

Revision of the genus *Microbrotula* (Teleostei: Bythitidae), with description of two new species and a related new genus

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ABSTRACT

Following recent systematic revisions of Anderson (2005, 2007), seven species of the viviparous genus *Microbrotula* (Teleostei: Bythitidae) have been described, all from the Indo-west Pacific Ocean. Six of these species are here recognised as valid: *M. bentleyi*, *M. greenfieldi*, *M. punicea*, *M. queenslandica*, *M. randalli* and *M. rubra*. *Microbrotula polyactis* is regarded as a junior synonym of *M. bentleyi*. Two additional new species, *M. andersoni* and *M. hamata*, obtained from Christmas Island (eastern Indian Ocean) and New Caledonia, respectively, are described herein. The main specific characters distinguishing the new species are the number of precaudal vertebrae, numbers of pectoral, caudal and dorsal fin rays, number and distribution of head pores, number and distribution of sensory papillae on the head and lateral line, presence or absence of a (mostly hidden) curved spine at the lower angle of the preopercle, and otolith morphology. The limits of the genus *Microbrotula* are redefined and the genus is compared with other shallow water bythitine genera. *Calamopteryx* is regarded as the genus that is most closely related to *Microbrotula*. As a result of the redefinition of *Microbrotula*, one of its previously assigned species, *M. randalli*, is placed in a new genus, *Ematops*, characterised by the head pore pattern, unique presence of scales partly covering the eye, number of precaudal vertebrae, number of pectoral and caudal fin rays and the otolith proportion.

KEYWORDS: Bythitidae, viviparous brotulas, Indo-west Pacific, coral reef fishes, new genus, new species, *Microbrotula*, *Ematops*.

INTRODUCTION

Fishes of the family Bythitidae are widely distributed in the world's oceans, ranging in habitats from intertidal pools, reefs and salt-water caves, across the continental slope, to bathyal depths. They are generally near-bottom fishes, benthopelagic in the deeper seas and often secretive on the continental rise and in reefal or rocky habitats. The secretive mode of life of many of the species of the subfamily Bythitinae results in relatively few of them being caught. Investigations over the last decade as well as ongoing research indicate that bythitins may not be as rare as previously thought in near-shore and continental slope environments. In fact, certain groups seem to be adapted to this specific mode of life. In shallow water, genera of cryptic tropical reef and occasional subtropical rocky shore dwellers include *Acarobythites* Machida, 2000, *Anacanthobythites* Anderson, 2008, *Calamopteryx* Böhlke & Cohen, 1966, *Grammonus* Gill, 1896, *Microbrotula* Gosline, 1953 and *Stygnobrotula* Böhlke, 1957. Some members of the genera *Grammonus* and *Lucifuga* Poey, 1858 have also invaded salt water caves, and occasionally even freshwater caves, and evolved endemics therein.

Microbrotula Gosline, 1953 is a genus of Bythitinae characterised by the male copulatory organ being an

integrated part of the fleshy genital hood with the penis present as a small soft papilla without pseudoclasps, and the caudal fins being broadly joined to the dorsal and anal fins (in all but a few species of *Lucifuga* and *Grammonus*). Fishes of the genus *Microbrotula* inhabit hollows and crevices in tropical reefs of the Indo-west Pacific. Since the description of the genus (Gosline 1953), six species are now recognised. One of these, *M. randalli* Cohen & Wourms, 1976, is significantly different from the other five and from the two new species herein described, and is therefore placed in a new genus, *Ematops*.

MATERIAL AND METHODS

A total of 39 specimens of *Microbrotula* and *Ematops* gen. nov. were examined for this study, including the type material of all the previously described species.

Institutional abbreviations follow Fricke & Eschmeyer (2011).

Comparative material of the three species of the genus *Calamopteryx* and one of two species of *Anacanthobythites* was also examined:

Calamopteryx goslinei Böhlke & Cohen, 1966: 2 paratypes, ZMUC P77464-465, Dominica; 1 non-type: USNM 359147, Navassa Island, between Jamaica and Haiti.

Calamopteryx jeb Cohen, 1973: 2 paratypes, ZMUC P77571-572, Galapagos Islands; 3 non-types: LACM 45592-22, Galapagos Islands.

Calamopteryx robinsorum Cohen, 1973: holotype, USNM 26748, Caribbean Panama; 2 paratypes, ZMUC P77573-574, Caribbean Mexico; 1 non-type, USNM 359299, off Caribbean Columbia.

Anacanthobythites tasmaniensis Anderson, 2008: 1 paratype, CSIRO H 6280-02, off Port Davey, Tasmania.

Morphometric characters are given as a percentage of standard length (SL) and head length (HL). In the descriptions, holotype values are given first, followed by paratype values in parentheses. The size of the eye is measured as the horizontal diameter of the pigmented eyeball. Counts were made from radiographs, except for the pectoral fin rays, gill rakers, teeth and scale rows. Abbreviations used for counts are: D/V = anterior dorsal fin ray above vertebra number; D/A = anterior anal fin ray below dorsal fin ray number; V/A = anterior anal fin ray below vertebra number.

Otoliths were removed through the gill cavity by making a small incision in the otic capsule above the gills on the right side. Otolith measurements include length, height and thickness of the otolith and length of the colliculum, a structure filling the sulcus on the inner face (for otolith terminology see Schwarzhans *et al.* 2005). Measuring of the colliculum was selected over measuring the sulcus, the usual measurement in otoliths, because in the otoliths of many bythitins, including *Microbrotula* and *Ematops*, the colliculum has a sharper outline than the sulcus, resulting in more repeatable values.

Head drawings and pore counts follow the standards established for the description of Dinematchthyinae in Møller *et al.* (2004) and Schwarzhans *et al.* (2005). In *Ematops*, an additional set of pores is present on the occiput that require specific description (see p. 156).

Scale length was taken on scales from under the pectoral fin.

The distribution map (Fig. 10) was created using Microsoft Encarta 2001 digital world atlas.

Family Bythitidae Gill, 1861

Subfamily Bythitinae Gill, 1861

KEY TO SHALLOW WATER GENERA OF BYTHITINAE

The following key includes genera, of which some species inhabit deeper water.

- 1a. Maxilla narrow posteriorly, not expanded 2
- 1b. Maxilla vertically expanded posteriorly 3
- 2a. Body and head naked; head pointed; precaudal vertebrae 12 or 13.....*Acarobythites*
- 2b. Body and part of head with scales; head blunt; precaudal vertebrae 14 *Stygnobrotula*
- 3a. Head scales partly extending over eye; precaudal vertebrae 13 or 15; caudal vertebrae 38–42; caudal fin rays 3 or 4; pectoral fin rays 9–11; supraorbital pores 6 or 7 (including one median interorbital) *Ematops* gen. nov.
- 3b. No scales extending over eye; precaudal vertebrae 10–13; caudal vertebrae 33–38; caudal fin rays 6–10; pectoral fin rays 11–29; supraorbital pores 0 or 1..... 4
- 4a. Pectoral fin rays 19–29; branchiostegal rays 8; lateral line with 2 or more series of papillae; no preopercular spine..... *Grammonus*
- 4b. Pectoral fin rays 11–19; branchiostegal rays 6 or 7; lateral line with single series of papillae; preopercle with exposed or covered forward-curved spine (absent in *Microbrotula punicea* and *rubra*) 5
- 5a. Pectoral fins supported by elongate radials..... *Calamopteryx*
- 5b. Pectoral fin radials not elongate 6

Table 1. Comparison of morphological characters between *Microbrotula*, *Ematops* gen. nov., *Calamopteryx* and *Anacanthobythites*.

	<i>Microbrotula</i>	<i>Ematops</i>	<i>Calamopteryx</i>	<i>Anacanthobythites</i>
Precaudal vertebrae	11–13	13–15	11–12	11–12
Caudal fin rays	6–9	3–5	10	10
Supraorbital pores	none	6–7	1	none
Lower preopercular pores	mostly 1–2	1–2	none	none
Spine at lower preopercle angle	mostly present, hidden	absent	free	free or hidden
Developed rakers on 1st gill arch	2–4	2–4	2	none
Palatine teeth	present / absent	present	present	none
Pectoral radials	short	short	elongated	short
Head squamation	patchy: cheek, opercle, occiput	entire head, partly over eye	patchy: cheek, opercle, occiput	patchy: cheek, occiput
Otolith length : otolith height	1.9–2.4	2.4–2.7	2.4–2.9	2.7
Interorbital width in % SL	3.9–7.0	1.1–1.7	3.9–6.4	5.4–5.7

