THE RAFFLES BULLETIN OF ZOOLOGY 1997 **45**(2): 341-368

NINE NEW SPECIES OF *PSEUDOBICEROS* (PLATYHELMINTHES: POLYCLADIDA) FROM THE INDO-PACIFIC

Leslie J. Newman and **Lester R.G. Cannon**

ABSTRACT. - Nine new species of marine flatworms (Platyhelminthes: Polycladida) belonging to the genus *Pseudobiceros* Faubel, 1984 are described from Indo-Pacific coral reefs including: the northern and southern Great Barrier Reef, eastern Australia; Ningaloo Reef and Exmouth, Western Australia; Madang, Papua New Guinea; and Koror, Palau, Micronesia. In addition, new records are given for seven recognised species from a range of Indo-Pacific locations.

KEY WORDS. - *Pseudobiceros*, Pseudocerotidae, Polycladida, taxonomy

INTRODUCTION

Prior to 1984, it was believed that the majority of conspicuous and flamboyantly coloured pseudocerotid flatworms belonged to the genus *Pseudoceros* Lang, 1884. However, Faubel (1984) clearly separated the speciose genus *Pseudobiceros* from *Pseudoceros* on the basis of its double male reproductive system. Newman & Cannon (1994a) redescribed *Pseudobiceros* based on the morphology and observations of living animals. *Pseudobiceros* includes the biggest and often most colourful of the polyclad flatworms. These are the only polyclads which actively swim with exaggerated undulations of their ruffled margin. This, along with flamboyant colouration, is thought to be aposematic or warning behaviour advertising their suspected unpalatability to visual predators such as fish (Newman & Cannon, 1994a; 1995a; Newman & Ang, 1996).

There are approximately 22 species of *Pseudobiceros* known worldwide (Newman & Cannon, 1994a). Species within the genus can be separated on the basis of their dorsal colour pattern in the absence of differences in the details of the reproductive anatomy. Further, observations on copulatory behaviour suggest that morphogical isolating mechanisms do

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not operate in these animals which presumably use chemical cues for intra and inter-species recognition (Michiels & Newman, pers. obs.).

Nine new species of *Pseudobiceros* are described here from Madang, Papua New Guinea (PNG); eastern and western Australia and Palau, Micronesia. Seven new records are also given for the following species described or redescribed in Newman & Cannon (1994a): *P. bedfordi* (Laidlaw, 1903); *P. damawan* Newman & Cannon, 1994; *P. fulgor* Newman & Cannon, 1994; *P. gloriosus* Newman & Cannon, 1994; *P. gratus* (Kato, 1937); *P. stellae* Newman & Cannon, 1994 and *P. uniarborensis* Newman & Cannon, 1994. New records of *Pseudobiceros* have also been added from the northern Great Barrier Reef (GBR), as well as, Coral Bay and northern Ningaloo Reef, Western Australia (WA). Additional records from other sources have also been provided from Lord Howe Island, Vanuatu, Sulawesi and Bali (Indonesia), Enewetak (the Marshall Islands), the Philippines, Murion and Rottnest Islands and Kimberley, WA.

MATERIALS AND METHODS

Specimens were hand collected from under rubble at the reef crest or from ledges on the reef slope by scuba from the Great Barrier Reef (GBR) including Lizard Island (14° 40' S, 145° 28' E) and Heron Island (23° 27' S, 151° 55' E); Coral Bay, WA (23° 9' S; 113° 46' E); Madang (5° 14' S, 145° 45' E), Papua New Guinea and Koror, Palau, Micronesia (07° 18' N; 134° 31' E). Animals were photographed in situ and in the laboratory and then fixed on frozen polyclad fixative (see Newman & Cannon, 1995b). Specimens were then preserved in 70% ethanol for histological examination. Whole mounts were stained with Mayer's haemalum, dehydrated in graded alcohols and then mounted in Canada balsam. Longitudinal serial sections of the reproductive region were obtained from specimens embedded in Paraplast (56^{o} C), sectioned at 5-7 µm, and then stained with Mayer's haemalum and eosin Y solution.

Measurements of the body were taken from live animals in a quiescent state and are given as length mm x width in mm. These measurements can only be used as a guide due to the 'plastic' nature of these animals. Measurements of the reproductive organs are taken from the paratypes. Diagrammatic reconstructions of the reproductive systems are given and are derived from the sections with minimal interpretation. Only one side of the male reproductive system has been illustrated. The female system has not been included as these structures are consistently homogeneous (see Newman & Cannon, 1994a). Abundance values are represented by; 1) abundant, more than 20 animals, 2) common, 6 to 20 animals, 3) rare, less than 5 animals.

Colour descriptions are based on live animals and colour numbers in brackets refer to Pantone Colors by Letraset, 1989, Series U and definitions of the colour terms used are given in Newman & Cannon (1994a). Colour Groups, based on the dorsal colour pattern, are modified from Newman & Cannon (1994a) and are given as new groups in Table 1. Drawings were made with the aid of a camera lucida by L.J.N. and K.A. Jennings. Specimens were collected and photographed by L.J. Newman and A.E. Flowers. This material is lodged at the Queensland Museum (QM) or the Western Australian Museum (WAM) as wholemounts (WM), serial sections (LS) and wet specimens (S). Colour transparencies (CT) are held by L.J.N.

TAXONOMY

FAMILY PSEUDOCEROTIDAE LANG, 1884

Pseudobiceros Faubel, 1984
(Figs. 1 A-E, 2)

Pseudobiceros Faubel, 1984: 215 - 216: type species: *Pseudobiceros strigosus* (Marcus, 1950)[junior synonym of *P. gratus* (Kato, 1937)]; Newman & Cannon, 1994a: 239- 240. Gender: masculine.

