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FULL PAPER

Apogon soloriens, a new species of cardinalfish (Perciformes: Apogonidae) from the Bonin Islands, Japan

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Abstract
The new cardinalfish *Apogon soloriens* is described on the basis of nine specimens collected from the Bonin Islands (northern island chain of Ogasawara Islands), Japan. The new species resembles *Apogon caudicinctus* Randall and Smith 1988 in coloration, lacking a black band below the second dorsal fin but with a black band on the caudal peduncle, but differs in having 13 pectoral-fin rays (vs. 12 rays in *A. caudicinctus*), greater interorbital width [9.1–11.1% of standard length (mean 9.8%) vs. 6.6–7.9% (7.3%)], and a wider blackish band on the caudal peduncle (vs. narrower black band). A key to the *Apogon talboti* look-alike group is provided.

Keywords *Apogon caudicinctus* · Taxonomy · Morphology · Teleostei · Ogasawara islands

Introduction

The apogonid genus *Apogon* Lacepède 1801 (Apogonidae) is characterized by II, 8 anal-fin rays, predorsal scales present, preopercular flap not extending beyond the vertical edge of the preopercle, and a pale stomach and intestine (Mabuchi et al. 2014). The genus includes several species complexes or groups: *Apogon coccineus* complex (defined by Greenfield 2001), *Apogon erythrinus* complex (Greenfield 2001), *Apogon talboti* group (Greenfield and Randall 2004), and *Apogon talboti* look-alike group (Greenfield and Randall 2004).

The Ogasawara Islands consist of two major island chains (Bonin and Volcano islands) and three isolated small islands and have never been connected to the Asian Continent and the mainland of Japan. The Bonin Islands, northern island chain, are located about 1,000 km south of Tokyo (Kuriiwa 2018). During an ichthyofaunal survey in the Bonin Islands in 2015, nine unidentified specimens belonging to the *A. talboti* look-alike group, having two supraneural bones and a membranous flap at the lower corner and along the ventral margin of the preopercle, were collected from the Bonin Islands. Although similar to *Apogon caudicinctus* Randall and Smith 1988 of the group in color pattern and several other characters, the former differed in their greater number of pectoral-fin rays, greater interorbital width, and a wider blackish band on the caudal peduncle. They are described herein as a new species, and a key to the species belonging to the *A. talboti* look-alike group is provided. The group includes *A. caudicinctus*, *Apogon deetsie* Randall 1998, *Apogon dianthus* Fraser and Randall 2002, and *Apogon rubrifuscus* Greenfield and Randall 2004, in addition to the new species.

Materials and methods

Counts and measurements followed Yoshida and Motomura (2016). Measurements were made to the nearest 0.1 mm with needlepoint calipers under a dissecting microscope. Standard

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and head lengths are abbreviated as SL and HL, respectively. Curatorial procedures for the newly collected specimens followed Motomura and Ishikawa (2013). Institutional codes follow Sabaj (2019). Osteological characters, including vertebral counts, were observed on a radiograph of one specimen of the new species (KAUM–I. 74617, 30.7 mm SL) and two specimens of *A. caudicinctus* (KAUM–I. 29534, 48.7 mm SL; KAUM–I. 45768, 48.5 mm SL). The formula for the configuration of supraneural bones, anterior neural spines, and anterior dorsal-fin pterygiophores follows Ahlstrom et al. (1976).

Key to the species belonging to the *Apogon talboti* look-alike group

1a. No blackish band on caudal peduncle 2
1a. Blackish band on caudal peduncle 3
2a. Caudal peduncle relatively deep, its depth 11.0–14.8 % of SL; 15 developed gill rakers .... *A. dianthus* (Indo-West Pacific)
2b. Caudal peduncle relatively shallow, its depth 10.0 % of SL; 20 developed gill rakers .... *A. rubrifuscus* (Easter Island)
3a. Black vertical band on body below second dorsal fin; 13–15 developed gill rakers ....*A. deetsie* (Hawaiian and Tuamotu islands)
3b. No black band on body below second dorsal fin; 8–12 developed gill rakers 4
4a. 12 pectoral-fin rays; narrower blackish band on caudal peduncle from midpoint to base of caudal fin; interorbital space narrow, its width 6.6–7.9 % of SL..... ..... *A. caudicinctus* (Indo-Pacific)
4b. 13 pectoral-fin rays; wider blackish band on caudal peduncle before midpoint to base of caudal fin; interorbital space wide, its width 9.1–11.1 % of SL .... *A. soloriens* sp. nov. (Bonin Islands)

Apogon soloriens sp. nov.