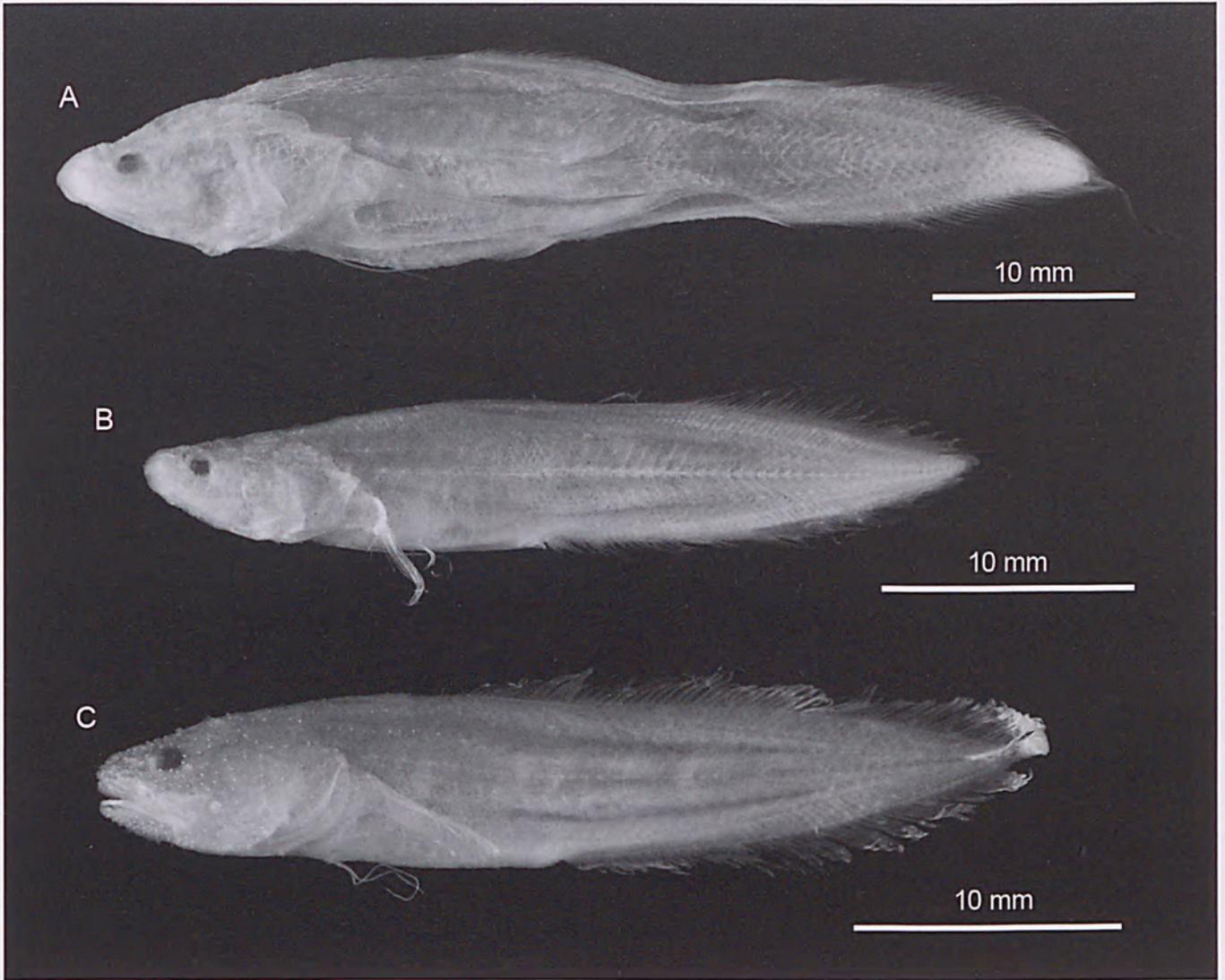


Fig. 1. Species of *Microbrotula*: **A**, *Microbrotula andersoni* sp. nov. Holotype, WAMP.26084-004, female, 52 mm SL; **B**, *Microbrotula hamata* sp. nov. Holotype, NMNZ.P.29559, female, 33.5 mm SL; **C**, *Microbrotula* aff. *bentleyi* Anderson, 2005, NSMT 71423, female, 34.5 mm SL.

- 6a. No palatine teeth; no preopercular pore; no developed rakers on first gill arch.....*Anacanthobythites*
 6b. Palatine teeth present or absent; preopercular pores 1 or 2; 2–4 developed rakers on first gill arch.....
*Microbrotula*

***Microbrotula* Gosline, 1953**

(Tables 1–3)

Gender feminine. Type species, by original designation, *Microbrotula rubra* Gosline, 1953. Type locality: Kaneohe Bay, Oahu Island, Hawaii.

As redefined in this paper, *Microbrotula* comprises seven species – *M. andersoni* sp. nov. (Fig. 1A), *M. bentleyi* Anderson, 2005, *M. greenfieldi* Anderson, 2007, *M. hamata* sp. nov. (Fig. 1B), *M. punicea* Anderson, 2007, *M. queenslandica* Anderson, 2005 and *M. rubra* Gosline, 1953. *Microbrotula polyactis* Anderson, 2005 is considered a junior synonym of *M. bentleyi* (see discussion of *M. bentleyi*). A previously recognised *Microbrotula*

species, *M. niger* Gosline, 1953, is now valid as *Grammonus waikiki* (Cohen, 1964) (see Nielsen *et al.* 1999).

Diagnosis (modified from Anderson 2005). Genus comprising four small species reaching 45 mm SL and three large species attaining 52–60 mm SL (*M. andersoni*, *M. bentleyi* and *M. punicea*). Vertebrae 11–13 + 33–38 = 44–51. Dorsal fin origin above vertebrae 7–11. Anal fin origin below vertebrae 13–17. Caudal fin rays 6–9. Pectoral fin rays 11–19. Pelvic peduncle not elongate. Branchiostegal rays 7. Head length 25.2–29.2% SL. Interorbital width 3.9–7.0% SL. Head with scales on cheek, opercle and occiput. Anterior nostril tubular, just above upper lip. Rear portion of maxilla vertically expanded. Vomerine teeth in 2 small patches; palatine teeth in single row or absent. Opercular spine thin, needle-like, often covered by skin; forward-curved spine at lower angle of preopercle covered by skin, absent in *M. rubra* and *M. punicea*. Developed gill rakers 2–4. Pores: 3 anterior mandibular, 3 posterior mandibular (except none in *M. greenfieldi*), no supraorbital, 1–2 lower preopercular, no upper preopercular (except 1 in

Table 2. Morphological comparison of the species of *Microbrotula* and *Ematops*. * includes one tentatively assigned specimen (outside values in brackets). ** Holotype included in range from original description.

	<i>Ematops</i>		<i>Microbrotula</i>					
	<i>randalli</i>	<i>andersoni</i>	<i>bentleyi</i> *	<i>greenfieldi</i> **	<i>hamata</i>	<i>punicea</i>	<i>queenslandica</i>	<i>rubra</i> **
Number of specimens studied	8	1	17	2	2	7	1	1
Precaudal vertebrae	13–15	11	11–12	11–12	11–12	11–13	12	11
Total vertebrae	51–57	46	44–47	45–47	48	49–53	48	46
Pectoral fin rays	9–11	19	15–17	13–14	15–16	14	11	12–14
Caudal fin rays	3–4	8	7–8	6	8–9	6	6	6
Dorsal fin rays	78–87	70	61–70	62–70	76	77–82	78–80	81–92
Anal fin rays	63–75	59	50–57	58–61	60–62	64–71	62–63	72–80
Dorsal fin origin above vertebra number	9–11	8	7–8 (9)	7–8	8	8–10	7	11
Anal fin origin below dorsal fin ray number	14–19	14	(12) 14–16	14–15	14–15	18–21	21	9
Anal fin origin below vertebra number	15–19	13	13–16	14	14	15–16	15–17	13
Forward curved preopercular spine hidden below skin	absent	present	present	present	present	absent	present, with two points	absent
Palatine teeth	strong, single row	absent	small, single row or absent	minute, single row	small, single row	strong, single row	tooth-like papillae	strong, single row
Mandibular pores (ant. + post.)	3+3	3+3	3+3	3+0	3+3	3+3	3+3	3+3
Preopercular pores (low. + up.)	1–2+0	2+0	1–2+0	0+0	1+0	1+0	1+0	1+1
Infraorbital pores (ant. + post.)	3+1	3+0	3+0	3+0	3+0	3+0	3+0	3+3
Head papillae	anterior half	between eyes and low. jaw	anterior half to entire head	lower jaw	anterior half	between eyes	entire head	entire head
Lateral line papillae	anterior ¼	few	anterior ¼ (½)	absent or few	absent or few	anterior ¼	absent	full
Head squamation		patches	patches	patches	continuous	continuous	patches	yes, no detail
Otolith length : otolith height	2.4–2.7	2.1	1.9–2.1 (2.2)	2.0	2.2	2.4	2.3	unknown
Otolith length : colliculum length	2.8–3.3	2.8	2.5–2.7	2.4	3.5	3.1–3.5	2.4	unknown
Interorbital width in % SL	1.1–1.7	3.9	4.5–7.0	5.7–6.4	4.3–4.5	4.1–4.3	4.2–4.5	6.1–7.0

M. rubra), 3 anterior infraorbital, no posterior infraorbital (except 3 in *M. rubra*).

Comparison and discussion. *Microbrotula* resembles *Calamopteryx*, *Anacanthobythites* and *Ematops* gen. nov. (Table 1). Of these genera, *Calamopteryx* was hitherto thought to be well defined by the forward-curved spine at the lower angle of the preopercle, but the observation of a similar spine in *Lucifuga inopinata* Cohen & McCosker, 1998, and also in the genus *Anacanthobythites* and many species of *Microbrotula* invalidates it as a diagnostic character of *Calamopteryx*. Thus, *Microbrotula* is presently distinguished from *Calamopteryx* merely by the short pectoral peduncle (versus elongate) and the presence of 1–2 lower preopercular pores (versus none). *Microbrotula* differs from *Anacanthobythites* by the presence of 1–2 lower preopercular pores (versus none), palatine teeth

present (versus absent) and 2–4 developed gill rakers on first branchial arch (versus none). Species of *Anacanthobythites* generally grow larger than species of *Microbrotula* (50–106 mm SL versus mostly less than 60 mm SL). For a comparison with *Ematops* gen. nov. see p. 159.

