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Luzonichthys kiomeamea (Teleostei: Serranidae: Anthiadinae), a new species from a mesophotic coral ecosystem of Rapa Nui (Easter Island)

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Abstract

A new species in the anthiadine genus *Luzonichthys* Herre, 1936 is described from a specimen collected at a depth of 83 m in a mesophotic coral ecosystem at Rapa Nui (Easter Island). *Luzonichthys kiomeamea* n. sp. can be distinguished from the 7 other valid *Luzonichthys* species by anal-fin and pectoral-fin counts, the number of lateral-line scales, the number and arrangement of gill rakers, and coloration pattern. Mitochondrial DNA sequencing shows that the new species is more than 11% divergent in the COI sequence (and about equally distant) from *Luzonichthys waitei*, *L. seaver*, *L. earlei* (Hawai'i), and *L.* aff. *earlei* (Coral Sea). Given the isolation of the island, and the uniqueness of its fish fauna, we suspect that the new species is endemic to the mesophotic reefs of Rapa Nui.

Key words: taxonomy, ichthyology, coral-reef fishes, endemism, South Pacific, Splitfin Anthias, Chile

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Introduction

Technical mixed-gas rebreather diving in mesophotic zones at depths between 60–150 m allows scientists to study small, active, cryptic, and demersal fishes safely and effectively, resulting in many new species discoveries and range extensions (Pyle 2000, Pinheiro et al. 2015, 2018, Pyle et al. 2016, Rocha et al. 2017, Shepherd et al. 2018, Arango et al. 2019). These new discoveries of species restricted to deeper reefs, coupled with ecological observations, have led to the conclusion that mesophotic coral reefs are unique, threatened, and in need of more research to understand how they are connected to shallow reefs in terms of organism mobility, species turnover, and the impacts of human activity (e.g. fishing, dredging, plastic pollution, and sedimentation) on mesophotic reefs (Baldwin et al. 2016, 2018a,b, Rocha et al. 2018).

Rapa Nui (Easter Island) is the most isolated inhabited island in the Indo-Pacific, located approximately 3,700 km west of Chile and 2,200 km from the Nazca Ridge (Randall & Cea 2010, Easton et al. 2017). Due to this isolation, the Rapa Nui fish fauna exhibits the second-highest degree of endemism in the Indo-Pacific (after the Hawaiian Islands), with up to 21.7% among shorefishes, but has very low overall diversity (Randall & Cea 2010). Two recent papers report a much higher endemism rate of 40.3% (Friedlander et al. 2013, Easton et al. 2017), however, this is the percentage of endemism represented in the dominant observed reef fish assemblages rather than the entire shorefish fauna known to occur at Rapa Nui. Although ichthyological studies since the 1980s have greatly expanded the knowledge of fish diversity in this ecoregion, there have been few surveys of fishes at depths greater than 40 m (DiSalvo et al. 1988, Hubbard & Garcia 2003).

Using closed-circuit rebreathers, our team collected a beautiful new anthiadine species of the genus *Luzonichthys* Herre, 1936 at a mesophotic coral ecosystem off Hanga Piko, Rapa Nui (Easter Island), Chile. *Luzonichthys* currently comprises 7 species that are widely distributed throughout the western Pacific and Indian Oceans, from the Seychelles to the Hawaiian and Line Islands (Randall & McCosker 1992, Copus et al. 2015). The genus is distinctive among anthiadine fishes in being small, slender-bodied, and possessing a near-complete division between the spinous and soft portions of the dorsal fin, hence their common name “splitfins”. Prior records of *Luzonichthys* show the easternmost distribution of the genus to be the Hawaiian and Line Islands (*Luzonichthys earlei* Randall, 1981) and Palmyra and Kiribati (*Luzonichthys whitleyi* Smith, 1955), a distance of at least 6,000 km from Rapa Nui. Here we describe the easternmost representative of the genus, and the fourth anthiadine species from Easter Island. The other anthiadine species known from Rapa Nui comprise *Caprodon longimanus* Günther, 1859; *Plectranthias parini* Anderson & Randall, 1991; and *Plectranthias ahiahiata* Shepherd, Phelps, Pinheiro, Pérez-Matus & Rocha, 2018; all appear to be restricted to mesophotic depths, adding to the uniqueness of this habitat (Rocha et al. 2018).