(New English name: Rising-sun Cardinalfish; new Japanese name: Asahi-tenjikudai)
(Figs. 1, 2, 5; Table 1)

Holotype. KAUM–I. 74702, 23.5 mm SL, Shika-hama, Ototo-jima island, Bonin Islands, Ogasawara Islands, 27°07′44″N, 142°11′01″E, 5–25 m depth, hand net, 5 July 2015, T. Yoshida.

Paratypes. 8 specimens, 18.9–30.7 mm SL, all from Bonin Islands, Ogasawara Islands. KAUM–I. 74505, 27.2 mm SL, off Kita Port, Haha-jima island, 26°41′59″N, 142°08′28″E, 4 m depth, hand net, 26 June 2015, K. Koeda; KAUM–I. 74,541, 23.8 mm SL, Dobuiso, Chichi-jima island, 27°05′22″N, 142°15′08″E, 5–45 m depth, hand net, 2 July 2015, S. Chiba et al.; KAUM–I. 74617, 30.7 mm SL, KAUM–I. 74618, 24.8 mm SL, KAUM–I. 74619, 25.0 mm SL, KAUM–I. 74620, 18.9 mm SL, east of Nishi-jima island, 27°07′14″N, 142°10′12″E, 5–25 m depth, hand net, 3 July 2015, S. Tashiro; KAUM–I. 74701, 27.8 mm SL, Shika-hama, Ototo-jima island, 27°07′44″N, 142°11′01″E, 26 m depth, hand net, 5 July 2015, K. Koeda; KAUM–I. 74703, 22.0 mm SL, same data as holotype.

Diagnosis. A species of *Apogon* with the following combination of characters: dorsal-fin rays VI-I, 9; anal-fin rays II, 8; pectoral-fin rays 13; developed gill rakers 8 or 9 (modally 9); total gill rakers (including rudiments) 15–18 (16); interorbital width 9.1–11.1% (mean 9.8%) of SL; supraneural bones 2; membranous flap at lower corner and along ventral margin of preopercle; no black band on body below second dorsal fin; wide blackish band with reddish suffusion on caudal peduncle from before midpoint to base of caudal fin.

Description. Meristics and morphometrics of the type specimens are shown in Table 1. Data for the holotype are presented first, followed by paratype data (if different) in parentheses. Vertebrae 10 + 14; formula for supraneural bones, anterior neural spines and anterior dorsal pterygiophores /00/1/1 + 1/1/1/1/ (based on paratype, KAUM–I. 74617; no data for holotype).

Body rounded, moderately deep, compressed, deepest at first dorsal-fin origin. Dorsal and ventral profiles of head and body convex. Caudal peduncle moderately deep. Head large, compressed. Eye large, round, orbit diameter 3.3 (2.8–3.3) in HL. Mouth oblique, forming angle of ca. 30 degrees to horizontal axis of body. Posterior margin of maxilla slightly concave, extending beyond vertical through anterior margin of pupil. Upper-jaw length 1.9 (1.7–1.9) in HL. Tip of upper jaw anterior to tip of lower jaw. No enlarged caniniform teeth on jaws. A tooth band on both jaws, irregular V-shaped patch of small teeth on vomer, narrow band of teeth rows on palatine, absent on ectopterygoid. Anterior nostril with short oval tube, uppermost margin of opening above level of ventral margin of pupil. Posterior nostril oval, opening vertically, rim absent, uppermost margin below level of dorsal margin of pupil. Gill rakers slender, moderately long. Posterior margin of preopercle serrated with flap. Lateral line well developed, extending from upper end of gill opening to caudal-fin base.