Apparently all four genera are closely related. *Calamopteryx* represents the New World counterpart of the Indo-west Pacific tropical genus *Microbrotula*, and *Anacanthobythites*, its southern temperate relative.

KEY TO SPECIES OF *MICROBROTULA*

- 1a. Pectoral fin rays 11; preopercular spine with 2 points *M. queenslandica*
- 1b. Pectoral fin rays 13–19; preopercular spine with single point or absent..... 2

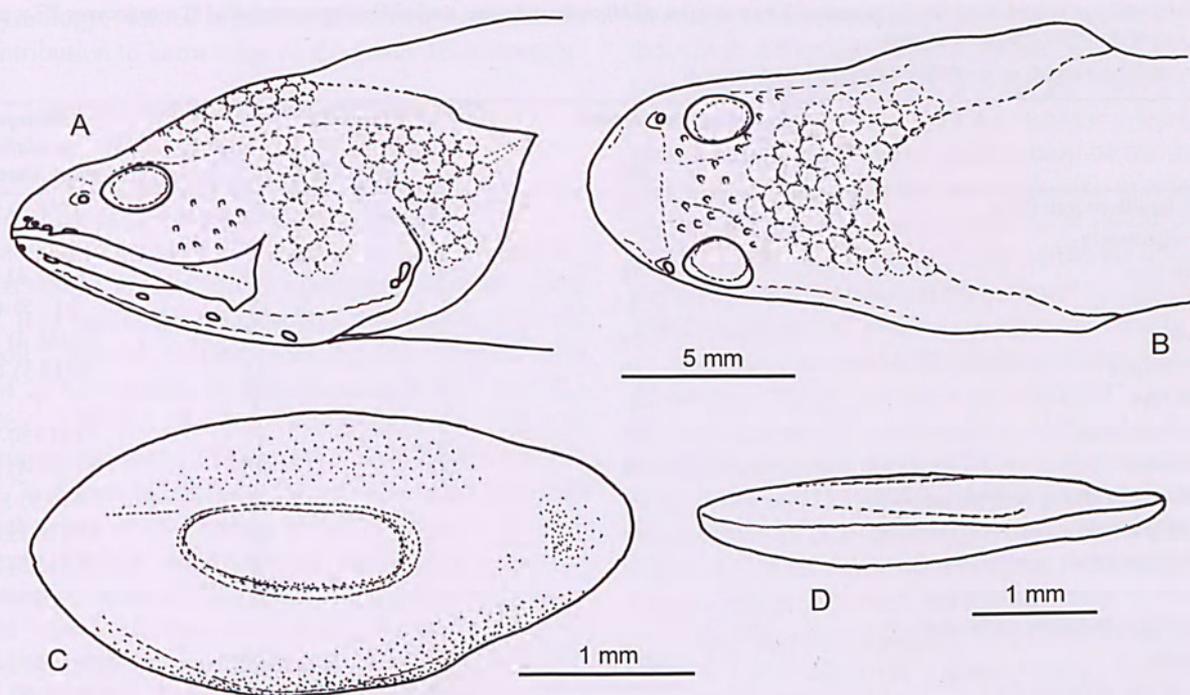


Fig. 2. *Microbrotula andersoni* sp. nov. Holotype, WAM P.26084-004, female, 52 mm SL: A, lateral view of head; B, dorsal view of head; C, median view of right otolith; D, ventral view of right otolith.

- 2a. Pectoral fin rays 12–14; caudal fin rays 6; preopercular spine present or absent 3
- 2b. Pectoral fin rays 15–19; caudal fin rays 7–9; preopercular spine present 5

- 3a. Dorsal fin rays 62–70; no cephalic lateralis pores; preopercular spine present; otolith length 2.4 times length of colliculum *M. greenfieldi*
- 3b. Dorsal fin rays 80–92; cephalic lateralis pores present; preopercular spine absent; otolith length 3.1–3.5 times length of colliculum (not known for *M. rubra*) 4

- 4a. Upper preopercular pore absent; posterior infraorbital pores absent; posterior 5 or 6 precaudal vertebrae without ribs; D/A 18–21; papillae on head only between eye *M. punicea*
- 4b. Upper preopercular pore 1; posterior infraorbital pores 3; posterior 1–2 precaudal vertebrae without ribs; D/A 9, papillae on entire head *M. rubra*

- 5a. Dorsal fin rays 76; scale patches on cheek, opercle and occiput connected; otolith length 3.5 times length of colliculum *M. hamata* sp. nov.
- 5b. Dorsal fin rays 61–70; scale patches on cheek, opercle and occiput separated; otolith length 2.5–2.8 times length of colliculum 6

- 6a. Pectoral fin rays 15–17; anal fin rays 50–57; papillae on anterior fourth to half of lateral line; otolith not expanded anteriorly *M. bentleyi*

- 6b. Pectoral fin rays 19; anal fin rays 59; few papillae on lateral line; otolith anteriorly expanded *M. andersoni* sp. nov.

***Microbrotula andersoni* sp. nov.**

(Tables 2, 3, Figs 1A, 2A–D, 10)

Material examined. (1 specimen, female, 52 mm SL). HOLOTYPE – WAM P.26084-004, Christmas Island (Indian Ocean), Ethel Beach, 10°29'S, 105°40'E, rotenone, 40–45 m, coll. G. Allen and R. Steene, 20 May 1978.

Diagnosis. Vertebrae 11+35=46, dorsal-fin rays 70, anal-fin rays 59, pectoral-fin rays 19, caudal-fin rays 8. D/V 8; D/A 14; V/A 13. Head with separated scale patches on cheeks, operculum and occiput. Papillae on anterior part of head only. Hidden, forward-curved spine at lower angle of preopercle. Posterior mandibular pores 3, lower preopercular pores 2. Palatine teeth absent. Otolith shape anteriorly expanded, otolith length to otolith height 2.1, otolith length to colliculum length 2.8.

Description (Figs 1A, 2A,B). The principally meristic and morphometric characters of *Microbrotula andersoni* are shown in Table 3. Head large with pointed snout. Head with separate scale patches on cheek (containing 3 vertical rows of scales), opercle and occiput, reaching anteriorly to posterior margin of eye (Fig. 2A,B). Horizontal diameter of scales on body about 3% SL. Maxillary ending far beyond eye, dorsal margin of maxillary covered by dermal lobe of upper lip, posterior end vertically expanded and angular. Small anterior nostril just above upper lip. Posterior nostril very small, about 0.1 size of eye. Opercular spine thin, needle-like, covered by skin. Forward-curved spine at lower

Table 3. Meristic and morphometric characters of 2 new species of *Microbrotula* spp. and of *Ematops randalli*. HT = holotype; PT = paratype; numbers in parentheses represent means

* The low numbers are most probably caused by broken rays

	<i>andersoni</i>		<i>hamata</i>		<i>Ematops randalli</i> 8 specimens
	HT		HT	PT	
Standard length in mm (SL)	53	33.5		23	25.5-39.5
Meristic characters					
Dorsal fin rays	70	76		76	78 (81.4) 87
Caudal fin rays	8	9		8	3 (3.5) 4
Anal fin rays	59	62		60	63 (68.4) 75
Pectoral fin rays	19	16		15	9 (10.3) 11
Pelvic fin rays	1	1		1	1
Precaudal vertebrae	11	12		11	13 (13.6) 15
Total vertebrae	46	48		48	51 (54.4) 57
Dorsal fin origin above vertebra number	8	8		8	9 (9.9) 11
Anal fin origin below dorsal ray number	14	14		15	14 (16.1) 19
Anal fin origin below vertebra number	13	14		14	15 (17.3) 20
Long rakers on anterior gill arch	3	3		3	3
Morphometric characters in % of SL					
Head length	29.0	28.5		29.5	27.0 (28.5) 31.0
Depth at origin of dorsal fin	17.5	18.0		15.0	16.0 (17.9) 19.0
Depth at origin of anal fin	17.0	16.0		13.0	14.0 (16.0) 19.0
Snout length	5.7	6.3		5.7	4.2 (4.5) 5.0
Max. head height	16.0	15.0		14.5	13.5 (14.7) 15.5
Max. head width	15.0	14.5		12.5	9.0 (10.9) 13.5
Upper jaw length	14.5	14.0		15.0	12.5 (13.2) 15.0
Diameter of eye ball	4.1	3.3		3.5	2.9 (3.4) 3.8
Interorbital width	3.9	4.5		4.3	1.1 (1.5) 1.7
Maxillary height	5.5	5.1		4.3	4.5 (5.0) 5.3
Postorbital length	19.5	19.0		18.5	17.0 (19.3) 21.0
Prepelvic length	26.0	25.0		24.5	20.5 (21.3) 22.5
Preanal length	47.0	52		47.0	48.5 (50.8) 52.0
Predorsal length	39.5	36.0		32.5	39.0 (41.9) 44.5
Base of pelvic fin to anal fin origin	23.0	25.0		21.5	28.0 (30.0) 31.0
Length of pectoral fin	15.5	17.5		14.3	13.0 (15.5) 19.5*
Length of pelvic fin	11.5+	19.0		22.6	10.5 (13.2) 18.0*

angle of preopercle covered by skin. Anterior gill arch with 3 elongate rakers.

Head sensory pores (Fig. 2A,B). No supraorbital pores. Anterior infraorbital pores 3, no posterior infraorbital pores. Mandibular pores 6 (3 anterior and 3 posterior). 2 lower preopercular pores, no upper preopercular pore.