Materials and Methods

The holotype is deposited in the fish collection of the California Academy of Sciences, San Francisco, CA, USA (CAS). This species is described from a single specimen collected while diving using a mixed-gas, closed-circuit rebreather (Hollis Prism 2). Counts were performed under a microscope and measurements were made to the nearest 0.1 mm with digital calipers following the conventions described in Anderson et al. (1990), Anderson & Heemstra (1980, 2012), Randall & McCosker (1992), and Copus et al. (2015). Comparative data were obtained from the key to the genus *Luzonichthys* in Randall & McCosker (1992); the recent description of *Luzonichthys seaver* Copus, Ka’apu-Lyons & Pyle, 2015; a review of the Atlantic and Eastern Pacific anthiadine fishes by Anderson & Heemstra (2012); and the species descriptions for *Anatolanthias apiomycter* Anderson, Perin & Randall, 1990; *Rabaulichthys suzukii* Masuda & Randall, 2001; and *Rabaulichthys squirei* Randall & Walsh, 2010.

Meristic and morphometric data for the holotype and comparisons with related species are presented in Table 1 and Table 2, respectively (data only available for 4 species in Table 2). Counts were performed under a microscope and measurements were made to the nearest 0.1 mm with digital calipers following the conventions described in Anderson et al. (1990), Anderson & Heemstra (1980, 2012), Randall & McCosker (1992), and Copus et al. (2015). Predorsal formulae are presented according to Ahlstrohm et al. (1976). Proportional measurements in the text are rounded to the nearest 0.1. Standard length (SL) was measured as the straight line from the front of the upper lip to the base of the caudal fin; head length (HL) measured from the front of the upper lip to the posterior end of the opercular flap; and body depth (BD) measured as the maximum depth from the origin of spinous dorsal fin. Gill-raker counts were made on the left-side first arch, and presented as upper + lower, including all rudiments.

A portion of the mtDNA marker cytochrome c oxidase subunit I (COI) was sequenced and analyzed for the new species (GB accession number MN010583). DNA extraction and PCR amplification of COI were performed following protocols of Weigt et al. (2012). Comparison COI sequences were obtained by us for *Luzonichthys waitei* (Fowler, 1931) from the aquarium trade (MN010584). Sequences for *L. seaver* (KP110513), *L. earlei* (Hawai'i) (MK970829–33, 35–37), and *L.* aff. *earlei* (Coral Sea) (MK970834) were obtained from other projects (Copus et al. 2015; BOLD database www.boldsystems.com). Mitochondrial DNA pairwise distances were calculated using Genius Prime 2019 (version 12).

Luzonichthys kiomeamea, n. sp.

Rapa Nui Splitfin

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Figures 1–4; Tables 1 & 2.

Holotype. CAS 244640, 45.7 mm SL, Chile, Rapa Nui, Hanga Piko, -27.15333°, -109.44778°, field number LAR 2646, handnet, B. Shepherd, 7 March 2017.

Diagnosis. Dorsal-fin elements X,16; anal-fin elements III,7; pectoral-fin rays 22; lateral-line scales 64; gill rakers 12+26; body moderately elongate, depth 4.8 in SL; head length 3.6 in SL; snout 4.1 in HL; caudal fin forked and without filaments, length 4.3 in SL; caudal-fin concavity 6.3 in SL; pectoral-fin length 4.0 in SL; pelvic-fin length 5.0 in SL; color in life: body orange-red dorsally, silver-magenta ventrally, with alternating magenta, red, and orange lines along sides of body; dorsal fin yellow-orange with red-orange spots (Fig. 1).