First dorsal-fin origin posterior to vertical through pectoral-fin base; second spine of first dorsal fin longest, its length 2.3 (2.0–2.4) in HL. Posterior end of first dorsal-fin base anterior to vertical through posterior tip of pelvic fin. Second dorsal-fin origin anterior to vertical through anal-fin origin; length of dorsal spine of second dorsal fin 3.6 (3.1–3.6) in HL; first soft ray of second dorsal fin longest, its length 2.0 (1.6–2.0) in HL; all second dorsal-fin rays branched. Posterior end of

Table 1 Meristics and morphometrics of *Apogon soloriens* sp. nov. and *A. caudicinctus*

	Apogon soloriens sp. nov			*A. caudicinctus*			
	Holotype	Paratypes		Holotype	Paratypes	Non-types	
	Japan	Japan		Rapa	Pacific	Japan	
	KAUM–I. 74702	$n=8$		BPBM 13002	$n=4$	$n=4$	
Standard length (SL; mm)	23.5	18.9–30.7	Modes	50.0	49.8–63.6	27.7–48.7	Modes
Dorsal-fin rays	VI-I, 9	VI-I, 9	VI-I, 9	VI-I, 9	VI-I, 9	VI-I, 9	VI-I, 9
Anal-fin rays	II, 8	II, 8	II, 8	II, 8	II, 8	II, 8	II, 8
Pectoral-fin rays (left/right)	13/13	13/13	13/13	12/12	12/12	12/12	12/12
Pelvic-fin rays	I, 5	I, 5	I, 5	I, 5	I, 5	I, 5	I, 5
Pored lateral-line scales	24	24	24	24	24	24	24
Transverse scale rows above lateral line	2	2	2	2	2	2	2
Transverse scale rows below lateral line	8	8	8	8	8	8	8
Median predorsal-fin scale rows	7	7–8	7	7	7–8	7	7
Circumpeduncular scales	16	16	16	16	16	16	16
Developed gill rakers	1 + 7 = 8	1 + 7–8 = 8–9	9	2 + 10 = 12	1 + 8–9 = 9–10	1 + 7–10 = 8–11	9–10
Gill rakers including rudiments	4 + 12 = 16	3–5 + 12–13 = 15–18	16	4 + 13 = 17	3–4 + 12–13 = 15–17	3–4 + 10–13 = 14–16	15
Upper series of procurrent caudal-fin rays	–	8	8	–	–	7–8	7–8
Lower series of procurrent caudal-fin rays	–	7	7	–	–	7	7
Principal caudal-fin rays	9 + 8	9 + 8	9 + 8	9 + 8	9 + 8	9 + 8	9 + 8
% of SL			Means				Means
Body depth at 1st dorsal-fin origin	31.5	30.0–33.2	32.0	36.4	35.2–37.3	29.6–36.3	35.1
Body width	17.9	17.6–19.8	18.5	19.8	17.3–19.7	18.1–19.8	18.8
Head length	40.9	37.9–42.3	40.3	39.8	37.9–39.4	38.9–40.4	39.2
Snout length	8.9	8.5–10.1	9.0	9.8	9.2–10.1	9.0–9.5	9.5
Eye diameter	12.3	11.8–15.3	13.1	13.6	11.7–13.7	11.9–13.4	12.9
Interorbital width	9.8	9.1–11.1	9.8	7.8	6.6–7.7	7.0–7.9	7.3
Upper-jaw length	21.3	20.5–23.3	22.1	21.6	20.1–20.8	19.9–21.4	20.7
Caudal-peduncle depth	11.9	11.2–13.2	12.1	15.2	14.5–15.0	12.2–13.4	14.0
Caudal-peduncle length	28.5	25.1–29.1	27.4	29.0	26.4–27.8	28.5–30.0	28.3
Pre-dorsal-fin length	43.0	42.0–46.6	43.8	44.8	42.8–44.6	42.6–44.1	43.7
Dorsal-fin base length	31.1	30.2–32.7	31.1	35.0	32.1–33.3	31.0–34.7	33.3
1st dorsal-fin spine length	4.3	3.6–4.8	4.2	4.0	4.4–5.2	3.6–4.6	4.4
2nd dorsal-fin spine length	17.9	16.8–18.9	18.1	21.4	21.6–24.1	18.4–23.4	22.2
3rd dorsal-fin spine length	15.7	14.3–16.9	15.8	19.0	17.5–18.7	15.5–21.2	18.5
4th dorsal-fin spine length	11.9	11.2–13.6	12.5	14.8	14.2–15.5	12.6–16.1	14.7
1st spine length of 2nd dorsal fin	11.5	11.3–12.8	11.9	14.0	13.9–14.1	13.4–15.3	14.1
Longest dorsal-fin soft ray length	20.4	20.2–23.7	21.6	23.2	20.7	23.6–24.2	22.9