Dentition. Premaxillary with several rows of granular teeth and a few fangs near symphysis. Teeth on vomer separated into 2 circular patches with fewer than 10 pointed teeth in each. Dentary with several rows of small granular teeth; inner row with somewhat larger pointed teeth. Palatine teeth absent.

Otolith (Fig. 2C,D). Elongate, otolith length to height 2.1. Anterior tip broadly rounded, expanded; posterior tip narrower. Dorsal and ventral rims regularly curved, smooth, highest anterior to the middle. Otolith length to sulcus length 2.8. Sulcus positioned slightly anteriorly, undivided, with single oval colliculum, not inclined against otolith axis. Ventral furrow feeble, close to ventral rim of otolith.

Axial skeleton. Neural spine of vertebrae 4–5 inclined and 6–8 depressed, with broad base. Parapophyses present on vertebrae 7 to 11. Pleural ribs on vertebrae 2 to 10. First anal fin pterygiophore not elongate.

Colour. Light brown to beige in alcohol.

Comparison. *Microbrotula andersoni*, together with *M. bentleyi* and *M. punicea*, are the only species of the genus growing to sizes greater than 45 mm SL. *Microbrotula andersoni* belongs to a group of species having 15 or more pectoral fin rays and 7–9 caudal fin rays, which also includes *M. bentleyi* and *M. hamata* sp. nov. *Microbrotula andersoni* is readily distinguished from these species by its large size and 19 pectoral fin rays (versus 15–17). It is closest to *M. bentleyi*, from which it is further distinguished by having few papillae on the head and a total lack of papillae on the lateral line as well as a different shape of its otolith.

Distribution (Fig. 10). Only known from the holotype, collected from Christmas Island in the eastern Indian Ocean.

Etymology. Named in honour of M. Eric Anderson for his contribution to knowledge of the genus *Microbrotula*.

***Microbrotula bentleyi* Anderson, 2005**

(Table 2, Figs. 1C, 3A–I, 10)

Microbrotula bentleyi Anderson, 2005, 36.

Microbrotula polyactis Anderson, 2005, 38.

Material examined: (17 specimens, 21.5–60 mm SL) – PARATYPES of *M. bentleyi* (5 specimens): BPBM 37875, Egypt, Red Sea, Gulf of Aqaba, Ras Abu Galum, 170–180 feet, coll. J. Randall, O. Gon and R. Kurutz, 2 August 1976; USNM 227220 (male, 36 mm SL, female 40.5 mm SL), Red Sea, Gulf of Aqaba, bay at El Hamira, 9–12 m, coll. V. Springer and party, 8 September 1969; USNM 227226 (male, 33.5 mm SL, female, 29 mm SL), Red Sea, Gulf of Aqaba, bay at El Hamira, 0–16 m, coll. V. Springer and party, 19 July 1969. – PARATYPES of *M. polyactis* (8 specimens): USNM 227221 (male, 39 mm SL), Philippines, Negros Island, off Bais, 9°36.9'N, 123°10.1'E, 0–37 m, coll. V. Springer and party, 17 June 1978; USNM 227224 (male, 32.5 mm SL, female, 26.5 mm SL), Philippines, Cebu Island, Caceres Reef, 24–31 m, coll. Libbey and party, 18 May 1979; USNM 227227 (4 males 21.5–33.5 mm SL and 1 female, 25.5 mm SL), Indonesia, Ambon Island, 3°47'S, 128°06'E, 11–18 m, coll. V. Springer and Gomon, 14 March 1974. – NON-TYPE MATERIAL (3 specimens): BPBM 18222 (male, 45 mm SL), Red Sea, Gulf of Aqaba, 1 km north of Coral Island, pro-noxfish, 15 m, coll. J. Randall and O. Gon, 23 September 1974; BPBM 38625 (male, 60 mm SL), Red Sea, Gulf of Aqaba, Eilat, rotenone, 15 m, coll. J. Randall and Gordon, 28 September 1974; BPBM 38626 (female, 49 mm SL), Red Sea, Gulf of Aqaba, Eilat, rotenone, coll. J. Randall and Gordon, 28 September 1974.

Tentatively assigned specimens: (1 specimen) NSMT 71423 (female, 34.5 mm SL), Indonesia, Ambon Island, Lilibooi, Ambon Bay, 3°45'S, 128°01'E, rotenone, 15 m, coll. K. Matsuura and K. Shibukawa, 5 December 1998.

Diagnosis. Vertebrae 11–12+33–35=44–47, dorsal-fin rays 61–70, anal-fin rays 50–57, pectoral-fin rays 15–17, caudal-fin rays 7–8. D/V 7–8, D/A 12–16, V/A 13–16. Small forward-curved spine at lower angle of preopercle, hidden by skin. Fleishy interorbital width 4.5–7.0% SL. Palatine teeth with papillae-like teeth or absent.

Discussion. *Microbrotula bentleyi* was based on the holotype taken off South Africa and five paratypes from the Gulf of Aqaba. *Microbrotula polyactis* was described from the holotype from off Cape York, northern Queensland, Australia, and nine paratypes from Indonesia and the Philippines. Anderson (2005) lists three characters as the diagnostic differences between the two species: the caudal fin ray count (6 in *M. bentleyi* versus 7–8 in *M. polyactis*), the pectoral fin ray count (14 in *M. bentleyi* versus 16–17 in *M. polyactis*), and the scale size (lateral scale rows 54–55 in *M. bentleyi* versus 47–50 in *M. polyactis*). All the paratypes of *M. bentleyi* and eight paratypes of *M. polyactis* were studied during the course of this review. The holotype of

M. bentleyi was studied again by O. Gon and M.E. Anderson at SAIAB. All investigated specimens as well as four non-type specimens exhibited 7 or 8 caudal fin rays except for some specimens, which did not warrant reliable caudal fin ray counts due to poor preservation of the caudal fin, and 16 or 17 pectoral fin rays. Only two specimens had 15 pectoral fin rays, one paratype of *M. bentleyi* (BPBM 37875), which is considered to be within the variability of the species and one tentatively assigned specimen (NSMT 71423). Differences in the scale sizes could not be verified.

In conclusion, none of the characters used for separating *M. bentleyi* and *M. polyactis* are validated. Consequently, we consider the two species are conspecific and select *M. bentleyi* as the senior synonym. We conclude that a relatively large degree of intraspecific variability occurs in *M. bentleyi*. These differences concern the abundance of papillae on the head and lateral line (Fig. 3A–E) and otolith proportions (length: height = 1.9 to 2.2) (Fig. 3F–I).

One specimen is tentatively placed in *M. bentleyi* – NSMT 71423 from off Ambon Island, Indonesia (Fig. 1C). Several of its meristic values are at the lower limit of, or just outside, the variation observed in *M. bentleyi* (Table 2): vertebrae 11+33=44, dorsal fin rays 61, anal fin rays 52, pectoral fin rays 15, D/A 12, V/A 13. The otolith is the most slender found in the species with a length to height ratio of 2.2 (Fig. 3I). Most strikingly though, the well-preserved specimen shows a short snout and abundant and well developed papillae all over its head and along the anterior half of the lateral line (Figs. 1C, 3D–E). This specimen may possibly represent yet another species, but we have refrained from establishing a separate species in light of the large spread of variation observed in *M. bentleyi* and the lack of further supporting material.

Distribution (Fig. 10). *Microbrotula bentleyi* is the most widely distributed species of the genus, ranging from South Africa to the Red Sea in the western Indian Ocean and from the Philippines to Cape York Peninsula in northern Australia. The large gap in the distribution is probably a collecting artefact rather than indicative of a true distribution.

***Microbrotula greenfieldi* Anderson, 2007**

(Table 2, Figs 4A–D, 10)

Material examined: (1 specimen, male, 30.5 mm SL). PARATYPE – CAS 223980, Fiji, Vanua Levu, Pascoe Reef, 16°50'S, 178°13'E, 10.6–13.7 m, coll. D. Greenfield and party, 4 April 2002. The holotype, CAS 222542, from the same location, was studied by the senior author prior to the description by Anderson.

Diagnosis. Vertebrae 11–12+34–35=45–47, dorsal-fin rays 62–70, anal-fin rays 58–61, pectoral-fin rays 14, caudal-fin rays 6. D/V 7–8; D/A 14–15; V/A 14. Small forward-curved spine at lower angle of preopercle. Head with separated scale patches on cheeks, operculum and occiput. Papillae on lower jaw only. No posterior mandibular pores, no lower preopercular pores. Palatine teeth minute, in single row. Otolith length to otolith height, 2.0, otolith