Description. (counts and measurements of holotype in Tables 1 & 2) Dorsal-fin elements X,16; anal-fin elements III,7; pectoral-fin rays 22, dorsalmost unbranched, others branched; pelvic-fin rays I,5; caudal-fin principal rays 8+7 (7+6 branched), procurrent rays 12 dorsal, 12 ventral; gill rakers 12+26; vertebrae 26 (11 precaudal + 15 caudal), pleural ribs on vertebrae 3 through 11; no supraneurals in preneural and first interneural space, one pterygiophore bearing two supernumerary spines in second interneural space; dorsal ray-pterygiophore-neural-spine digitization pattern //2/1+1/1/ (Fig. 2).

Figure 1. *Luzonichthys kiomeamea*, sp. n., holotype, CAS 244640, 45.7 mm SL, shortly after death (L.A. Rocha).

Figure 2. *Luzonichthys kiomeamea*, sp. n., radiograph of preserved holotype, CAS 244640, 45.7 mm SL (J. Fong).

Body moderately elongate, greatest body depth 4.6 in SL (depth at origin of dorsal fin 4.8 in SL), and compressed, body width 1.7 in BD; head length 3.6 in SL; orbit moderately large, diameter 3.2 in HL; snout short and bluntly rounded, 4.1 in HL; caudal-peduncle depth 2.3 in HL, peduncle length about 1.6 peduncle depth

Mouth terminal, slightly upturned; upper and lower jaws about equal in length; maxilla wide, width 7.4 in HL, reaching just posterior to vertical through middle of eye, maxilla abruptly expanded distally, labial border without a rostrally directed hook, supramaxilla lacking; posterior margin of preopercle with 13 fine serrae, ventral margin of preopercle smooth; opercle with three flat spines, center spine well developed, upper spine in line with upper edge of orbit, lower spine in line with center of pupil; posterior half of margin of orbit with 22 fleshy papillae. Teeth small and conical; one enlarged pair of canines on upper front, two pairs on lower jaw (front and side); palatine with band of small conical teeth; vomer edentate with papillae; dentary and premaxilla symphysis edentate; tongue pointed and edentate.

Scales ctenoid; head densely covered with scales, except scaleless on anterior end of snout and lower jaw; cheek-scale rows 8; scale rows between lateral line and mid-base of spinous dorsal fin 5; scales from dorsal-fin origin to lateral line 6; scales from anal-fin origin to lateral line 12; scales cover anterior third of pectoral fins and anterior two-thirds of caudal fin; circumpeduncular scales 28. Lateral line complete, extending to base of caudal fin, 64 tubed scales.

Dorsal fin incised nearly to base, rather than to base (as in other *Luzonichthys* species); origin of dorsal fin in line with vertical from fourth lateral-line scale; first dorsal-fin spine 8.0 in HL; second dorsal-fin spine 3.9 in HL; longest dorsal-fin spine fifth, 2.4 in HL; longest dorsal-fin soft ray tenth, 1.6 in HL; first anal-fin spine short, 13.5 in HL; second and third anal-fin spines about same length, 4.7 in HL; longest anal-fin soft ray sixth, 2.5 in HL; origin of anal fin in line with vertical from 34th lateral-line scale; pectoral fins rounded, length 1.1 in HL; pelvic fins originate below center of base of pectoral fins, pelvic-fin spine 2.6 in HL; caudal fin forked, with filamentous rays, length 4.3 in SL, caudal concavity 6.3 in SL and 1.7 in HL.