Table 1 (continued)

	Apogon soloriens sp. nov			*A. caudicinctus*			
	Holotype	Paratypes		Holotype	Paratypes	Non-types	
	Japan	Japan		Rapa	Pacific	Japan	
	KAUM–I. 74702	$n=8$		BPBM 13002	$n=4$	$n=4$	
Pre-anal-fin length	57.0	56.5–61.4	58.6	59.8	59.9–61.4	57.4–59.8	59.5
Anal-fin base length	14.0	12.6–14.3	13.6	14.4	11.8–14.2	13.4–15.0	13.6
1st anal-fin spine length	3.0	1.8–3.2	2.6	2.6	1.7–2.7	1.5–2.3	2.1
2nd anal-fin spine length	11.5	10.3–13.2	11.1	13.8	10.9–12.9	11.6–14.0	12.4
Longest anal-fin soft ray length	19.1	20.2–22.3	21.0	20.6	19.7–21.8	20.6–20.7	20.7
Caudal-fin length	32.3	29.5–33.9	31.7	–	28.0	32.0–32.8	31.2
Caudal-fin concavity length	14.0	11.4–14.3	13.2	–	–	13.8–14.6	14.2
Pectoral-fin base length	6.0	5.5–7.4	6.3	5.2	5.0–5.4	4.7–5.4	5.2
Pectoral-fin length	25.5	24.4–28.3	26.6	25.2	24.5–27.0	26.4–27.1	26.0
Pre-pelvic-fin length	37.0	34.5–39.7	37.0	38.8	36.0–40.4	37.2–38.6	38.5
Pelvic-fin spine length	13.6	13.4–15.3	14.2	16.4	14.2–16.6	13.7–17.5	15.9
Longest pelvic-fin soft ray length	21.3	20.2–23.6	21.4	21.8	24.1	23.7	23.3

Fig. 1 Photographs of fresh specimens of *Apogon soloriens* sp. nov. **a** Holotype, KAUM–I. 74702, 23.5 mm SL, Ototo-jima island, Bonin Islands, Ogasawara Islands; **b** paratype, KAUM–I. 74617, 30.7 mm SL, Nishi-jima island, Bonin Islands, Ogasawara Islands

Fig. 2 Photographs of preserved specimens of *Apogon soloriens* sp. nov. **a** Holotype, KAUM–I. 74702, 23.5 mm SL, Ototo-jima island, Bonin Islands, Ogasawara Islands; **b** paratype, KAUM–I. 74617, 30.7 mm SL, Nishi-jima island, Bonin Islands, Ogasawara Islands