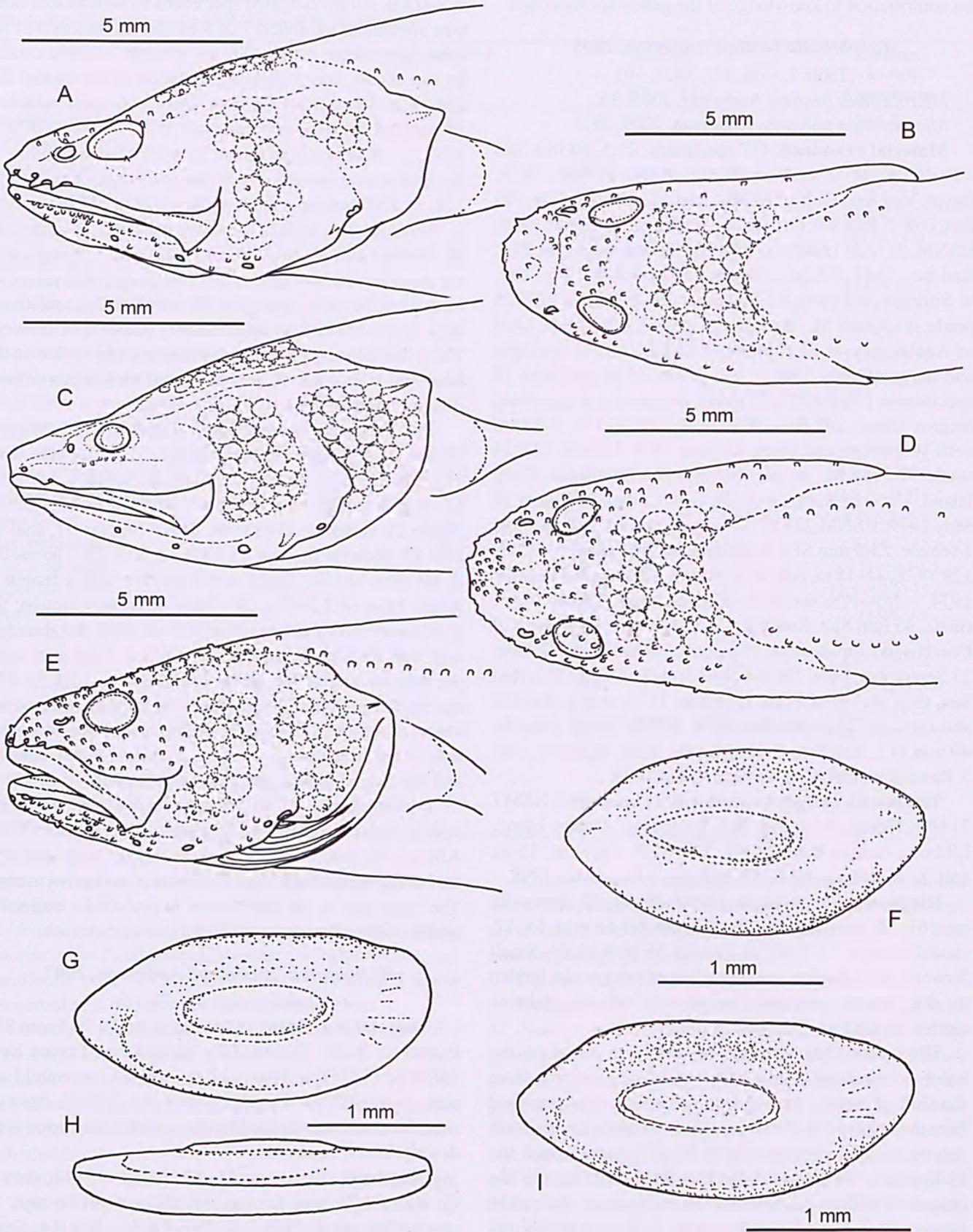


Fig. 3. *Microbrotula bentleyi* Anderson, 2005: **A**, Paratype of *M. bentleyi*, USNM 227220, female, 40.5 mm SL, lateral view of head; **B**, Paratype of *M. polyactis* Anderson, 2005, USNM 227224, male, 32.5 mm SL, dorsal view of head; **C**, Paratype of *M. bentleyi*, BPBM 37875, male, 37.5 mm SL, lateral view of head; **D-E**, tentatively assigned specimen, NSMT 71423, 34.5 mm SL, **D**, lateral view of head, **E**, dorsal view of head; **F**, Paratype of *M. polyactis* Anderson, 2005, USNM 227227, male, 33.5 mm SL, median view of right otolith; **G-H**, Paratype of *M. bentleyi*, BPBM 37875, male, 37.5 mm SL, **G**, median view of right otolith, **H**, ventral view of right otolith; **I**, tentatively assigned specimen, NSMT 71423, 34.5 mm SL, median view of right otolith.

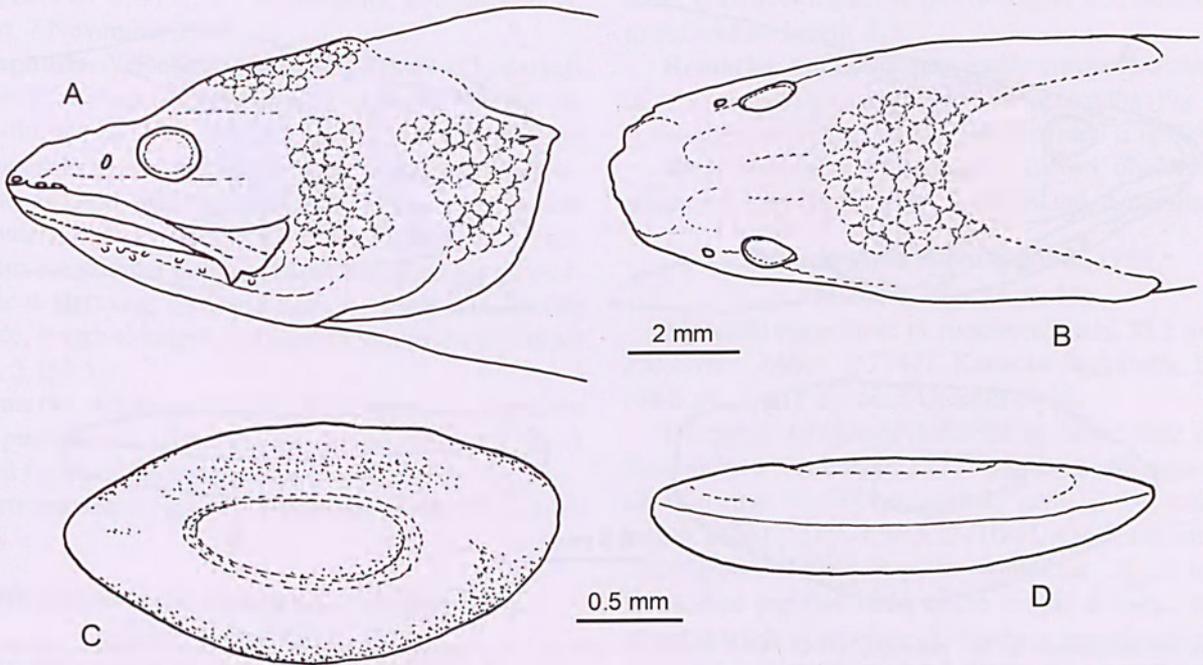


Fig. 4. *Microbrotula greenfieldi* Anderson, 2007, Holotype, CAS 222542, male, 34 mm SL.: A, lateral view of head; B, dorsal view of head; C, median view of right otolith; D, ventral view of right otolith.

length to colliculum length, 2.4. Male copulatory organ with 3 small papillae at base of genital hood.

Remarks. Additional previously unreported characters of *M. greenfieldi* are related to the otoliths (Fig. 4C,D). A detailed figure of the head is also provided (Fig. 4A,B).

Distribution (Fig. 10). It is endemic to Fiji.

***Microbrotula hamata* sp. nov.**

(Tables 2, 3, Figs 1B, 5A-D, 10)

Material examined. (2 specimens, 22.5–33.5 mm SL). HOLOTYPE (33.5 mm SL, female) – NMNZ 29559, New Caledonia, 8 nautical miles WSW. of Noumea, Seche Croissant Reef, 22°19.0'S, 166°21.0'E, 8–10 m, coll. C. Roberts and C. Paulin, 29 October 1992. PARATYPE (22.5 mm SL) – MNHN 2011-0815, same data as holotype.

Diagnosis. Vertebrae 11–12+36–37=48, dorsal-fin rays 76, anal-fin rays 60–62, pectoral-fin rays 15 or 16, caudal-fin rays 8–9. D/V 8; D/A 14–15; V/A 14. Head with continuous scale patches from cheek and opercle to occiput, except for narrow gap between cheek and opercle. Few papillae on anterior half of head. Forward-curved spine at lower angle of preopercle, hidden by thin skin. Posterior mandibular pores 3, lower preopercular pores 1. Palatine teeth very small. Otolith elongate, posterior-dorsally expanded, length to height, 2.2; otolith length to colliculum length, 3.5.

Description (Figs 1B, 5A,B). The principal meristic and morphometric characters of *Microbrotula hamata* are in Table 3. Head slender with pointed snout. Head with interconnected scale patches on cheek, opercle and occiput, except for narrow gap between patches on cheek and opercle (Fig 5A,B). Horizontal diameter of scales on body about 2% SL. Maxillary ending far beyond eye, dorsal margin of maxillary covered by dermal lobe of upper lip, posterior

end angular and vertically expanded. Small anterior nostril just above upper lip. Posterior nostril very small, about 0.1 diameter of eye. Opercular spine thin, needle-like, covered by skin. Well-developed forward-curved spine at lower angle of preopercle covered by thin skin. Anterior gill arch with 3 elongate rakers.

Head sensory pores (Fig. 5A,B). No supraorbital pores. Anterior infraorbital pores 3, no posterior infraorbital pores. Mandibular pores 6 (3 anterior and 3 posterior). 1 lower preopercular pore, no upper preopercular pore.

Dentition (holotype). Premaxillary with several rows of granular teeth and a few fangs near symphysis. Teeth on vomer separated in 2 circular patches each with about 10 teeth of which 1–4 are developed as fangs. Dentary with a few rows of granular teeth and inner row with many fangs. Palatine with very small teeth.

