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## *Acanthoplesiops cappuccino*, a new species of acanthoclinine fish from the Red Sea (Teleostei: Plesiopidae)

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### Abstract

*Acanthoplesiops cappuccino* is described from the 16.4 mm SL holotype collected from Jeddah, Saudi Arabia, Red Sea. The following combination of characters distinguishes it from congeners: dorsal-fin rays XVIII,4; anal-fin rays VII,4; pectoral-fin rays 18; caudal fin not connected to last rays of dorsal and anal fins by membrane; and caudal peduncle with a pale yellowish brown bar, which extends broadly on to caudal fin. An underwater photo of the anaesthetised holotype is provided, as well as one of the freshly dead holotype and only known specimen of the similar species *A. naka*. Tables summarizing diagnostic characters of the six known species of *Acanthoplesiops* are included.

**Key words:** ichthyology, systematics, morphology, Acanthoclininae

### Introduction

The Plesiopidae is an Indo-Pacific family of small, tropical and subtropical reef-associated fishes. The family is divided into six subfamilies: Trachinopinae, Assessorinae, Paraplesiopinae, Fraudellinae, Plesiopinae and Acanthoclininae (Mooi 1993). The Acanthoclininae were most recently revised by Smith-Vaniz and Johnson (1990) who recognized twelve species in four genera: *Acanthoclinus* Jenyns (1841), *Acanthoplesiops* Regan (1912), *Beliops* Hardy (1985) and *Belonepterygion* McCulloch (1915). Subsequently, Mooi and Gill (2004b) added the genus *Notograptus* Günther (1867), which had been previously classified in its own family (Notograptidae). The genus *Acanthoplesiops* is unique among acanthoclinines (and plesiopids) in having the following characters: 1 or 2 secondary opercular spines; pectoral radial formula 3-0-1; supracleithral lateral-line canal absent; anterior/posterior ceratohyal suturing both medial and lateral; scales in mid-lateral series bilobed (Mooi & Gill 2004b). Smith-Vaniz and Johnson (1990) included four species in *Acanthoplesiops*, and an additional species was added by Mooi and Gill (2004a): *A. echinatus* Smith-Vaniz and Johnson (1990) from the Sulu Archipelago (Philippines) and eastern Indonesia; *A. hiatti* Schultz (in Schultz *et al.* 1953) from throughout the tropical West Pacific; *A. indicus* (Day 1888) from the western Indian Ocean (east Africa, Seychelles, southern Oman, and southeast India); *A. naka* Mooi and Gill (2004a) from Tonga (misidentified by Randall *et al.* 2003 as *A. indicus*); and *A. psilogaster* Hardy (1985) from the northern Philippines, Taiwan and southern Japan (Fig. 1). Although *Acanthoplesiops* spans the longitudinal range of the subfamily (east Africa to Tonga)—and is the only acanthoclinine genus in the western Indian Ocean—it is unknown from Australia, where it is replaced by its sister genus *Notograptus* (Mooi & Gill 2004b). Up until now it was unknown from the Red Sea. However, in June 2013, during field work conducted by King Abdulaziz University, the second author collected a single specimen at Jeddah, Saudi Arabia. The specimen represents a new species, which we herein describe.



**FIGURE 1.** Distribution records for *Acanthoplesiops* species: *A. cappuccino* (inset star); *A. echinatus* (open stars); *A. hiatti* (closed circles); *A. indicus* (open circles); *A. naka* (closed star); *A. psilogaster* (closed triangles). Distribution records corrected from Mooi & Gill (2004b: fig.8), with additional records from Randall (1995—Oman record for *A. indicus*), Allen & Erdmann (2012—Halmahera record for *A. echinatus*), and the Royal Ontario Museum collection (ROM 63962—New Caledonia record for *A. hiatti*).

## Materials and methods

Scales in longitudinal series were counted along the midside from the first tubed lateral-line scale to the hypural edge. Scales above the anal-fin origin were counted anterodorsally along the scale row extending from the anal-fin origin to the dorsal-fin base. Circumpeduncular scales were counted in a zigzag fashion around the middle part of the caudal peduncle. Other methods of counting and measuring follow Mooi and Gill (2004a), except that all measurements were taken directly from the holotype. Where bilateral counts were made, both counts are provided and presented in the form left count/right count. Osteological details were taken from an x-radiograph. The holotype is deposited in Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany (SMF). Comparisons with other *Acanthoplesiops* species are based on data summarised by Smith-Vaniz and Johnson (1990), and Mooi and Gill (2004a).