Color in life. (Fig. 1) Body overall orange-red on dorsal half, predominantly silver on ventral half, chest, and belly; small, irregular, orange-red spots especially pronounced and dense anteriorly and at base of pectoral fin; faint, parallel, orange-red lines on dorsal half of posterior two-thirds of body, alternating with lighter orange to yellow and following contour of lateral line on posterior half of body; red lines transition to approximately 6 parallel magenta lines along midbody just below lateral line and extend from operculum to caudal region, magenta lines interspaced with silver background color; a series of faint, unpronounced, orange-red, vertical bars follow contours of myomeres from behind pectoral-fin origin to caudal peduncle, bars interspersed with yellow spots, especially pronounced on silver interspaces between parallel magenta lines; posterior third of lateral line pale yellow to white, outlined with faint red lines, ending at base of caudal fin. Head orange anteriorly, becoming

TABLE 1

Meristic values for *Luzonichthys kiomeamea* sp. n.
and the other 7 species of *Luzonichthys*

Luzonichthys species	*kiomeamea*	*earlei*	*microlepis*	*seaver*	*taeniatus*	*waitei*	*whitleyi*	*williamsi*
Catalogue number	CAS 244640			BPBM 41205	BPBM 32336			USNM 322225
Source		R & M 1992	R & M 1992	Copus et al 2015	R & M 1992	R & M 1992	R & M 1992	R & M 1992
Dorsal-fin rays	X,16	X,16–17	X,16	X,16	X,16	X,16	X,16	X,16
Anal-fin rays	III,7	III,7	II,9	III,7	III,7	III,7	III,7	II,9
Pectoral-fin rays	22	19–21 (20)	21–23	19–21	19	17–21	19–22	21–23
Principal caudal-fin rays	8+7 (7+6 branched)			13 branched	13 branched			13 branched
Gill rakers	12+26	6–9+19–22	7–8+21–22	8+18–19	7+19	7–10+19–22	7–8+20–23	7–8+21–22
Lateral-line scales	64	59–68	70–76	63–64	56–60	51–59	65–74	70–78
Cheek-scale rows	8							
Scales from 1st dorsal-fin spine to lateral line	6			5	5			7
Scales from middle of dorsal fin to lateral line	5							
Scales from base of anal fin to lateral line	12			12	17–18			19
Serrae on posterior preopercle margin	13				13–14			
Pelvic-fin rays	I,5			I,5	I,5			I,5
Circumpeduncular scales	28				30			31

TABLE 2

Morphometric measurements of selected *Luzonichthys* species

(all measurements are percentage of SL unless otherwise noted)

	L. kiomeamea	*L. seaver*	*L. taeniatus*	*L. williamsi*
	CAS 244640	BPBM 41205	BPBM 32336	USNM 322225
Source		Copus et al. 2015	R & M 1992	R & M 1992
Standard length (mm)	45.7	42.5	38.2	42.0
Body depth at dorsal fin origin	20.8	25.9	26.1	18.8
Greatest body depth	22.0			
Body width	12.4	14.1	14.5	11.4
Head length	27.7	28.2	30.1	29.0
Snout length	6.8	7.1	7.0	6.5
Bony orbit diameter	8.6	8.2	9.1	10.6
Interorbital width	6.7	9.4	7.2	5.5
Internarial distance in snout length	2.0			
Postorbital head length	12.3			
Upper-jaw length	12.5	17.6	14.8	12.6
Maxilla width	3.7			
Caudal-peduncle depth	12.0	11.8	11.2	10.4
Caudal-peduncle length	18.9	25.9	20.8	20.1
Predorsal length	31.2	35.3	36.0	31.0
Preanal length	63.1	62.4	61.0	66.7
Prepelvic length	32.1	33.0	30.5	30.5
Dorsal-fin base	55.9		51.2	50.5
First dorsal spine	3.5	3.5	4.1	3.3
Second dorsal spine	7.2	9.4	10.4	9.2
Third dorsal spine	8.6	10.6	12.4	11.7
Fourth dorsal spine	11.0	11.8	13.1	12.1
Fifth dorsal spine	11.7			
Sixth dorsal spine	9.5			
Tenth dorsal spine	5.1			
Longest dorsal soft ray	17.0			
Anal-fin base	18.2		15.7	16.5
Depressed anal-fin length	27.1			
First anal spine	2.1	2.4	2.9	1.9
Second anal spine	5.9	4.7	7.3	4.4
Third anal spine	5.9		7.7	
First anal ray	8.9	11.8		7.6
Longest anal ray	11.2	14.1	14.6 (3rd)	13.3
Caudal-fin length	23.2	24.7	35.7	26.0
Caudal concavity	15.9	11.8	21.9	14.9
Pectoral-fin length	25.3	25.9	28.3	21.4
Pelvic-spine length	10.5	9.4	12.4	11.9
Pelvic-fin length	19.9	17.6	21.2	19.1