Diagnosis. - Emended from Newman & Cannon (1994a). Flamboyantly or cryptically coloured. Body soft and delicate, raised medially, elongate oval, tapering posteriorly, margin with numerous deep ruffles (Figs. 1 A & B). Pseudotentacles well developed, either ear-like or square with lateral ruffles (Figs. 1 C -E). Cerebral eyespot small, horseshoe shaped, with 20 to 200 eyes in semi-circular rows, eyespot may be in a clear area which is either oval or pointed anteriorly and posteriorly. Dorsal pseudotentacular eyes occur in four elongate clusters (not along the anterior margin), ventral pseudotentacular eyes in four dense clusters extending medially over the pseudotentacles, with 100's of eyes. Pharynx anterior, oval, with 10 to 20 shallow simple pharyngeal folds (Fig. 1 B). Intestine wide, extends to about 2/3 body length with numerous extremely narrow, lateral intestinal branches not extending to the posterior end of the intestine. Two symmetrical male pores are situated posterior to pharynx, pores may be small and close together, appearing as one large pore or large and well separated. Female pore between and posterior to the male pores. Sucker further posterior, usually small and indistinct, situated three to five times the distance between the gonopores. Male copulatory organs double, each with seminal vesicle and penis papilla armed with a small, pointed, sclerotised stylet (Fig. 2). Prostatic vesicle orientated antero-dorsally to the male complex.

Remarks. - The following 22 known species may be reliably placed in *Pseudobiceros* sensu stricto based on details of the morphology of the pharynx, eyes, pseudotentacles or reproductive anatomy (Newman & Cannon, 1994a): *apricus* Newman & Cannon, 1994; *bajae* (Hyman, 1953); *bedfordi* (Laidlaw, 1903); *cinereus* (Palombi, 1931); *damawan* Newman & Cannon, 1994; *dendricticus* (Prudhoe, 1989); *evelinae* (Marcus, 1950); *flavocanthus* Newman & Cannon, 1994; *flavolineatus* (Prudhoe, 1989); *fulgor* Newman & Cannon, 1994; *fulvogriseus* (Hyman, 1959); *gardineri* (Laidlaw, 1902); *gloriosus* Newman & Cannon, 1994; *gratus* (Kato, 1937); *hancockanus* (Collingwood, 1876); *izuensis* (Kato, 1944); *nigromarginatus* (Yeri & Kaburaki, 1918); *periculosus* Newman & Cannon, 1994; *philippinensis* (Kaburaki, 1923); *splendidus* (Stummer-Traunfels, 1933); *stellae* Newman & Cannon, 1994; *uniarborensis* Newman & Cannon, 1994.

Pseudobiceros bedfordi (Laidlaw, 1903)

Pseudoceros bedfordi Laidlaw, 1903: 302, 314, Pl. 23, fig. 9; Bock, 1913: 254, pl. III, figs. 2 - 4; Bresslau, 1933: 59; Kato, 1943, 87; 1944; 299; Marcus, 1950: 84; Dawydoff, 1952: 82; Hyman, 1954: 220; 1959: 566; Prudhoe, 1977: 586; George & George, 1979: 43, pl. 49, fig. 10.
Pseudoceros micronesianus Hyman, 1955: 66, fig. 5.
Pseudobiceros bedfordi (Laidlaw, 1903): Faubel, 1984: 216; Newman & Cannon, 1994a: 241-243, figs. 33a-d, 50b.

Material Examined.- CT, Enewetak, Marshall Is., Micronesia, coll. S. Johnson, no date; CT, Manado, Sulawesi, Indonesia, coll. C. Anderson, Jun.1994; CT, 2 m, under rubble, night, Lizard Is. Lagoon, N GBR, 7 Apr.1995; CT, 6 m, under rubble, S Coral Bay, WA, 6 May.1996.