### *Acanthoplesiops cappuccino*, new species

Red Sea Spiny Basslet  
 Figures 1–3, Tables 1–2

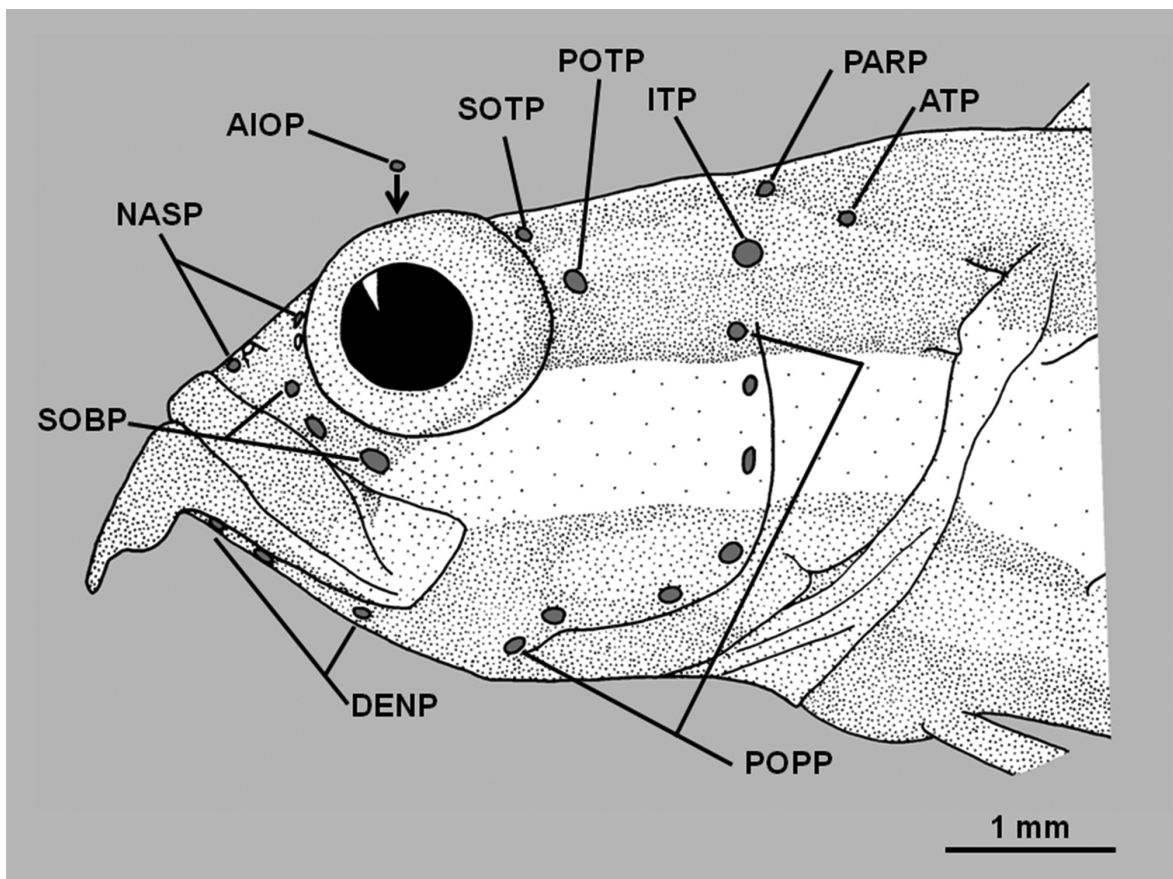
**Holotype.** SMF 34909, 16.4 mm SL, Red Sea, Saudi Arabia, Jeddah, Sharm Obhur, 21°42'30"N, 39°05'44"E, coral-reef slope, 17 m, coll. S.V. Bogorodsky, 03 July 2013.