darker orange to red on dorsal surface of head; eye overall red-orange, with pupil outlined with a thin yellow line; edge of iris outlined in dark red-gray; preopercle yellow, becoming silver on operculum and base of pectoral fins; small orange-red speckles on operculum, jaws, and throat; lips orange, maxilla clear to silvery with small orange-red speckles. Dorsal fins overall yellow, with orange-red spots in between spines and rays, except for first 4 spines; spots larger and overlapping closer to body, becoming smaller and more widely spaced toward distal ends of fins; margin of dorsal fins outlined in pale red; tips of spinous dorsal fin red, especially from the second to sixth spines. Caudal fin predominantly yellow, with orange highlights on fin rays and outlining dorsal and ventral margins. Anal fin overall pale yellow. Pectoral fins translucent. Pelvic fins mostly translucent with pale yellow regions in between several fin rays.

Color in alcohol. (Fig. 3) Straw-colored head and body; only markings a number of irregular melanophores on top of head between eyes.

Etymology. The specific epithet is from the Rapa Nui name; the phrase *kio-meamea* means "red fish that takes refuge in a cave". Treated as a noun in apposition.

Distribution and habitat. The new species is currently known only from Rapa Nui. The holotype was collected at a depth of 83 m in a rocky patch reef surrounded by a large sandy area (Fig. 4). It was caught by hand using hand nets and transported alive to the surface in a perforated-plastic collecting jar.

Comparisons. The new species is the eighth species of the genus. As with the other 7 recognized species in the genus, *L. kiomeamea* is a small (~5 cm in TL), slender-bodied fish that possesses 11+15 vertebrae and a dorsal fin deeply notched between the spinous and soft portions. It can be distinguished from congeners by the number of pectoral-fin rays, anal-fin rays, lateral-line scales, the number and arrangement of gill rakers, and the color in

Figure 3. *Luzonichthys kiomeamea*, sp. n., preserved holotype, CAS 244640, lateral, dorsal, and ventral views (J Fong).

Figure 4. *Luzonichthys kiomeamea* in its natural habitat, 83 m, Hanga Piko, Rapa Nui (Easter Island), Chile (L.A. Rocha).

life (Table 1; Randall & McCosker 1992, Copus et al. 2015). Also of note is that our specimen has three opercular spines, while other *Luzonichthys* species generally have two (Randall & McCosker 1992).