Fig. 3 Photographs of fresh specimens of *Apogon caudicinctus*. **a** Non-type, KAUM–I. 99992, 27.7 mm SL, Iwo-tou island, Volcano Islands, Ogasawara Islands; **b** non-type, KAUM–I. 21765, 32.9 mm SL, Yaku-shima island, Osumi Islands

second dorsal-fin base posterior to vertical through base of seventh anal-fin soft ray. Anal-fin origin below base of first (first or second) soft ray of second dorsal fin; first spine of anal fin short; second anal spine long, its length 3.6 (3.0–4.0) in HL; first soft ray of anal fin long, its length 2.1 (1.7–2.1) in HL; all anal-fin rays branched. Pelvic-fin origin anterior to vertical through origin of first dorsal fin; pelvic-fin spine long, its length 3.0 (2.6–3.0) in HL; first pelvic-fin soft ray longest, its length 1.9 (1.7–2.0) in HL. Posterior tip of depressed pelvic fin reaching to vertical through origin of second dorsal fin. Pectoral fin long, its length 1.6 (1.3–1.7) in HL, posterior tip anterior to vertical through base of fourth (fourth to sixth) dorsal-fin soft ray. Caudal fin forked. Anus closer to anal-fin origin than to pelvic-fin origin.

Color when fresh (Fig. 1). Head reddish orange, with black pigmentation on snout and opercle. Body reddish orange with blackish band suffused with reddish orange on caudal peduncle from before midpoint to base of caudal fin, no black band on body below second dorsal fin. Iris yellowish gold to reddish gold. Black pigmentation scattered on upper part of body from nape to below second dorsal-fin base (sometimes with anal-fin base). Small specimen (holotype, 23.5 mm SL; Fig. 1a) with irregular black patches on scales on upper part of body, anal-fin base and caudal peduncle. Large specimen (30.7 mm SL; Fig. 1b) with black pigmentation at middle of scales on upper part of body and caudal peduncle.

Fig. 4 Photographs of preserved specimens of *Apogon caudicinctus*. **a** Holotype, BPBM 13002, 50.0 mm SL, Rapa, Bass Islands, French Polynesia; **b** non-type, KAUM–I. 99992, 27.7 mm SL, Iwo-tou island, Volcano Islands, Ogasawara Islands; **c** non-type, KAUM–I. 21765, 32.9 mm SL, Yakushima island, Osumi Islands

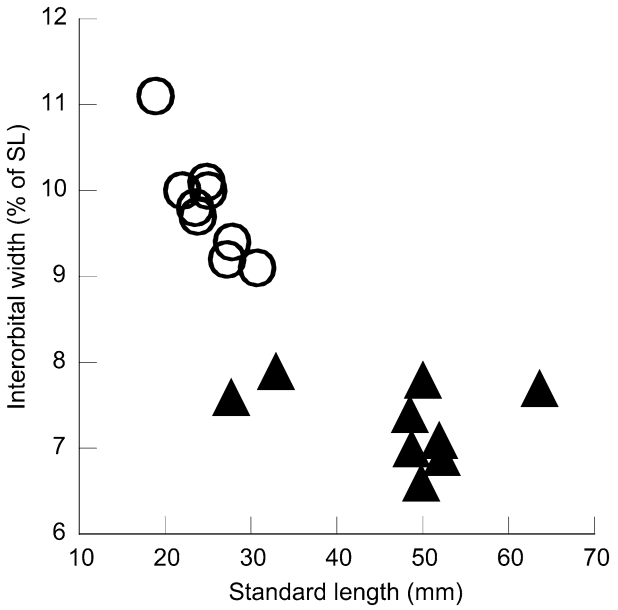

Fig. 5 Relationship of interorbital width (% of SL) to SL (mm) in *Apogon soloriens* (*open circles*) and *A. caudicinctus* (*closed triangles*)

Color in alcohol (Fig. 2). Head and trunk pale. Snout, behind eye, posteroventral margin of orbit, lower part of opercle, upper part of body and caudal peduncle with black pigmentation. Iris black. Fins semi-translucent (sometimes with black pigmentation on first dorsal fin, rarely with black pigmentation on second dorsal and anal fins). Stomach and intestine pale.

Distribution. Restricted to the Ogasawara Islands (Bonin Islands only), Japan. Collection data indicate capture depths of 4–45 m.

Etymology. The specific name "*soloriens*" is derived from Latin, meaning "Rising-sun", in reference to the body color.