**Diagnosis.** A species of *Acanthoplesiops* with the following combination of characters: dorsal-fin rays XVIII,4; anal-fin rays VII,4; pectoral-fin rays 18; caudal fin not connected to last rays of dorsal and anal fins by membrane; and caudal peduncle with a pale yellowish brown bar, which extends broadly on to caudal fin.

**Description.** Dorsal-fin rays XVIII,4, all segmented rays branched; anterior dorsal-fin pterygiophore formula S/S/I/I+I/I/I/I/I/I/I; anal-fin rays VII,4, all segmented rays branched; pectoral-fin rays 18/18; pelvic-fin rays I,2, inner segmented ray unbranched; segmented caudal-fin rays 8 + 8, and 2 dorsal and 2 ventral procurrent rays. Caudal fin not connected by membrane to last ray of dorsal and anal fins. Vertebrae 13 + 14 = 27; ribs present on precaudal vertebrae 3–13; epineural bones present to at least caudal vertebra 4.



**FIGURE 2.** *Acanthoplesiops cappuccino*, SMF 34909, anaesthetised holotype, 16.4 mm SL, Jeddah, Saudi Arabia, Red Sea. (Photo by S.V. Bogorodsky.)



**FIGURE 3.** Head of *Acanthoplesiops cappuccino*, SMF 34909, holotype, 16.4 mm SL, showing preserved colour pattern and distribution of cephalic sensory pores. Nasal openings shown in white, sensory pores in dark grey (arrow indicates pore not visible in lateral view): AIOP, anterior interorbital pore; ATP, anterior temporal pore; DENP, dentary pores; ITP, intertemporal pore; NASP, nasal pores; PPARP, parietal pore; POPP, preopercular pores; POTP, posterior otic pore; SOB, suborbital pores; SOTP, supraotic pore. (Drawing by A.C. Gill.)

Cephalic sensory pore openings (Fig. 3): nasal pores 2/2, one pore just posterior to upper lip, second pore just above posterior nostril; anterior interorbital pores 1/1; supraotic pores 1/1; posterior otic pores 1/1; suborbital pores 3/3; preopercular pores 7/7; dentary pores 3/3; intertemporal pores 1/1; parietal pores 1/1; anterior temporal pores 1/1; no posttemporal pores.

Gill membranes fused together ventrally but free from isthmus; branchiostegal rays 6; gill rakers not counted. Scales in longitudinal series 31/30; lateral-line scales 2/2; scales above anal-fin origin 13/14; circumpeduncular scales 14. Olfactory capsule with two openings; anterior opening a short tube, positioned about midway between posterior opening and edge of lip; posterior opening with slightly raised rim, positioned near anterodorsal rim of orbit (Fig. 3). Opercle with secondary opercular spine ventral to the primary spine and overlapping the subopercle (Fig. 3). Free ventral margin of lower lip forming a barbel-like flap (Figs 2, 3). Head and body in front of pectoral fins scaleless, posterior body with ctenoid scales. Teeth numerous, conical and small.