Otolith (Fig. 5C,D). Elongate, length to height, 2.2. Anterior tip pointed, narrowed; posterior tip dorsally expanded. Ventral rims regularly curved, smooth, deepest at middle; dorsal rim shallow, smooth, without prominent angles. Otolith length to sulcus length, 3.5. Sulcus positioned slightly towards anterior end, undivided, with single, oval colliculum, slightly inclined against otolith axis. Ventral furrow very feeble; dorsal depression indistinct.

Axial skeleton. Neural spine of vertebrae 4 or 5 inclined and 6–8 depressed, with broad bases. Parapophyses present from vertebrae 7 or 8 to 11 or 12. Pleural ribs on vertebrae 2–10. First anal fin pterygiophore not elongate.

Colour. Preserved specimens dark grey to brown.

Comparison. *Microbrotula hamata*, together with *M. andersoni* and *M. bentleyi*, belong to a group of species having 15 or more pectoral fin rays and 7–9 caudal fin rays. However, *M. hamata* differs in having a higher number of

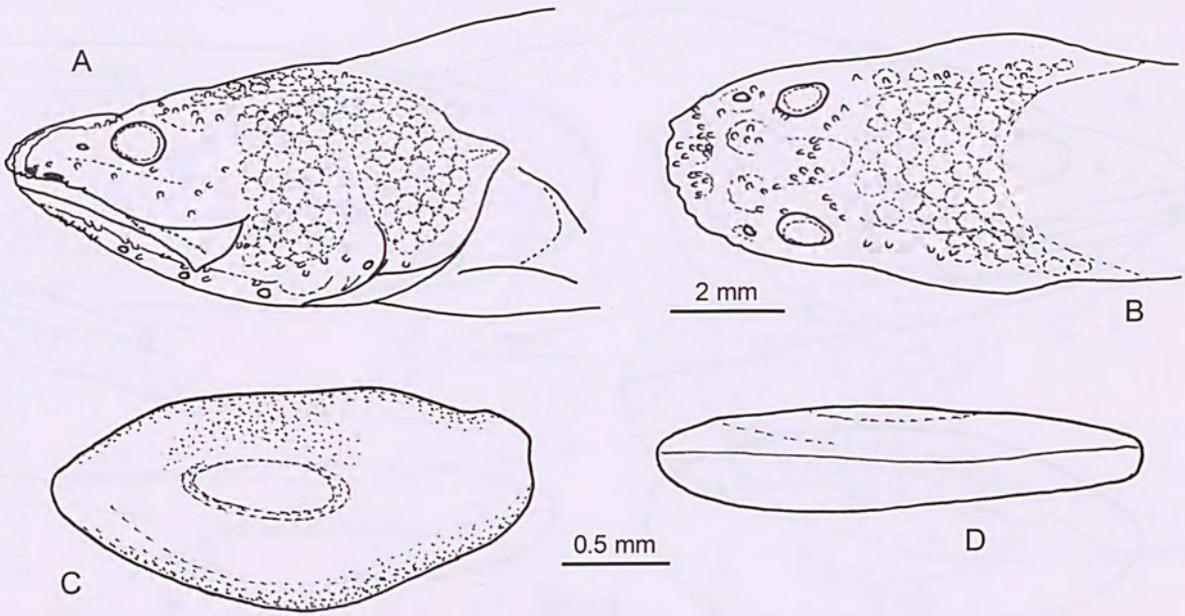


Fig. 5. *Microbrotula hamata* sp. nov. Holotype, NMNZ 29559, female, 33.5 mm SL: A, lateral view of head; B, dorsal view of head; C, median view of right otolith; D, ventral view of right otolith.

dorsal fin rays (76 versus 61–70), continuous squamation on the head, and an extraordinary small sulcus of the otolith expressed in the high ratio of otolith length to colliculum length (3.5 versus 2.5–2.8). It is further distinguished by the presence of only 1 lower preopercular pore (versus 2, occasionally 1 in *M. bentleyi*). It further differs from *M. andersoni* in having a lower number of pectoral fin rays (15 or 16 versus 19).

Distribution (Fig. 10). It is endemic to New Caledonia.

Etymology. From *hamatus* (Latin) = hook, referring to the forward-curved spine at the lower angle of the preopercle. The name is intended as a noun in apposition.

***Microbrotula punicea* Anderson, 2007**

(Table 2, Figs 6A–D, 10)

Material examined: (7 specimens, 38.5–57.5 mm SL). HOLOTYPE – NMNZ P.41062 (male, 43 mm SL), Kermadec Islands, Raoul Island, 29°16.3'S, 177°57'W, rotenone, 8.5–11.5 m, coll. A. Stewart, 6 November 2004. PARATYPES – NMNZ P.41036 (1 male, 38.5 mm SL, 2 females, 52–57.5 mm SL), Kermadec Islands, Raoul Island, Meyer Islet, 29°14.7'S, 177°53.1'W, 8.5–11.5 m, coll. A. Stewart and party, 7 November 2004; NMNZ P.41086 (female, 52 mm SL), Kermadec Islands, Raoul Island, 29°17.25'S, 178°11.2'W, rotenone, 14–16 m, coll. A. Stewart and party, 10 November 2004. NON-TYPE MATERIAL – NMNZ P.45355 (2 specimens, 42+–45 mm SL), Kermadec Islands, Raoul

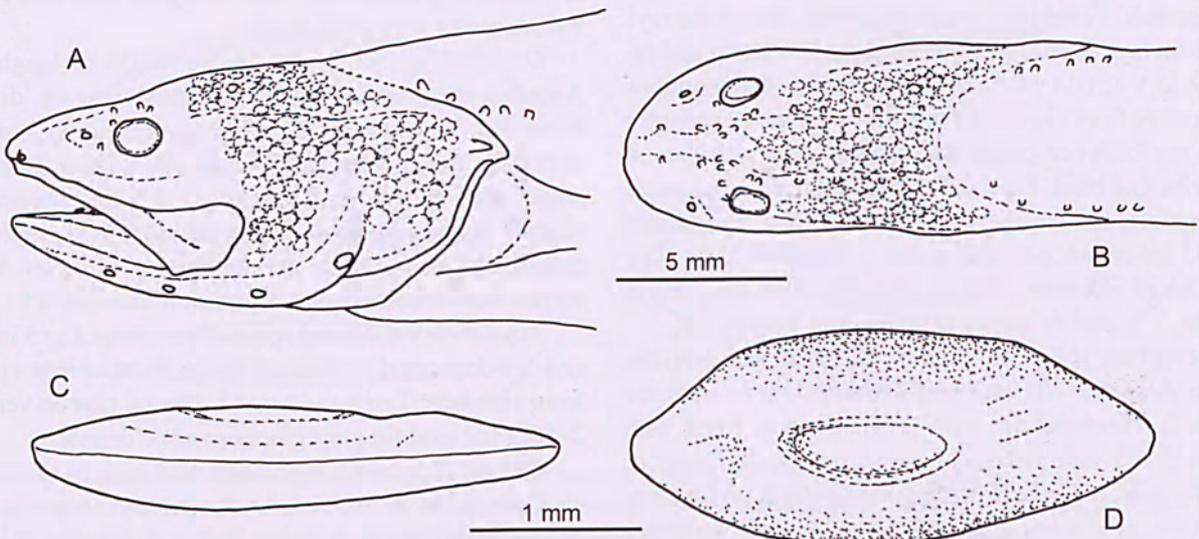


Fig. 6. *Microbrotula punicea* Anderson, 2007, Paratype, NMNZ P.41036, female, 52 mm SL: A, lateral view of head; B, dorsal view of head; C, median view of right otolith; D, ventral view of right otolith.

Island, 29°14.7'S, 177°53.1'W, rotenone, 9–12 m, coll. A. Stewart, 7 November 2004.

Diagnosis. Vertebrae 11–13+38–41=49–53, dorsal-fin rays 77–82, anal-fin rays 64–71, pectoral-fin rays 14, caudal-fin rays 6. D/V 8–10; D/A 18–21; V/A 15–16. Head with connected scale patches on cheek, opercle and occiput. Papillae on head only between eyes; lateral-line papillae along anterior quarter. No spine at lower angle of preopercle. Posterior mandibular pores 3, lower preopercular pores 1. Palatine with strong, recurved teeth, in single row. Otolith elongate, length to height, 2.4; otolith length to colliculum length, 3.1–3.5.

Remarks. Additional previously unreported characters of *M. punicea* are related to the otoliths (Fig. 6C,D). A detailed figure of the head is also provided (Fig. 6A,B).

Distribution (Fig. 10). Endemic to the Kermadec Islands.

***Microbrotula queenslandica* Anderson, 2005**

(Table 2, Figs 7A–C, 10)

Material examined: (1 specimen, 31 mm SL). PARATYPE – AMS I.20206-041, Australia, Great Barrier Reef, One Tree Island, 23°30'S, 152°05'E, 22–30 m, coll. F. Talbot and party, 3 December 1969.

Diagnosis (Holotype included in range from original description). Vertebrae 12+36=48, dorsal-fin rays 78–80, anal-fin rays 62 or 63, pectoral-fin rays 11, caudal-fin rays 6. D/V 7; D/A 21; V/A 15–17. Head with separated scale patches on cheek and occiput, no scales on opercle. Papillae numerous, on entire head; no lateral-line papillae. Forward-curved spine at lower angle of preopercle with two points, hidden by skin. Posterior mandibular pores 3, lower preopercular pores 1. Palatine with papillae-like

teeth. Otolith elongate, length to height, 2.3; otolith length to colliculum length, 2.3.

Remarks. Additional previously unreported characters of *M. queenslandica* are related to the otoliths (Fig. 7B,C). A detail figure of the head is also provided (Fig. 7A).