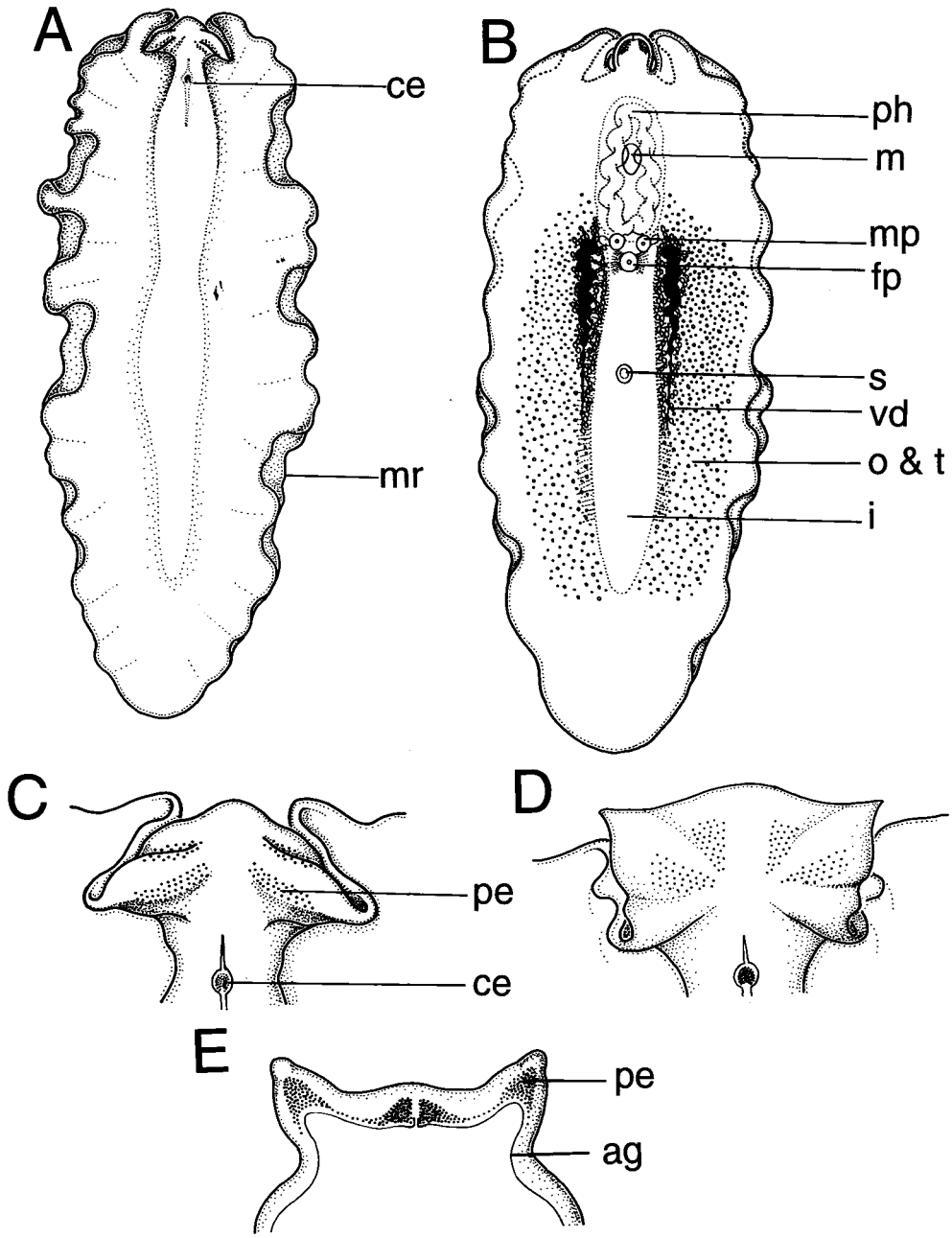

Fig. 1. Diagrams of *Pseudobiceros*, A) morphology of the dorsal surface, B) morphology of the ventral surface and internal anatomy; morphology of the pseudotentacles and eyes, C) ear-like, D) square and ruffled, E) ventral side (after Newman & Cannon, 1994a) (Legends for all figures: ag - auricular groove, ce - cerebral eyes, cg - cement glands, fp - female pore, i - intestine, m - mouth, mp - male pore, mr - margin ruffles, o - ovaries, ov - oviducts, p - prostate, pe - pseudotentacular eyes, ph - pharynx, s - sucker, st - stylet, sv - seminal vesicle, t- testes, v - vagina, vd - vas deferens).

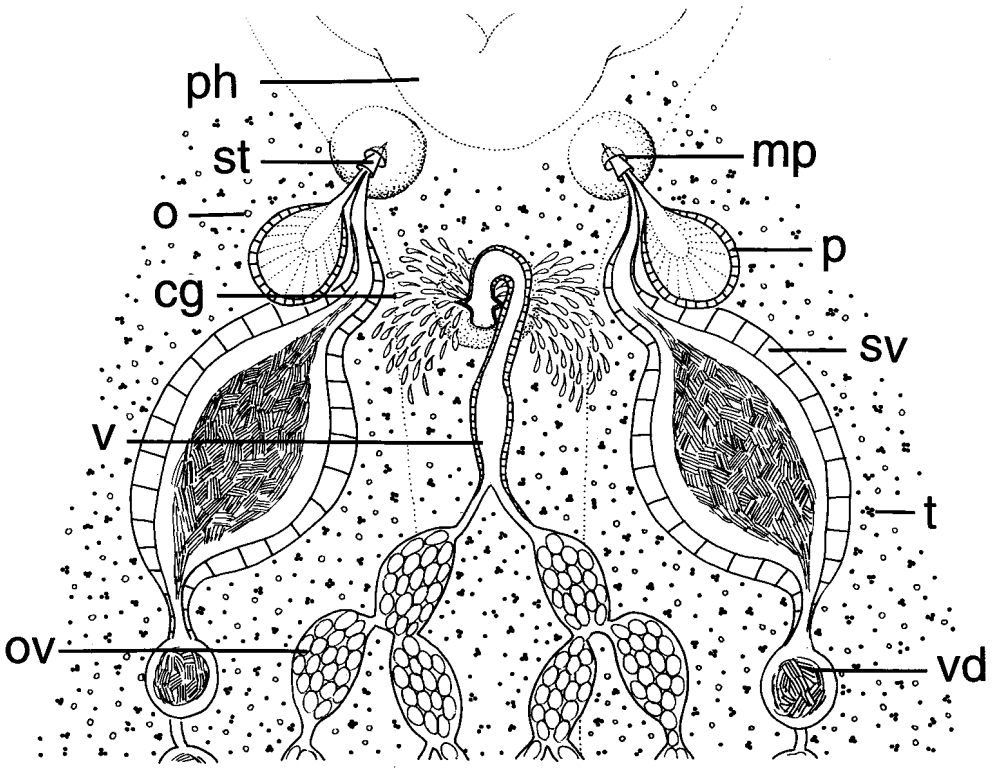

Fig. 2. Diagrammatic representation of the male reproductive anatomy of *Pseudobiceros* from dorsal surface.

Remarks. - This species belongs in Group 5 (Table 1) and remains the only species in this group. *Pseudobiceros bedfordi* has a distinctive colour pattern which is unmistakable across the Indian and Pacific Oceans.

Habitat & distribution. - Found under boulders at the reef crest, out swimming in lagoonal waters and under ledges on the reef slope. Common from Heron Is., S GBR and rare from Madang and Laing Is., PNG and recorded from Singapore, Philippines and Micronesia (Newman & Cannon, 1994a). New records: Lizard Island, N GBR; Coral Bay, WA; Sulawesi, Indonesia and Enewetak, Marshall Is., Micronesia.

Pseudobiceros brogani, new species
(Figs. 3 A-C, 12 A)

Material examined. - Holotype - WM (QM G210860), 2 m, under rocks, N Coral Bay, 29 Apr.1996.

Paratypes - LS (QM G210866), 3 m, under rubble, S Coral Bay, 27 Apr.1996; S (QM G210867), same data; S (QM G210801), 4 ex., 2 m, under rubble, N Coral Bay, 1 May.1996; S (QM G210799), 3 ex., 6 m, under rubble, S Coral Bay, 4 May.1996; S (QM G210800), 3 ex., 5 May.1996.