Morphometrics (as % of SL; also reported as % of HL where appropriate): head length (HL) 31.7; head depth at posterior margin of eye 17.7 (56 % HL); eye diameter 9.8 (31 % HL); snout length 6.1 (19% HL); bony interorbital 3.7 (12 % HL); upper jaw length 13.4 (42 % HL); lower jaw length 15.9 (50 % HL); dorsal-fin base 62.8; 1<sup>st</sup> dorsal-fin spine length 6.7; 2<sup>nd</sup> dorsal-fin spine length 7.9; 3<sup>rd</sup> dorsal-fin spine length 10.4; 4<sup>th</sup> dorsal-fin spine length 11.6; 5<sup>th</sup> dorsal-fin spine length 11.6; 6<sup>th</sup> dorsal-fin spine length 12.2; 16<sup>th</sup> dorsal-fin spine length 14.6; 17<sup>th</sup> dorsal-fin spine length 14.6; 18<sup>th</sup> dorsal-fin spine length 15.2; 1<sup>st</sup> dorsal-fin ray length 18.3; 2<sup>nd</sup> dorsal-fin ray length 16.5; 3<sup>rd</sup> dorsal-fin ray length 12.2; 4<sup>th</sup> dorsal-fin ray length 9.8; anal-fin base 25.0; 1<sup>st</sup> anal-fin spine length 6.1; 2<sup>nd</sup> anal-fin spine length 8.5; 3<sup>rd</sup> anal-fin spine length 12.2; 4<sup>th</sup> anal-fin spine length 13.4; 5<sup>th</sup> anal-fin spine length 14.0; 6<sup>th</sup> anal-fin spine length 14.6; 7<sup>th</sup> anal-fin spine length 15.2; 1<sup>st</sup> anal-fin ray length 20.1; 2<sup>nd</sup> anal-fin ray length 18.9; 3<sup>rd</sup> anal-fin ray length 14.6; 4<sup>th</sup> anal-fin ray length 11.0; pectoral-fin length 12.2; pelvic-fin spine length 17.7; 1<sup>st</sup> pelvic-fin ray length 32.3; middle caudal-fin ray length 27.4; snout tip to dorsal-fin origin 33.5; snout tip to pelvic-fin origin 29.3; snout tip to origin of anal fin 67.7; body depth at anal-fin origin 21.3; dorsal-fin origin to pelvic-fin base 23.2; dorsal-fin origin to anal-fin origin 42.7; dorsal-fin origin to anal-fin insertion 63.4; pelvic-fin base to anal-fin origin 38.4; anal-fin origin to dorsal-fin insertion 30.5; dorsal-fin insertion to anal-fin insertion 12.2; hypural depth 11.6; peduncle length 11.6; peduncle depth 12.2; anal-fin insertion to upper hypural 13.4; dorsal insertion to lower hypural 13.4.

Life coloration (based on underwater photograph of anaesthetised holotype; Fig. 2): head and body dark brown, paler on posterior body; yellowish brown median stripe extending from anterior tip of upper lip to dorsal fin origin, cream to white posteriorly and narrowly on edges; tip of lower lip, including anterior edge of fleshy lobe, yellowish brown; second broad pale yellowish brown stripe extending from lower part of upper jaw to vertical below base of last dorsal-fin spine, the stripe more diffuse and irregular behind pectoral-fin base; anterior part of stripe on head and pectoral-fin base edged with pale blue to white; body with scattered tiny to large pale blue to white spots and blotches, which are mostly concentrated around edges of pale stripe; iris dark brown with yellowish brown blotch in front of pupil; caudal peduncle and basal third of caudal fin with broad pale yellowish brown bar; rest of half of caudal fin blackish, edged posteriorly with bright yellow, white and hyaline, respectively, with indistinct tiny blue spots scattered over fin; dorsal and anal fins dark grey-brown to dark grey, the distal tips of lappets from fin spines narrowly edged with white to pale yellow, with scattered tiny blue spots over fins; dorsal and anal fins each with large white spot over last two rays basally; pelvic fins brownish grey, with distal tip of longest branch of first segmented ray narrowly white; pectoral fins hyaline.

Preserved coloration: similar to life pattern; head and body become dark greyish brown; pale median stripe on head indistinct behind interorbital area, no longer apparent on snout or lips; other pale markings on body become pale brown; dorsal, anal, caudal and pelvic fins dark grey-brown, pale markings in life becoming pale brown; pectoral fins pale brown.

**Habitat and distribution.** At present known from the holotype collected at depth of 17 m from the entrance of Sharm Obhur, Jeddah, Saudi Arabia. It was collected on a small reef platform (about 3 x 1 m), with small corals on sand, on steep coral reef slope. The coral slope had mixed patches of corals and caves and extended down to a depth of 30 m, becoming a sandy slope below this depth.

**Etymology.** The specific epithet alludes to the various brown and white markings reminiscent of a cappuccino. To be treated as a noun in apposition.