Comparisons. The new species can be easily distinguished from *A. deetsie*, *A. dianthus*, and *A. rubrifuscus* by having a blackish band on the caudal peduncle (vs. band absent in *A. dianthus* and *A. rubrifuscus*), 8 or 9 developed gill rakers (vs. 13–15 in *A. deetsie*, 15 in *A. dianthus*, and 20 in *A. rubrifuscus*), and 15–18 total gill rakers (vs. 19 in *A. dianthus* and 20 in *A. rubrifuscus*), and lacking a black band on the body below the second dorsal fin (vs. band present in *A. deetsie*) (Randall 1998; Fraser and Randall 2002; Greenfield and Randall 2004; Greenfield 2007; this study).

Apogon soloriens is most similar to *A. caudicinctus* (Figs. 3, 4), both species lacking a black band on the body below the second dorsal fin, but having a blackish band on the caudal peduncle. However, *A. soloriens* has more pectoral-fin rays (13 vs. 12 in *A. caudicinctus*; Table 1) and a greater interorbital width [9.1–11.1% of SL (mean 9.8%) vs. 6.6–7.9% (mean 7.3%); Fig. 5]. In addition, the blackish band on the caudal peduncle of *A. soloriens* is relatively wider than that of *A. caudicinctus*, in which the band extends only from the midpoint of the peduncle (Figs. 1, 2, 3, 4).

Apogon caudicinctus has been recorded from Réunion Island, Indian Ocean, as well as from the following Pacific Ocean localities: Pitcairn Islands, Marquesas Islands, Rapa, Fiji, and Japan (Randall and Smith 1988; Randall 2005; this study). In the Ogasawara Islands, *A. soloriens* and *A. caudicinctus* have been collected only from the Bonin (northern island chain) and Volcano islands (southern island chain), respectively. Although comprehensive surveys of specimens of *Apogon* in museum collections have been made by the authors, no additional examples of the new species from beyond the area of the Bonin Islands were located, suggesting that *A. soloriens* is most likely endemic to the Bonin Islands.

Comparative material. *Apogon caudicinctus* (9 specimens, 27.7–63.6 mm SL): BPBM 7398, paratype, 49.8 mm SL, Ishigaki-jima island, Yaeyama Islands, Japan, 6–11 m, 22 May 1968, J. Randall and A. Banner; BPBM 13002, holotype, 50.0 mm SL, south side of Mei Point, Rapa, Bass Islands, French Polynesia, 14 Feb. 1971, J. Randall and D. Cannoy; BPBM 16799, 2 paratypes, 51.9–63.6 mm SL, Big Pool, St. Paul's Point, southeastern Pitcairn Island, Pitcairn Islands, 0.6 m, 7 Jan. 1971, J. Randall et al.; KAUM–I. 21765, 32.9 mm SL, west of Kamazenohana, Kurio, Yaku-shima island, Osumi Islands, Japan, 30°16′03″N, 130°24′48″E, 0–4 m depth, hand net, 30 July 2009, KAUM fish team; KAUM–I. 29534, 48.7 mm SL, off south coast of Iwo-jima island, Osumi Islands, Japan, 30°46′32″N, 130°16′43″E, 10–60 m depth, hand net, 26 May 2010, KAUM fish team; KAUM–I. 45768, 48.5 mm SL, off Tomori Fishing Port, Yoron-jima island, Amami Islands, Japan, 27°01′54″N, 128°24′29″E, 5–10 m depth, hand net, 15 Apr. 2012, M. Yamashita and T. Yoshida; KAUM–I. 99992, 27.7 mm SL, off Mount Suribachi, Iwo-tou island, Volcano Islands, Ogasawara Islands, Japan, 24°44′38″N–24°44′46″N, 141°17′02″E–141°17′13″E, 13–17 m depth, hand net, 6 June 2017, T. Yoshida; WAM P.29385-001, paratype, 52.2 mm SL, Marotiri, Austral Islands, French Polynesia, 0–1.5 m, 20 Feb. 1971, A. Sinito et al.

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