Description. - Background pattern variable, either olive green (397U) or light brown (465U) mottled with white; evenly spaced brown and white dots over the entire dorsal surface, darker medially (Figs. 3 A, 12 A). Margin wide, either light olive green with an extremely narrow, dark green and white interrupted rim (without dots or mottling) or orange-brown

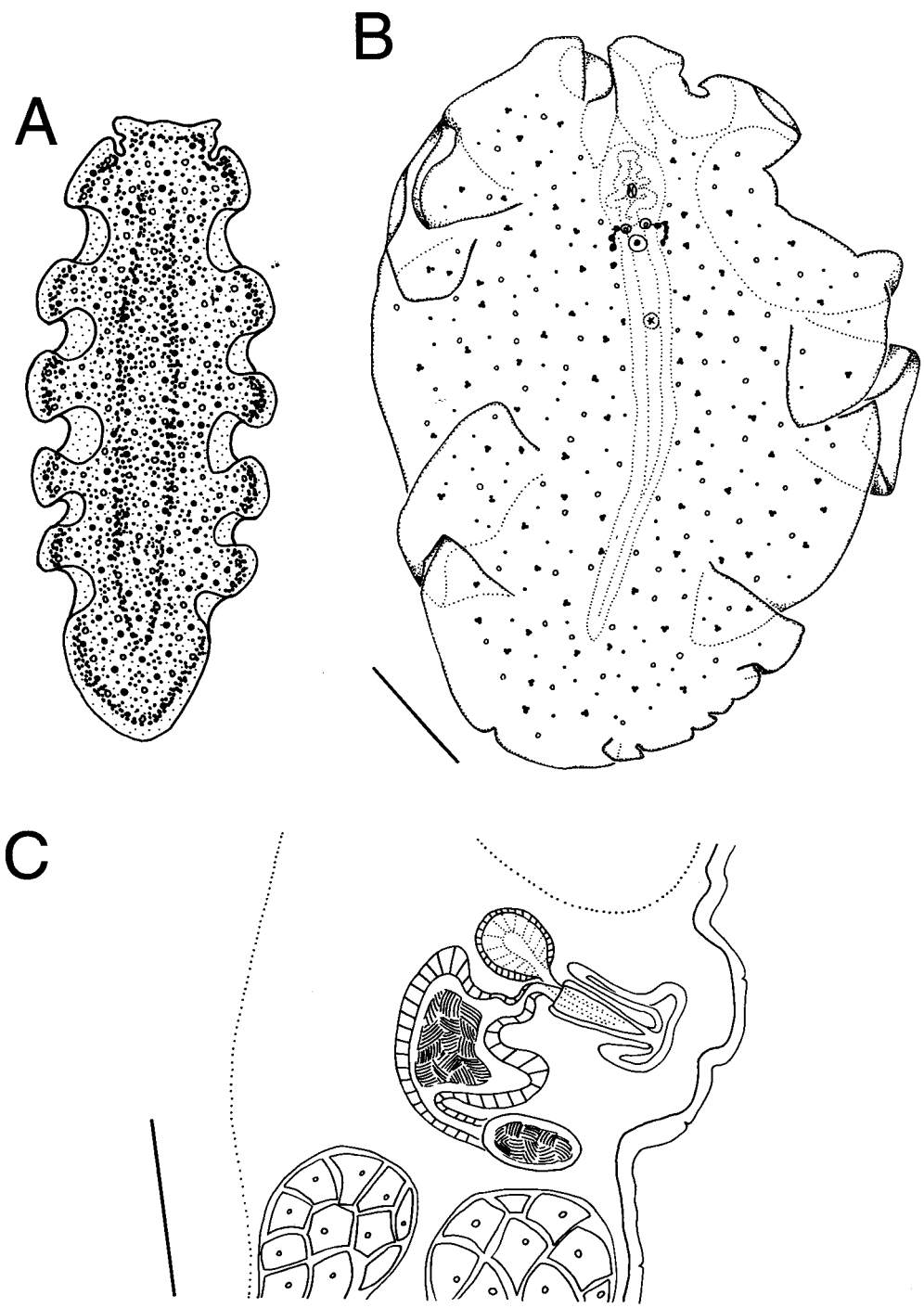

Fig. 3. *Pseudobiceros brogani*, new species., A) diagram of the dorsal surface, B) wholemount from the ventral side, C) reconstruction of one side of the male structures. Scales: B, 5 mm; C, 500 µm.

with an extremely narrow dark grey and white interrupted rim. Pseudotentacles with white tips, lacking marginal bands. Ventrally mottled olive green and white. Pseudotentacles square and ruffled (Fig. 3 B). Cerebral eyespot round with about 60 eyes (not in a clear area). Size range: 10 x 6 mm (immature) to 45 x 15 mm (mature).

Male pores well separated (Fig. 3 B). Vas deferens branching. In one system, seminal vesicle rounded oblong (470 µm long), prostate rounded oval (215 µm long); stylet long and narrow (265 µm long x 60 µm wide), length: width ratio = 1: 0.2 (Fig. 3 C). Male antrum narrow and deep.

Diagnosis. - Mottled olive green or brown and white; brown and white dots over the entire dorsal surface, margin solid green or orange-brown, interrupted at rim.

Etymology. - Named in honour of Dr Bill F. Brogan for his kind support in WA.

Remarks. - This species belongs in Group 4 (Table 1) and only one other species, *P. kryptos*, new species, possesses a green background (see Remarks for *P. kryptos*). The colour of this species appears to be variable as smaller animals are usually green and larger animals more brown (Fig. 12 A). One animal regurgitated its gut contents which contained whole semi-digested colonial ascidians (*Didemnum* sp.).

Habitat & distribution. - Common from under rubble, Coral Bay, WA.

Pseudobiceros damawan Newman & Cannon, 1994

Pseudobiceros damawan Newman & Cannon, 1994a: 243 - 245, figs. 34 a-d, 50c.

Material Examined. - S (QM G210885), 3 m, under rubble, Madang, PNG, 28 May.1994; S (QM G210811), 6 m, under rubble, S Coral Bay, WA, 6 May.1996; S (QM G210812), 2 ex., 8 May.1996.

Remarks. - This species belongs in Group 4 (Table 1). Animals from WA possessed a red tinge compared to those from Madang, PNG which were light orange.

Habitat & distribution. - Found on colonial ascidians under boulders at reef crest and on reef slope. Common from Madang, rare from Laing Is., PNG and Heron Is., S GBR (Newman & Cannon, 1994a). New record: rare from Coral Bay, WA.

Pseudobiceros flowersi, new species
(Figs. 4 A-C; 12 B,C)

Pseudobiceros sp. 1 Gosliner, Behrens & Williams, 1996: 102, fig. 339.

Material examined. - Holotype - WM (QM G210793), under rubble, 3 m, Lizard Is. Lagoon, N GBR, 2 Apr.1995.

Paratypes - S (QM G210827), 3 ex., 3 m, under rubble, Lizard Is. Lagoon, 10 Apr.1995; LS (QM G210770), 31 Mar.1995; WM (QM G210794), 7 Apr.1995.