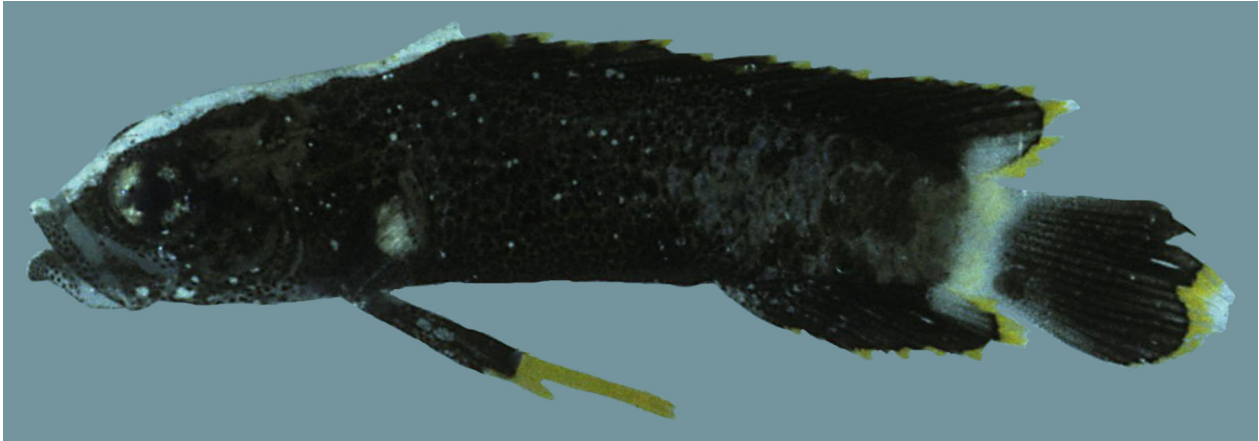
**Comparisons.** Characters distinguishing the six species of *Acanthoplesiops* are summarised in Tables 1–2. *Acanthoplesiops cappuccino* resembles *A. indicus* and *A. naka* in having a pale bar on the caudal peduncle and basally on the caudal fin; this bar is absent in the remaining three species of the genus (colour photos of fresh specimens of *A. echinatus*, *A. hiatti*, and *A. psilogaster* are reproduced in Allen & Erdmann 2012). It differs from

*A. indicus* in other coloration details (cf. Fig. 2 with colour illustrations/photos in Smith & Heemstra 1995, Randall 1995): pale bar on caudal peduncle and fin pale yellowish brown (versus white, bordered anteriorly or bisected by yellow to red bar); no pale spot on anterior base of anal fin (versus white spot present); pale yellowish brown lateral stripe extending from lower part of upper jaw to posterior body (versus no lateral stripe, with white spot on pectoral-fin base). Moreover, *A. cappuccino* differs from *A. indicus* in having the dorsal and anal fins free from the caudal fin (versus broadly attached posteriorly by membrane); fewer dorsal- and anal-fin rays (XVIII,4 [total rays 22] and VII,4 [total rays 11] versus XIX–XX,3–4 [total rays 23–24] and IX–X,3–4 [total rays 13–14], respectively); fewer dentary pores (3 versus 4); and more pectoral-fin rays (18 versus 15–17).

**TABLE 1.** Frequencies of selected meristics of *Acanthoplesiops* species (modified from Mooi & Gill 2004a). Asterisks mark holotype values except where values are unique.