The nearest species geographically are *L. earlei* (Hawaiian and Line Islands) and *L. whitleyi* (central Pacific, Palmyra, and Kiribati). *Luzonichthys earlei* resembles *L. kiomeamea* in snout length, 3.9–4.25 in HL (vs. 4.1), number of lateral-line scales, 59–68 (vs. 64), caudal-fin concavity 6.05–7.25 in SL (vs. 6.3), pectoral-fin length 3.65–4.0 in SL (vs. 3.96), and pelvic-fin length 4.4–5.2 in SL (vs. 5.03) (Randall & McCosker 1992). *Luzonichthys earlei* can be distinguished by having 19–21 pectoral-fin rays (vs. 22), being less elongate, body depth 3.6–4.1 in SL (vs. 4.8), having a larger head, 3.15–3.35 in SL (vs. 3.6), and by having a more varied and predominantly orange-red coloration. The pectoral-fin ray count of the new species (22) is shared with *Luzonichthys microlepis* (Smith, 1955), *Luzonichthys williamsi* Randall & McCosker, 1992, and *L. whitleyi*; however *L. microlepis* and *L. williamsi* have II,9 anal-fin elements (vs. III,7) and many more lateral-line scales, 70–76 and 70–78, respectively (vs. 64). Additionally, *L. whitleyi* has a wider caudal peduncle, 2.45–2.9 in HL (vs. 2.3); a shorter snout, 4.2–4.75 in HL (vs. 4.1); a longer third anal-fin spine 3.3–3.7 in HL (vs. 4.7), and many fewer gill rakers, 7–8+20–23 (vs. 12+26) and marginally more lateral-line scales, 65–74 (vs. 64). *Luzonichthys seaver* has fewer pectoral-fin rays, 19–21 (vs. 22); fewer scales between the lateral line and the first dorsal-fin spine, 5 (vs. 6); a shallower caudal concavity, 8.4–8.5 in SL (vs. 6.3); and shorter pelvic fins, 5.7–6.6 in SL (vs. 5.0). *Luzonichthys taeniatus* Randall & McCosker, 1992 and *L. waitei* have fewer pectoral-fin rays, 19 and 17–21 (vs. 22); fewer lateral-line scales 56–60 and 51–59 (vs. 64); a deeper body, body depth 3.7–4.0 and 3.3–3.8 in SL (vs. 4.8); and *L. taeniatus* has more scales from the base of the anal fin to the lateral line, 17–18 (vs. 12).

Discussion. Mitochondrial DNA sequencing shows that the new species falls within the set of lineages representing *Luzonichthys* species. The new species' COI sequence is more than 11% divergent, and about equally distant, from the sequences obtained from *Luzonichthys waitei* (11.22%), *L. seaver* (11.27%), *L. earlei* (Hawai'i) (11.54%), and *L.* aff. *earlei* (Coral Sea) (11.38%) (all minimum pairwise distance by BOLD similarity algorithm).

Morphological analyses by Anderson et al. (1990) suggest that the genus *Luzonichthys* may form a monophyletic grouping with the 4 valid species of *Rabaulichthys* Allen, 1984 and *Anatolanthias apiomycter* Anderson, Parin & Randall, 1990. The shape of the dorsal fin differs greatly among the genera: *A. apiomycter* has a continuous dorsal fin, *Luzonichthys* possesses a dorsal fin that is incised to near its base between the spinous and soft portions, and male specimens of *Rabaulichthys* have a single, greatly enlarged, sail-like dorsal fin (Anderson et al. 1990, Masuda & Randall 2000, Randall & Walsh 2010). Other characters that differ between the three genera are a greatly reduced or absent ventralmost opercular spine in *Luzonichthys* and, in *A. apiomycter*, an abrupt distal expansion of the maxilla with a rostrally directed hook present at the labial border. This hook is lacking in *Luzonichthys* and *Rabaulichthys*, and has been suggested to be an autapomorphy for *A. apiomycter* (Anderson et al. 1990). *Luzonichthys kiomeamea* exhibits both the third opercular spine and the abrupt distal expansion of the maxilla, but without the hook at the labial border.

Classification of the Anthiadinae is problematic; several genera are in need of revision as they are not currently defined on the basis of synapomorphies and there is high variation among defining characters (Anderson & Heemstra 2012, Gill et al. 2016). Additional morphological analyses and wider genetic sampling is needed to paint a more complete picture of the Anthiadinae, including relationships within the genus *Luzonichthys* and between these species and the other two genera in the proposed monophyletic grouping (*Rabaulichthys* and *Anatolanthias*).

Luzonichthys kiomeamea sp. n. was found at 80–90 m depth in a mixed shoal with an undescribed *Pseudanthias* species, on the same rocky mesophotic coral habitat as the recently described *Plectranthias ahiahiata* (Shepherd et al. 2018) (Fig. 4). The discovery of these new species underscores the diversity and high endemism of the Rapa Nui fish fauna.

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