Description. - Background varies from bright olive green (103U) or dark brown (456U), intensifying to chocolate brown or black near the margin, smaller animals with scattered

speckles of white; narrow, median longitudinal white line starting at cerebral eyespot and ending anteriorly to the posterior margin, bordered by darker pigment (Figs. 4 A, 12 B,C). Margin with three bands; inner wide, black; then olive green (103U) or brown, with a narrow, white rim. Pseudotentacles with white tips and white triangle in between. Ventrally light green or brown with white dots, evenly spaced (Fig. 12 C), intensifying near margin; margin narrow black, narrow white at rim. Extremely ruffled marginally and crenulated when resting, ruffles overlapping dorsally, tapering slightly posteriorly. Pseudotentacles square and ruffled (Fig. 4 A). Cerebral eyespot with 100's of small eyes forming a dense oval cluster. Size range: 40 x 18 mm (mature) to 90 x 35 mm (mature).

Male pores well separated (Fig. 4 B). Vas deferens branching. In one system: seminal vesicle rounded oblong (530µm long); prostate oval, about 1/2 the size of the seminal vesicle (230 µm long); stylet short and wide (90 µm long x 60 µm wide); length: width ratio = 1: 0.7 (Fig. 4 C). Male antrum wide and deep.

Diagnosis. - Green or brown, darker marginally, white longitudinal line; margin black then green, white at rim.

Etymology. - Named in honour of Dr Andrew E. Flowers for all his help.

Remarks. - This species belongs in Group 2 and no other species possesses a brown or green background (Table 1).

Habitat & distribution. - Found from under rubble in shallow lagoon waters. Rare from Lizard Is., N GBR. Record: Luzon, Philippines (Gosliner et al., 1996).

Pseudobiceros fulgor Newman & Cannon, 1994

Pseudobiceros fulgor Newman & Cannon, 1994a: 245 - 246; figs. 36a-d, 50e.

Material Examined. - CT, Bali, Indonesia, coll. C. Anderson, Apr.1995; CT, Kwajalein, Marshall Is., coll. S. Johnson, no date.

Remarks. - This species belongs in Group 6 (Table 1). The other two species in this group have a yellow or brown ground colour, however, *P. fulgor* possesses broken streaks not concentric stripes as in *P. flavolineatus* or longitudinal stripes as in *P. dendricticus* (see Newman & Cannon, 1994a).

Habitat & distribution. - Found under boulders at reef crest. Common from Heron Is., rare from the Philippines (Newman & Cannon, 1994a). New records: Indonesia and the Marshall Islands, Micronesia.

Pseudobiceros gratus (Kato, 1937)

Eurylepta striata Schmarda, 1859: 27-28, fig. 62.
Pseudoceros striatus (Schmarda, 1859): Stummer-Traunfels, 1933: 3487, 3540, 3544, figs. 95, 96.
Pseudoceros gratus Kato, 1937: 227-229; Kato, 1944: 300; Hyman, 1959: 566; Prudhoe, 1977: 593-594.
P. strigosus Marcus, 1950: 88.
P. habroptilus Hyman, 1959, fig. 8.

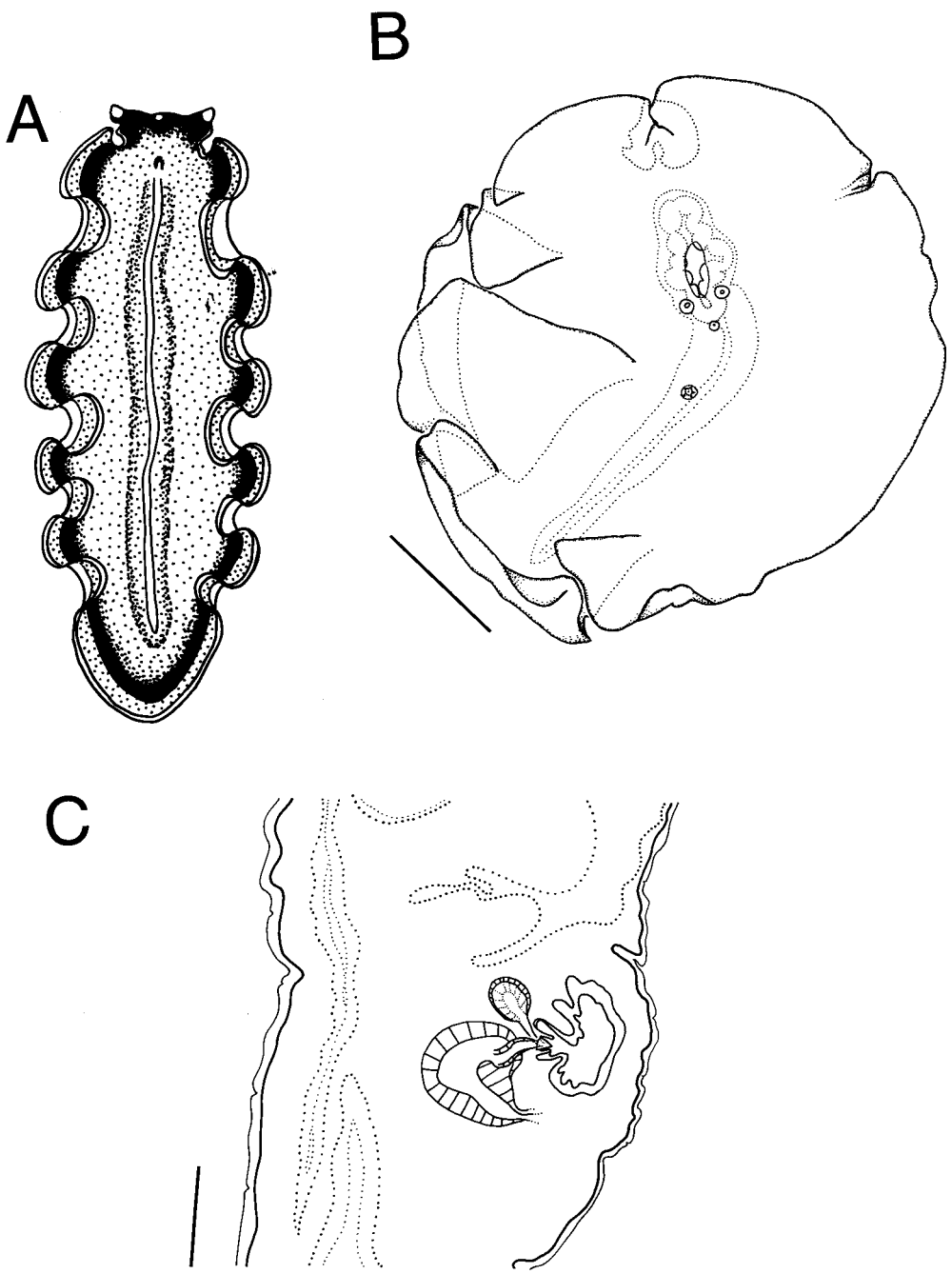

Fig. 4. *Pseudobiceros flowersi*, new species, A) diagram of the dorsal surface, B) wholemount from the ventral side, C) reconstruction of one side of the male structures. Scales: B= 5 mm, C= 500 μm.