	Dorsal fin												
	Spines				Segmented rays				Total rays				
	XVIII	XIX	XX	XXI	3	4	5	6	22	23	24	25	26
<i>A. cappuccino</i>	1	-	-	-	-	1	-	-	1	-	-	-	-
<i>A. echinatus</i>	-	3	2*	-	-	-	2	3*	-	-	1	3	1*
<i>A. hiatti</i>	-	10*	11	1	-	17*	5	-	-	5*	16	1	
<i>A. indicus</i>	-	11*	2	-	1	12*	-	-	-	12*	1	-	-
<i>A. naka</i>	1	-	-	-	-	1	-	-	1	-	-	-	-
<i>A. psilogaster</i>	-	9*	1	-	1	7	2*	-	-	8	2*		
	Anal fin												
	Spines				Segmented rays				Total rays				
	VII	VIII	IX	X	3	4	5	6	11	12	13	14	
<i>A. cappuccino</i>	1	-	-	-	-	1	-	-	1	-	-	-	
<i>A. echinatus</i>	1	4*	-	-	-	-	2*	3	-	-	3*	2	
<i>A. hiatti</i>	-	4	10*	8	3	14*	5	-	-	2	12*	8	
<i>A. indicus</i>	-	-	9	4*	2	11*	-	-	-	-	11	2*	
<i>A. naka</i>	1	-	-	-	-	1	-	-	1	-	-	-	
<i>A. psilogaster</i>	4	6*	-	-	-	9*	1	-	3	7*	-	-	
	Vertebrae												
	Precaudal			Caudal				Total					
	12	13	14	14	15	16	17	27	28	29	30		
<i>A. cappuccino</i>	-	1	-	1	-	-	-	1	-	-	-		
<i>A. echinatus</i>	-	-	5	-	2	3*	-	-	-	2	3*		
<i>A. hiatti</i>	2	20*	-	-	2	17*	3	-	3	17*	2		
<i>A. indicus</i>	13	-	-	-	1	12*	-	1	12*	-	-		
<i>A. naka</i>	-	1	-	1	-	-	-	1	-	-	-		
<i>A. psilogaster</i>	-	3	7*	9*	1	-	-	-	10	-	-		
	Caudal procurrent rays												
	Dorsal		Ventral										
	2	3	2	3									
<i>A. cappuccino</i>	1	-	1	-									
<i>A. echinatus</i>	-	5	1*	4									
<i>A. hiatti</i>	-	21	2	19*									
<i>A. indicus</i>	13	-	13	-									
<i>A. naka</i>	1	-	1	-									
<i>A. psilogaster</i>	10	-	10	-									





**FIGURE 4.** *Acanthoplesiops naka*, USNM 327794, 9.9 mm SL, freshly dead holotype, Ofolanga Island, Ha'apai Group, Tonga. (Photo by J.T. Williams.)

**TABLE 2.** Comparison of selected characters of *Acanthoplesiops* species (modified from Smith-Vaniz & Johnson 1990).

Character	<i>A. cappuccino</i>	<i>A. echinatus</i>	<i>A. hiatti</i>	<i>A. indicus</i>	<i>A. naka</i>	<i>A. psilogaster</i>
Dentary pores	3	3	4	4	3	3
Teeth present on PB2	?	yes	no	no	?	yes
Supraneurals	2	2	2	0–1, rarely 1	?	1
Pterygiophores between neural spines 2 and 3	1	1	1–2, rarely 2	1	2	2
Autogenous medial radials present in segmented D and A rays	yes	yes	no	yes	?	yes
Preopercle occasionally with 2 secondary spines	no	no	yes	no	no	no
Scales on posterior part of body	ctenoid (typical)	ctenoid (typical)	ctenoid (typical)	“cycloid”	ctenoid (typical)	ctenoid (derived)
Scales on belly anteriorly	yes	yes	yes	yes	no	no
D and A broadly bound by membrane to C	no	no	no	yes	no	no
Caudal peduncle with pale bar	yes, broad	no	no	yes, broad	yes, narrow	no
Minute papillae on head	no	yes	no	no	no	no
Pectoral rays	18	18	17	15–17	16	16–17

The life coloration of *A. naka* has not been reported, but shortly after it was described by Mooi and Gill (2004a), J.T. Williams discovered that he had taken a photograph of the 9.9 mm SL holotype (the only known specimen) when freshly dead. This photograph is reproduced here (Fig. 4). *Acanthoplesiops cappuccino* differs from *A. naka* in having a relatively broad, though less distinct pale bar on the caudal peduncle (pale yellowish brown and extending broadly on to caudal fin versus white and barely extending on to caudal-fin base); pelvic fins with extreme tip of longest branch of first ray white (versus both pelvic fin rays broadly tipped with yellow); and a pale yellowish brown stripe extending from lower part of upper jaw to posterior body (versus no stripe, with white spot on pectoral-fin base). Furthermore, *A. cappuccino* differs from *A. naka* in having more pectoral-fin rays (18 versus 16); scales present on belly anteriorly (versus no scales); and one dorsal pterygiophore inserted between neural spines 2 and 3 (versus two pterygiophores). The last two characters of *A. naka* are derived features shared with *A. psilogaster*.