Distribution (Fig. 10). It is known only from the southern Great Barrier Reef, Queensland, Australia.

***Microbrotula rubra* Gosline, 1953**

(Table 2, Figs 8A,B, 10)

Material examined: (1 specimen, male, 35.5 mm SL). PARATYPE – ZMUC P 77471, Kaneohe Bay, Oahu, Hawaii, rotenone, 1 m, Gosline, 2 October 1948.

Diagnosis (Holotype included in range from original description). Vertebrae 11+35=46, dorsal-fin rays 81–92, anal-fin rays 72–80, pectoral-fin rays 12–14, caudal-fin rays 6. D/V 11; D/A 9; V/A 13. Head with scales on cheek, opercle and occiput. Papillae numerous, on entire head; lateral-line papillae along entire length of body. No spine at lower angle of preopercle. Posterior mandibular pores 3, posterior infraorbital pores 3, lower preopercular pores 1, upper preopercular pore 1. Palatine teeth strong, in single row.

Remarks. The otoliths were not preserved in the paratype of *M. rubra* we studied. A detailed figure of the head is provided (Fig. 8A,B).

Distribution (Fig. 10). Endemic to Hawaii.

***Ematops* gen. nov.**

(Tables 1–3, Figs 9A–F, 10)

Gender masculine. Type species, here designated, *Microbrotula randalli* Cohen & Wourms, 1976.

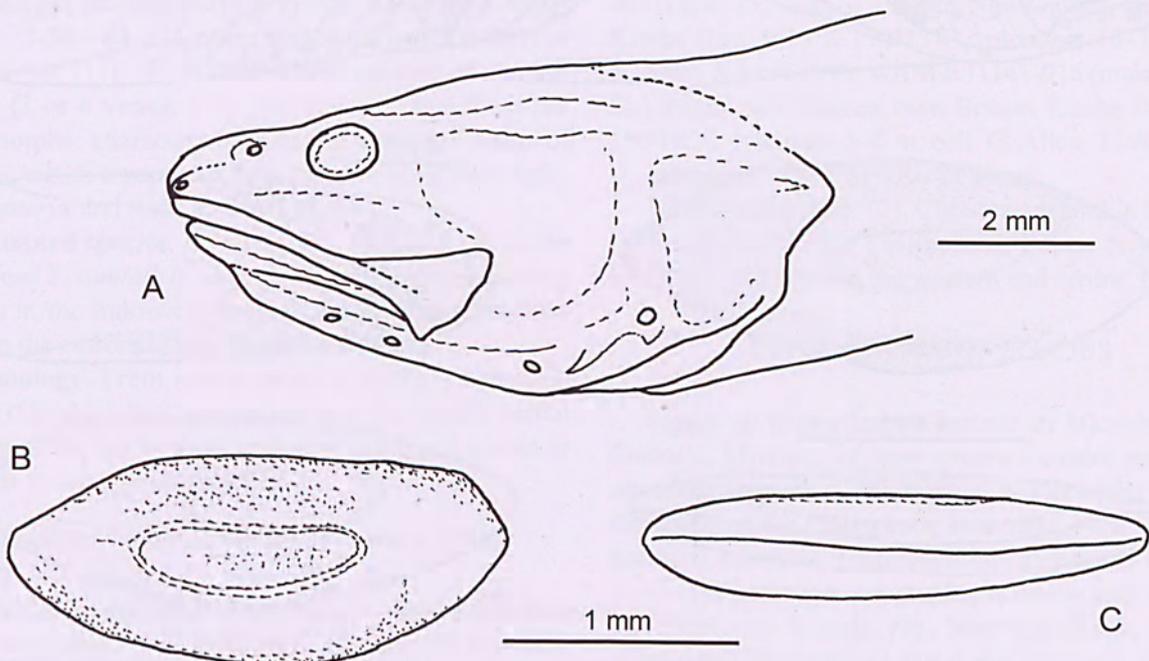


Fig. 7. *Microbrotula queenslandica* Anderson, 2005, Paratype, AMS I.20206-041, male, 31 mm SL.: A, lateral view of head (head scales rubbed off); B, median view of right otolith; C, ventral view of right otolith.

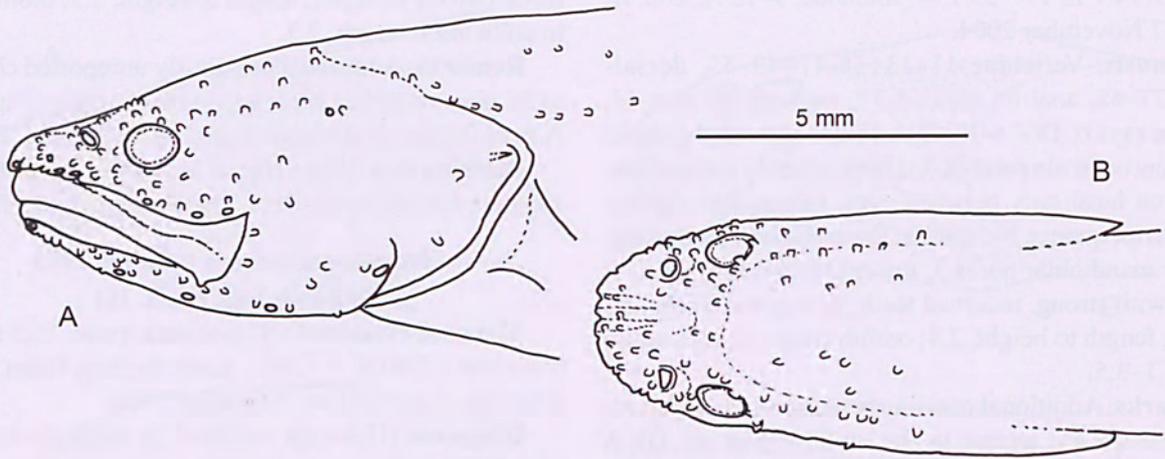


Fig. 8. *Microbrotula rubra* Gosline, 1953, Paratype, ZMUC P77471, male, 35.5 mm SL.: A, lateral view of head; B, dorsal view of head (head covered with mucus obscuring scales).

Diagnosis. Dwarf bythitine species, reaching 40 mm SL. Head continuously covered by scales on cheek, opercle and occiput, extending over eye from behind and above, covering almost half of eye. Head pores: 3 anterior mandibular, 3 posterior mandibular, 6–7 supraorbital positioned as follows from anterior to posterior: 1 on snout in cavity above nostril, 1 in front of eye, 1 median interorbital, 3 or 4 above and behind eye, the last situated above lower preopercular pores, 2 lower preopercular, no

upper preopercular, 3 anterior infraorbital, 0 or 1 posterior infraorbital situated below eye close to last anterior infraorbital pore. Head length 27.0–31.0% SL. Dorsal fin rays 78–87. Anal fin rays 63–75. Vertebrae 13–15 + 38–42 = 51–57. Caudal fin rays 3 or 4. Dorsal fin origin above vertebrae 9–11. Anal fin origin below vertebrae 15–19. Pectoral fin rays 9–11. Pectoral peduncle not elongate. Branchiostegal rays 7. Interorbital width 1.1–1.7% SL. Anterior nostril tubular, situated just above upper lip. Rear