Pseudobiceros strigosus (Marcus, 1950): Faubel, 1984: 216.
Pseudobiceros gratus (Kato, 1937): Poulter, 1987: 46, pl. 2.I.2.d; Newman & Cannon, 1994a: 248-249, figs. 38a-d, 51a,b.

Material examined. - S (QM G210891), 3 m, under rubble, Madang, PNG; S (QM G210803), 3 ex., 10 m, under rubble, Heron Is., S GBR, Mar.1996; S (QM G210889), 15 m, outer barrier, N Ningaloo Reef, WA, 25 Apr.1996; S (WAM 185-96), 22 m, under rubble, outer barrier, N Ningaloo Reef, 26 Apr.1996; S (WAM 180-96), 5 m, under rubble, S Coral Bay, 8 May.1996.

Remarks. - This species belongs in Group 2 (Table 1) and is the only species with a white or cream background.

Habitat & distribution. - Found under rubble from the reef slope and crest. Common from Heron Is., S GBR and Madang, PNG and rare from One Tree Is., S GBR. Records: Ceylon, Japan, Micronesia, and Hawaii (Newman & Cannon, 1994a). New record: Lizard Is., N GBR.

Pseudobiceros gloriosus Newman & Cannon, 1994

Pseudobiceros gloriosus Newman & Cannon, 1994a: 246-248; figs. 37a-d, 50f.

Material Examined. - CT, Vanuatu, N. Coleman, 8 Jul.1982; CT, 12 m, reef slope, Mac Guillivray Reef, off Lizard Is., N GBR, 6 Apr.1995; CT, 15 m, reef slope, outer barrier, off Lizard Is., 8 Apr.1995; CT, on sand, 10 m, Navy Pier, Exmouth, WA, 24 Apr.1996; S (WAM 181-96), under rubble, 15 m, outer barrier, N Ningaloo Reef, WA, 25 Apr.1996; CT, Murion Is., WA, C. Bryce, no date.

Remarks. - This species belongs in Group 1 (Table 1) where the majority of species are black with brightly coloured marginal bands. However, this species is the only one with a wide marginal band of three colours; orange then pink with a purple rim (see Newman & Cannon, 1994a).

Habitat & distribution. - Found under ledges on the reef slope. Common from Heron Is., rare from Bagabag Is., N Madang, PNG and Fiji (Newman & Cannon, 1994a). New records: Lizard Island, N GBR; Exmouth, WA and Vanuatu.

Pseudobiceros hymanae, new species
(Figs. 5 A-C, 12 D)

Material examined. - Holotype - WM (QM G210624), reef slope, N Madang, PNG, T. Gosliner, 7 Jun.1992.

Paratypes - S (QM G210766), 3 m, under rubble, N Madang, 29 Apr.1994; WM (QM G210797), reef crest, Heron Is., 9 Jun.1995.

Other material - S (QM G210619), under rubble, reef crest, Heron Is., S GBR, 16 Jun.1991; WM (QM G210620), 25 Jun.1991; WM (QM G210621), 18 Jan.1992; WM (QM G210622), 31 Jan.1992; WM (QM G210623), 22 Feb.1992; S (QM G210823), 11 Jun.1995; LS (QM G210822), 14 Jun.1995. Record: CT, Rottnest Is., WA, C. Bryce, no date.

Description. - Background velvety black, opaque; margin with two distinct bands, rusty orange (150 or 163U) with narrow black rim (Figs. 5 A, 12 D). Pseudotentacles black with the same marginal bands laterally only. Ventrally grey-black with the same marginal bands.