**Remarks.** Smith-Vaniz and Johnson (1990) cladistically diagnosed *Acanthoplesiops* by several synapomorphies, one of which was the presence of a symphyseal flap on the lower lip. Mooi and Gill (2004b) noted that the flap is relatively long in some individuals, and concluded that it is homologous with the elongate barbel-like flap in *Notograptus* and thus a synapomorphy linking the two genera. The flap is extremely well developed in the holotype of *A. cappuccino*—where it is as well developed as in some *Notograptus* specimens—lending support to Mooi and Gill’s homology assessment.

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## References

- Allen, G.R. & Erdmann, M.V. (2012) *Reef Fishes of the East Indies. Vol. 1*. Tropical Reef Research, Perth, Western Australia, 424 pp.
- Day, F. (1888) Observations on the fishes of India. Part I. *Proceedings of the Zoological Society of London*, 1888, 258–265.  
<http://dx.doi.org/10.1111/j.1469-7998.1888.tb06706.x>
- Günther, A. (1867) Additions to the knowledge of Australian reptiles and fishes. *Annals and Magazine of Natural History*, series 3, 20, 45–68.
- Hardy, G.S. (1985) Revision of the Acanthoclinidae (Pisces: Perciformes), with descriptions of a new genus and five new species. *New Zealand Journal of Zoology*, 11, 357–393.  
<http://dx.doi.org/10.1080/03014223.1984.10428252>
- Jenyns, L. (1840–42) Part IV. Fish. In: *The Zoology of the Voyage of H. M. S. Beagle, Under the Command of Captain Fitzroy, R. N., During the Years 1832 to 1836*. Smith, Elder, and Co., London, pp. i–xvi + 1–172, pls. 1–29.
- McCulloch, A.R. (1915) Notes and illustrations of Queensland fishes. *Memoirs of the Queensland Museum*, 3, 47–56, pls. 16–18.
- Mooi, R.D. (1993) Phylogeny of the Plesiopidae (Pisces: Perciformes) with evidence for the inclusion of the Acanthoclinidae. *Bulletin of Marine Science*, 52, 284–326.
- Mooi, R.D. & Gill, A.C. (2004a) Description of a new species of the fish genus *Acanthoplesiops* Regan (Teleostei: Plesiopidae: Acanthoclininae) from Tonga. *Zootaxa*, 432, 1–10.
- Mooi, R.D. & Gill, A.C. (2004b) Notograptidae, sister to *Acanthoplesiops* Regan (Teleostei: Plesiopidae: Acanthoclininae), with comments on biogeography, diet and morphological convergence with Congrogadinae (Teleostei: Pseudochromidae). *Zoological Journal of the Linnean Society*, 141, 179–205.  
<http://dx.doi.org/10.1111/j.1096-3642.2004.00119.x>
- Randall, J.E. (1995) *Coastal Fishes of Oman*. Crawford House Publishing, Bathurst, 439 pp.
- Randall, J.E., Williams, J.T., Smith, D.G., Kulbicki, M., Mou Tham, G., Labrosse, P., Kronen, M., Clua, E. & Mann, B.S. (2003) Checklist of the shore and epipelagic fishes of Tonga. *Atoll Research Bulletin*, 502, 1–35.  
<http://dx.doi.org/10.5479/si.00775630.502.1>
- Regan, C.T. (1912) The classification of the blennioid fishes. *Annals and Magazine of Natural History*, series 8, 10, 265–280.  
<http://dx.doi.org/10.1080/00222931208693236>
- Schultz, L.P., Herald, E.S., Lachner, E.A., Welander, A.D. & Woods, L.P. (1953) Fishes of the Marshall and Marianas islands. Vol. I. Families from Asymmetronidae through Siganidae. *Bulletin of the United States National Museum*, 202, 1–685.  
<http://dx.doi.org/10.1086/400149>
- Smith, M.M. & Heemstra, P.C. (1995) *Smiths’ Sea Fishes*. Third impression. Southern Book Publishers, Halfway House, pp. i–xxi + 1–1047.
- Smith-Vaniz, W.F. & Johnson, G.D. (1990) Two new species of Acanthoclininae (Pisces: Plesiopidae) with a synopsis and phylogeny of the subfamily. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 142, 211–260.