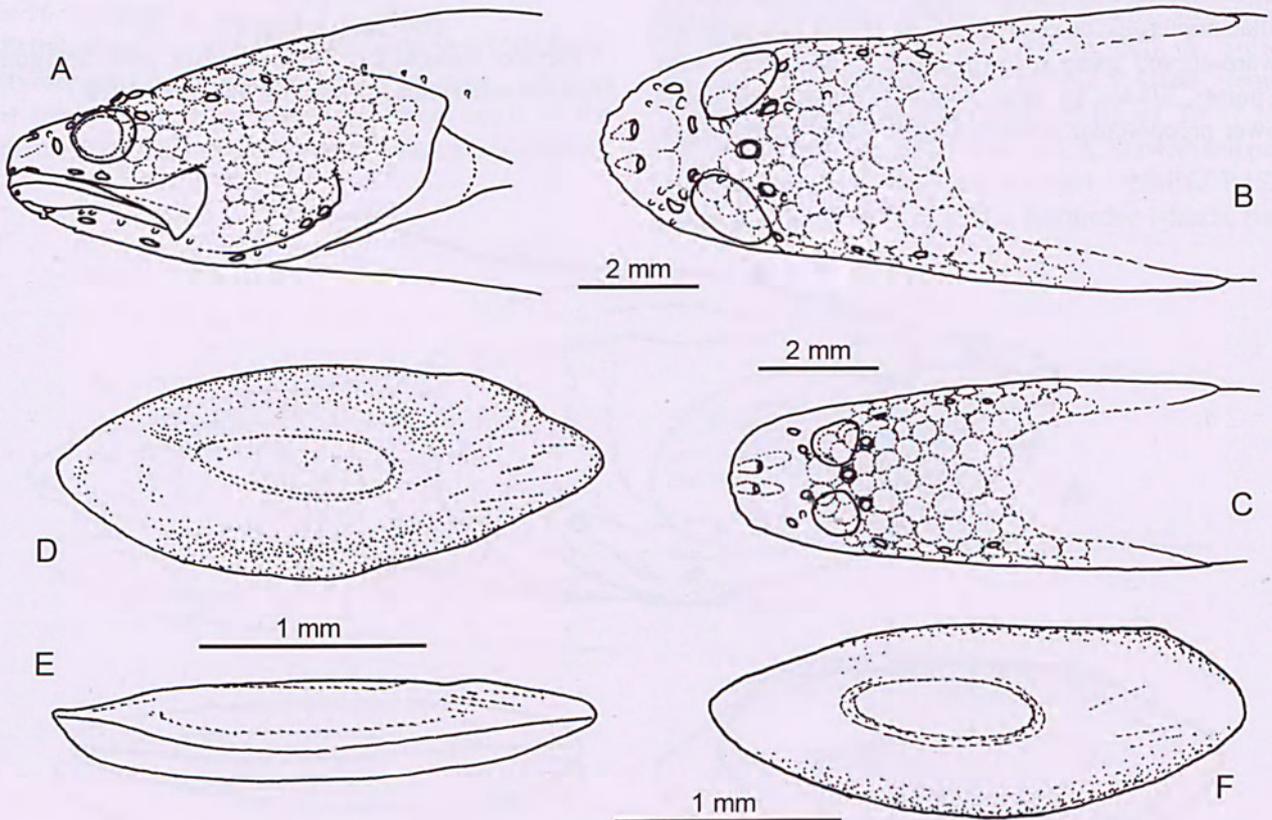


Fig. 9. *Ematops randalli* (Cohen & Wourms, 1976): A, USNM 227223, male, 29 mm SL, lateral view of head; B, USNM 227225, female, 39.5 mm SL, dorsal view of head; C, WAM P.26097-011, female, 31.5 mm SL; D–E, USNM 227225, female, 39.5 mm SL; D, median view of right otolith; E, ventral view of right otolith; F, USNM 363745, female, 38 mm SL, median view of right otolith.

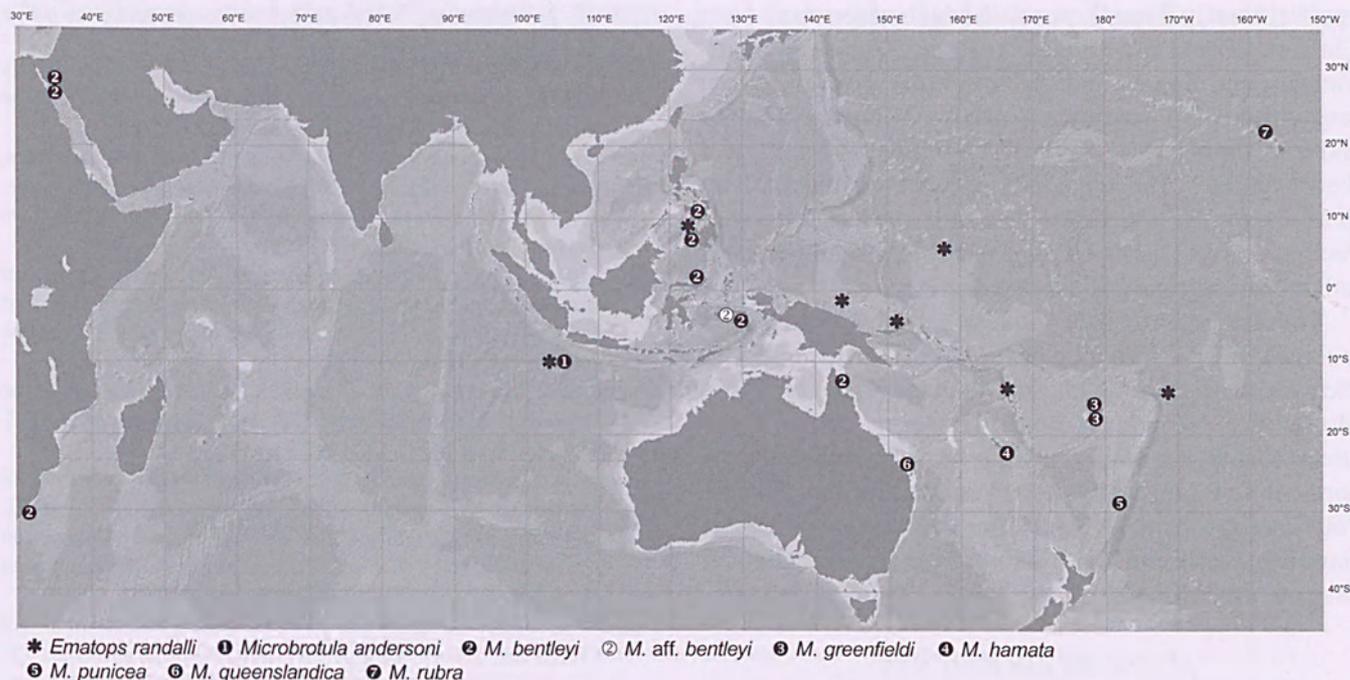


Fig. 10. Sample sites for specimens examined of species of the genera *Microbrotula* and *Ematops*. One symbol may represent several samples.

portion of maxilla vertically expanded. Vomerine teeth in 2 small patches; strong palatine teeth in single row. Opercular spine thin, needle-like, covered by skin; no spine at lower angle of preopercle. Developed gill rakers 2–4.

Comparison and discussion. *Ematops* is readily recognised and distinguished from all other bythitine genera by the unique development of the head squamation, which extends partially over the eye. The pore pattern on the occiput is also highly diagnostic and very similar to the presumably unrelated, bathyal genus *Pseudonus* Garman, 1899. *Ematops randalli* was previously placed in *Microbrotula*, from which it is further distinguished by its higher number of vertebrae (13–15 + 38–42 = 51–57 versus 11–13 + 33–38 = 44–51), lower number of pectoral-fin rays (9–11 versus (11) 13–19) and lower number of caudal-fin rays (3 or 4 versus 6–8). We postulate that these are autapomorphic characters, supporting a derived status of *Ematops*, which separates it from the genera *Microbrotula*, *Calamopteryx* and *Anacanthobythites*.

Contained species. *Ematops* is monospecific, with the widespread *E. randalli* (Cohen & Wourms, 1976) occurring on reefs in the Indo-west Pacific Ocean, from Christmas Island in the eastern Indian Ocean to Vanuatu.

Etymology. From *ichthy-emata* (Greek) = fish-scale and *ops* (Greek) = face, eye; referring to the unique partial covering of the eye by head scales, which is not known in any other living ophidiiform fish.

Ematops randalli (Cohen & Wourms, 1976)

(Tables 2, 3, Figs 9A–F, 10)

Material examined: (8 specimens, 25.5–39.5 mm SL): 2 PARATYPES – USNM 214112 (female, 37 mm SL), American Samoa, Tutuila Island, Fagafele Bay, 30–38 m, coll. J. Randall and party, 8 May 1974; USNM 214703

(male, 38 mm SL), Vanuatu, Efate (Vate) Island, February 1974. NON-TYPE MATERIAL: USNM 227223 (male, 29 mm SL), Philippines, Apo Island, 9°04'38"N, 123°16'44"E, 0–40 m, coll. V. Springer and party, 7 June 1978; USNM 227225 (female, 39.5 mm SL), Papua New Guinea, Hermit Island, 1°33'S, 144°59'E, 0–15 m, coll. V. Springer and party, 30 October 1978; USNM 363745 (female, 38 mm SL), Vanuatu, Rowa Islands, 13°38'32"S, 167°30'18"E, 23–29 m, coll. J. Williams and party, 20 May 1997; WAM P.26097-011 (female, 31.5 mm SL), Christmas Island (Indian Ocean), White Beach, 10°29'S 105°40'E, 30–40 m, coll. G. Allen and R. Steene, 26 May 1978; WAM P.31140-003 (male, 25.5 mm SL), Papua New Guinea, New Britain, Kimbe Bay, 5°13'S 150°23'E, rotenone, 10–11 m, coll. G. Allen, 8 April 1996; WAM P.31141-015 (male, 29.5 mm SL), Papua New Guinea, New Britain, Kimbe Bay, 5°18'S 150°08'E, rotenone, 5–6 m, coll. G. Allen, 13 April 1996.

Diagnosis. See diagnosis of genus.

Distribution (Fig. 12). Christmas Island in the eastern Indian Ocean to the Philippines, Papua New Guinea, Vanuatu and Samoa in the western and central Pacific.

DISTRIBUTION OF SPECIES

Figure 10 shows known records of *Microbrotula* and *Ematops*. Members of these genera are most speciose and abundant on reefs of the tropical western Pacific, chiefly the coasts of the Philippines, Indonesia, New Guinea and northern Australia. Endemism has apparently developed in areas of prolonged geographic isolation such as Hawaii, the Kermadec Islands, Fiji, New Caledonia, Christmas Island, and the southern Great Barrier Reef. In contrast, there appears to be only two geographically widespread

species, namely *Ematops randalli* which ranges from from Christmas Island to the Philippines, New Guinea, Pohnpei, Vanuatu and Samoa, and *Microbrotula bentleyi* which ranges from off northeastern South Africa and the Red Sea and from the northeastern tip of Australia to Indonesia and the Philippines. The apparently disjunct distribution seen in *M. bentleyi* is a recurrent pattern in modern Indo-west Pacific coral reef fishes and is probably a collecting artefact rather than indicative of the true distribution.

The distribution of *Microbrotula* and its endemic species is similar to the distribution of species in Dinematchthyini (Schwarzhans *et al.* 2005; Schwarzhans & Møller 2007; Møller & Schwarzhans 2008). However, unlike in the Dinematchthyini, *Microbrotula* is not (yet) recorded from northern New Zealand, Western Australia, Taiwan, Japan or Polynesia. On the other hand, *Microbrotula* does occur off Hawaii and the Kermadec Islands, where Dinematchthyini have not been recorded.

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