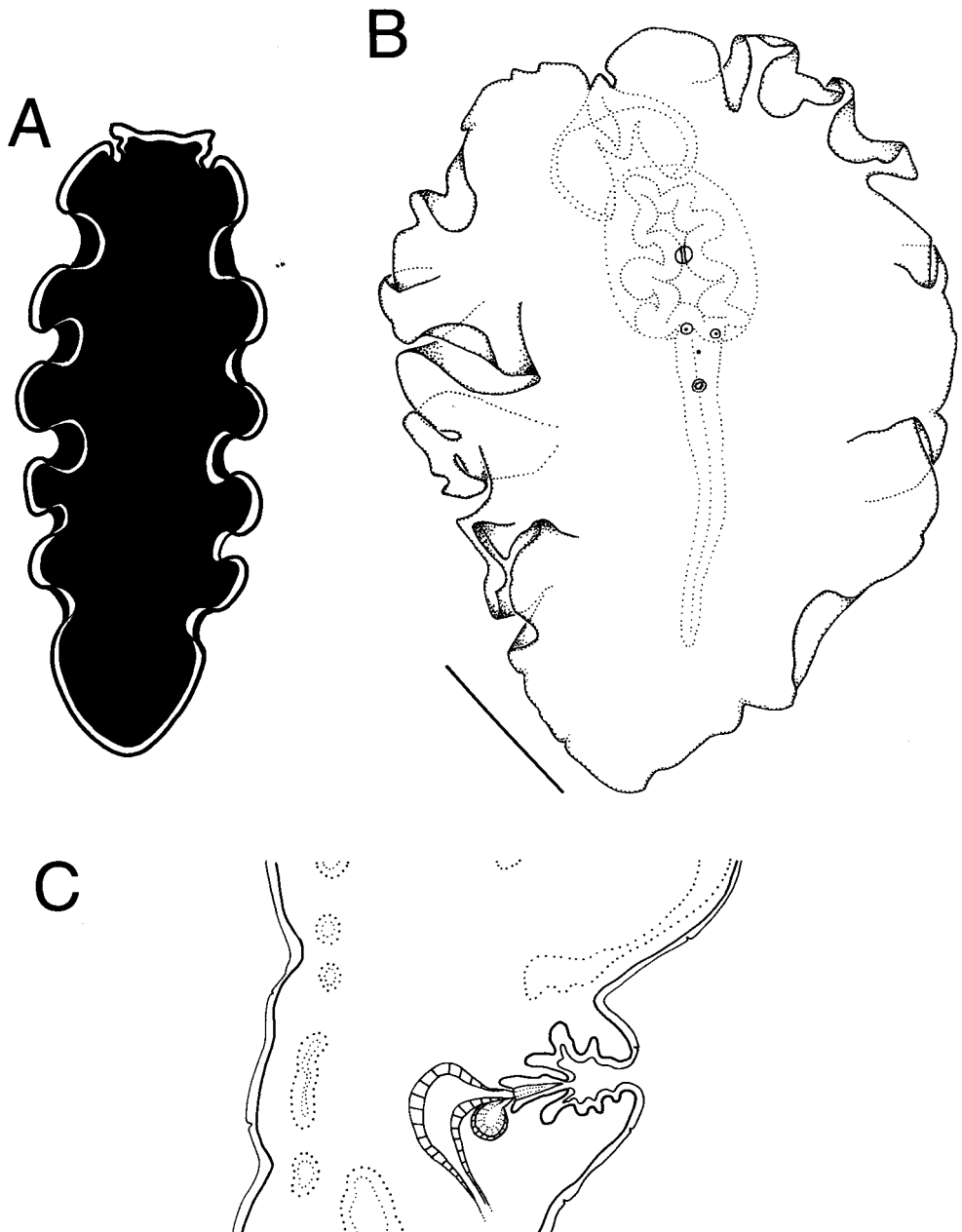

Fig. 5. *Pseudobiceros hymanae*, new species., A) diagram of the dorsal surface, B) wholemount from the ventral side, C) reconstruction of one side of the male structures. Scales: B= 5 mm, C= 500 µm.

Pseudotentacles square and ruffled (Figs. 5 A). Cerebral eyespot with about 30 eyes in a clear grey area which is pointed and elongate anteriorly and posteriorly. Sucker relatively large and distinct. Size range: 11 x 5 mm (immature) to 70 x 35 mm (mature).

Male pores well separated (Fig. 5 B). Vas deferens branching. In one system: seminal vesicle oval (515 µm long), ejaculatory duct short and straight; prostate round (200 µm wide); stylet long and narrow (280 µm long x 100 µm wide), length: width ratio = 1: 0.3 (Fig. 5 C). Male antrum deep and narrow.

Diagnosis. - Velvety black with distinct marginal bands; rusty orange with narrow, black at rim.

Etymology. - Named in honour of the late Dr Libbie H. Hyman for her contributions to the study of polyclads.

Remarks. - This species belongs in Group 1 (Table 1). The majority of species in this group are opaque black with brightly coloured marginal bands. Only one other species, *P. periculosus* Newman & Cannon, 1994 is black with an orange margin, however, this species lacks the distinct black rim as found in *P. hymanae*. It is believed that this colour pattern is aposematic and acts to warm potential predators, such as fish, of its unpalatability (Newman & Cannon, 1994a; 1995a; Newman & Ang, 1996).

Pseudoceros hymanae resembles *Pseudoceros affinis* (Kelaart, 1858) as described by Hyman (1960) from Hawaii. However, *Eurylepta affinis* Kelaart, 1858 does not match Hyman's (1960) description of the colour pattern, which she described as purple with a yellow border. Faubel (1984) and Newman & Cannon (1994a) considered Kelaart's species *incerta sedis*; thus, the species described by Hyman (1960) is new and we are pleased to name it in her honour.

Lang (1884) described a similar species, *Pseudoceros superbus* [= *P. splendidus* (Stummer-Traunfels, 1933)] as black with an orange margin, with small white dots, an anterior white line along the rim and two male pores. Prudhoe (1989) stated that this species occurs in the Mediterranean, Vietnam, Galapagos, Puerto Rico and Bermuda. We suggest that there may be confusion between *P. hymanae* and *Pseudobiceros splendidus* (Stummer-Traunfels, 1933) nov. comb. with the former being Indo-Pacific in distribution and the latter a Mediterranean and Atlantic species. Newman & Cannon (1994a) placed *P. splendidus* in their Group 2, i.e. with marginal bands. Here we place greater emphasis on the white flecks or dots and place this species in Group 3 (Table 1).

Habitat & distribution. - Found on colonial ascidians and sponges on the reef slope. Common from Heron Is., S GBR and rare from Madang, PNG.

***Pseudobiceros kryptos*, new species**

(Figs. 6 A- C, 12 E)

Pseudoceros sp. 3 Gosliner et al, 1996: 103, fig. 341.

Material examined. - Holotype - WM (QM G210796), 2 m, under rubble, Lizard Is. Lagoon, N GBR, 5 Apr.1995.

