SL, female, Gambier Archipelago. Photo: J.T. Williams.

**Description.** Dorsal rays VII, 21–22 (one specimen with 20); anal rays III, 16–18 (two each with 16 and 18); pectoral rays 15–16 (one specimen with 14); LL scales usually 36–40 for specimens ranging from 30–58 mm, LL length long, 1.6–1.9 (mean=1.8) in SL; no fully developed second LL; longitudinal scale series 48–53; gill rakers 5–6 + 11–12; vertebrae 10 + 15 or 16.

Body depth 3.2–4.2 in SL (mean=3.7); HL 2.4–2.6 (mean=2.5) in SL; snout 5.0–5.9 in HL; caudal-peduncle length 4.4–6.3 in head; peduncle depth 3.3–4.0 in HL. Mouth large, the maxilla extending posteriorly to a vertical at rear edge of orbit; maxilla 2.0–2.3 (mean= 2.1) in HL; a band of villiform teeth in jaws; upper jaw with a small canine tooth in outer row on each side at front of jaw; villiform teeth on palatines in 3–5 rows in adults, the band distinctly longer than side of V-shaped patch of teeth on vomer.

No dermal flap or small tentacle dorsally on eye. Cephalic sensory pores as shown in Fig. 1, supraorbital and some infraorbital pores variably present on head and may be absent or covered by scales when present. Tubular anterior nostril near edge of snout at base of upper lip, the tube not long, reaching one-third the distance to and almost to posterior nostril when depressed onto snout. A sharp spine projecting downward (45–80° to horizontal axis of body, mean= 60°) on posterior edge of preopercle at level of upper base of pectoral fin; upper surface of preopercular spine V-shaped with a central furrow. Three flat spines on opercle nearly in vertical alignment, middle spine closer to lower than upper spine (preopercular and opercular spines usually covered with scales).

Scalation on the head moderately developed (Fig. 2B). Interorbital scalation extending anteriorly to at least anterior border of orbits ( $InO_2$ ) in smallest specimens (below 40mm), extending mid-way between  $InO_3$  and  $N_1$  pores in largest specimens. Cheek scalation extending anteriorly to infraorbital pore  $IO_D$ , largest specimens with scalation reaching  $IO_C$ . Dentary naked in small specimens and scalation extending anteriorly at least to first dentary pore ( $D_1$ ) in large specimens.

Fifth or sixth dorsal spines longest, 3.2–5.0 (mean= 3.8) in head; longest dorsal soft ray 3.6–4.3 (mean=4.0) in head; posterior dorsal and anal rays nearly reaching, just reaching, or extending slightly posterior to a vertical at caudal-fin base, second anal spine 4.5–5.6 (mean= 5.0) in head; longest anal soft ray 3.4–4.5 (mean= 3.8) in head; caudal fin short and rounded, 2.2–2.9 (mean= 2.5); pectoral fins barely reaching origin or to anal spines (but not to segmented rays), 1.5–1.9 in head. Interorbital width 12.5–25.0 (mean= 15.6) in HL.

**Color pattern.** Based on photos of freshly dead specimens from Gambier (Fig. 8) and the Australs. Head brown, becoming pinkish brown in larger specimens, pale streak extending ventroposteriorly from ventral border of orbit, across preopercle toward upper end of pectoral-fin base; large black spot on opercle sometimes bordered by pale ring; anterior nostril short brown tube with pale stripe laterally; cheek and branchiostegal membranes pale

brown, becoming pinkish with increasing size; iris of eye brown with narrow irregular ring of yellow or orange bordering pupil; ventral border of orbit black. Body with mottled checkerboard pattern of alternating dark brown and tan spots. Fins dusky brown, yellowish brown or pinkish brown, caudal fin with narrow pale bar on base bordered posteriorly by half-moon shaped yellowish to pinkish brown crescent. Color in alcohol essentially the same as fresh color, but without yellowish tones. Juveniles (Fig. 9) with less pronounced opercular spot, body brown with small white spots.



**FIGURE 9.** *Pseudogramma galzini* new species, paratype, 4000461, 17.3 mm, juvenile, Gambier Archipelago. Photo: J.T. Williams.

**Etymology.** The species is named in honor of René Galzin, who has spent his career working on fish ecology in French Polynesia. We name this the Galzin Podge.

**Remarks.** We have examined specimens of *P. galzini* n. sp. from Gambier, Rapa and the Austral Islands from depths of 1–30 m (Fig. 5). Our genetic analysis (Fig. 4) places *P. galzini* n. sp. closest to *P. brederi* (about 4.4% divergence). These two species occur sympatrically at the Austral Islands and the greatest sequence divergence is seen at this locality. These two species maintain their genetic and morphological differences in the area of sympatry.

### ***Pseudogramma xantha* Randall, Baldwin & Williams, 2002**

Yellow Podge

Figure 10

*Pseudogramma xanthum* Randall, Baldwin & Williams, 2002 (type locality Temoe Atoll)

*Pseudogramma australis australis* (in part) Randall and Baldwin, 1997

**Remarks.** Randall *et al.* (2002) discussed the taxonomic history and confusion related to this species. They described *P. xantha* as a new species for the non-Easter Island specimens previously referred to as *P. australis australis*. Our genetic analysis (Fig. 4) shows *P. xantha* to be highly divergent from its congeners.

*Pseudogramma xantha* was previously known only from four localities, Temoe Atoll, Pitcairn Island, Rarotonga, and Tonga. One of us (JTW) subsequently collected specimens of this species from outer reef slopes around 30 m depth at small islets of the Gambier archipelago and from outer reef slopes at Maria Atoll in the Austral Islands. These cryptic fishes are undoubtedly more widespread, but their depth of occurrence and cryptic habits make them difficult to collect. It appears to be a subtropical species with no specimens yet collected north of about 20 degrees S latitude. Like other members of *Pseudogramma*, they have only been seen and/or collected after the application of a rotenone solution used for sampling cryptic species.

**Additional material examined:** GAMBIER: USNM 400617, 41.0 mm; 400622, 34.4 mm; 400624, 31.8 mm; 400626, 33.1 mm; 411811, 4 spec. AUSTRAL ISLANDS, Maria Atoll: USNM 422907, 17.5 mm; USNM 423287, 34.3 mm.



**FIGURE 10.** *Pseudogramma xantha*, USNM 400622, 35.4 mm SL, Austral Islands. Photo: J.T. Williams.

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