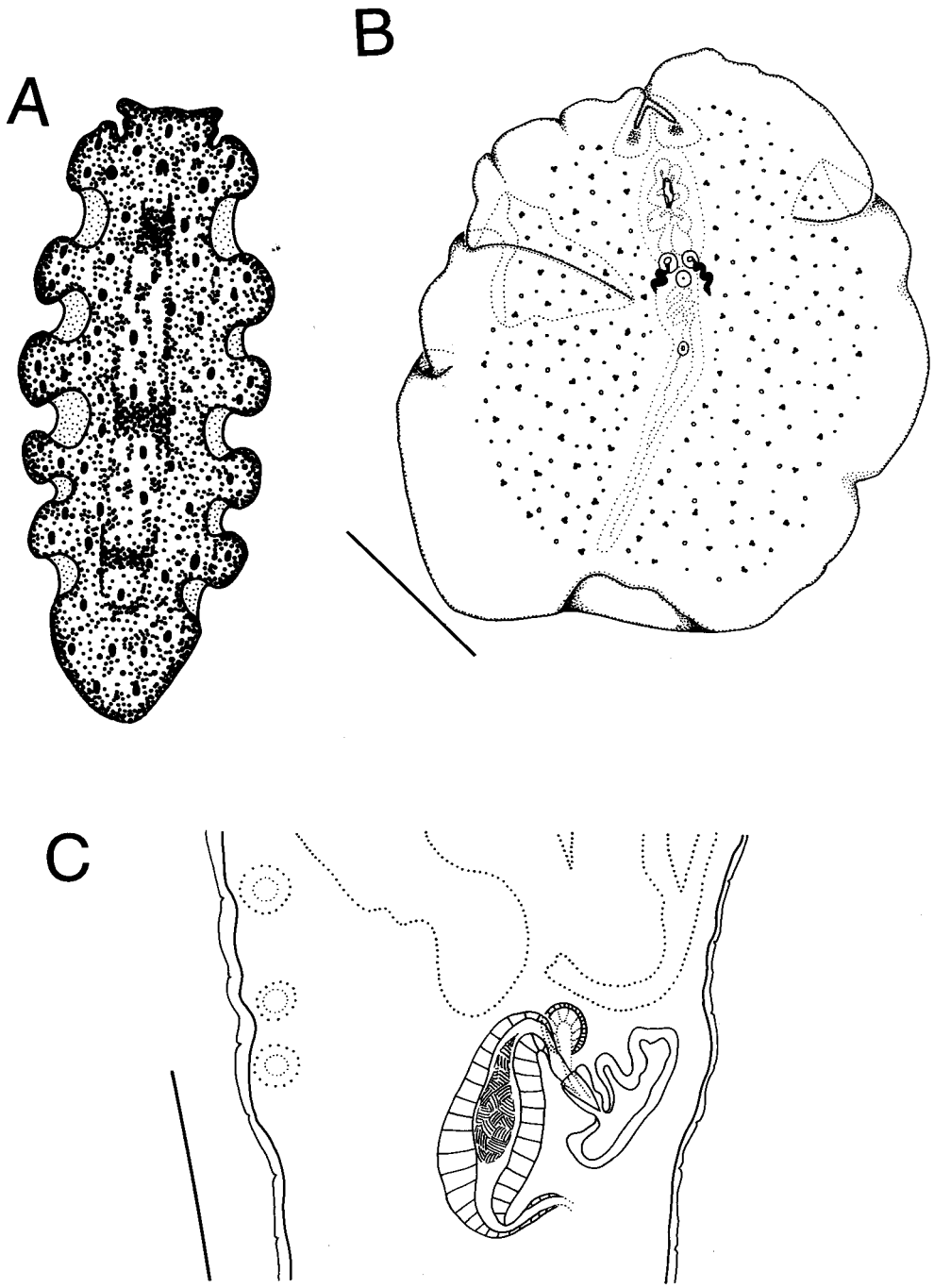

Fig. 6. *Pseudobiceros kryptos*, new species., A) diagram of the dorsal surface, B) wholemount from the ventral side, C) reconstruction of one side of the male structures. Scales: B= 5 mm, C= 500 µm.

Paratypes - WM (G210795), same data as holotype; LS (QM G210781); LS (QM G210782), 10 Apr.1995; S (QM G210820), 2 ex.

Other material - WM (QM G210777), 10 m, on reef slope, Madang, PNG, 5 May.1992; LS (QM G210780), 3 m, under rubble, T. Gosliner, 16 Jun.1992; WM (QM G210776), 10 m, Nagada Harbour, Madang, 22 Jun.1992; S (QM G210778), 30 Mar.1994; LS (QM G210899); LS (QM G210779), 1 Apr.1994; LS (QM G210783), under rubble, reef crest, Heron Is., S GBR, 13 Jun.1995; S (QM G210813), 6 m, under rubble, S Coral Bay, WA, 28 Apr.1996.

Records - CT, Apr.1994, Bali, Indonesia, coll. C. Anderson, no date; CT #372, 20 m, Sugar Loaf Is., Lord Howe Is., N. Coleman, 24 Feb.1980.

Description. - Background colour variable; mottled olive (104U) green to lime green (390U) and white, large irregular brown and olive green spots on the margin, large irregular orange-brown spots and white dots scattered over the dorsal surface, darker medially (Figs. 6 A, 12 E). Margin narrow yellow. Gut diverticula usually green. Largest animals with narrow interrupted brown margin and large transverse cream-white bands. Ventral surface light olive green (383U). Pseudotentacles square and ruffled (Fig. 6 A). Cerebral eyespot in clear, oval area with up to 100 eyes. Size range: 12 x 7 mm (immature) to 40 x 18 mm (mature).

Male pores well separated (Fig. 6 B). Vas deferens branching. In one system: seminal vesicle elongate oblong (535 µm long); prostate round (125 µm wide); stylet 115 µm long x 40 µm wide, length: width ratio = 1: 0.4 (Fig. 6C). Male antrum deep and wide.

Diagnosis. - Mottled olive green and white, with orange-brown and white spots and large irregular brown and green spots on the margin; narrow, yellow margin.

Etymology. - Named from the Latin (masculine) *kryptos* = hidden, for its cryptic colouration.

Remarks. - This species belongs in Group 4 (Table 1) and only one other species is mottled green, *P. brogani*. *Pseudoceros kryptos* differs from *P. brogani* by its more irregular mottling and absence of regularly spaced brown spots (vs. regular green or brown) and green margin (vs. brown or orange). Both of these species appear to be cryptically coloured.

One animal was found with several symbiotic copepods (*Pseudoanthessius* sp.) which appeared to be living near the pharynx (Humes, pers. comm.).

Habitat & distribution. - Found on colonial ascidians under rubble on the reef crest or reef slope. Common from Madang, PNG; rare from Lizard Is., Heron Is., GBR and Coral Bay, WA. Records: Bali, Indonesia and Lord Howe Is.

Pseudobiceros mikros, new species

(Figs. 7 A-C, 12 F)

Material examined. - Holotype - WM (QM G210763), 3 m, under rubble, N Madang, PNG, coll. H. & C. Peterken, 6 Apr.1994.

Paratypes - LS (QM G210761), same data as holotype, 22 Mar.1994; WM (G210762), 23 Mar.1994.

Description. - Background transparent, mottled brown (166U) and grey, interspersed

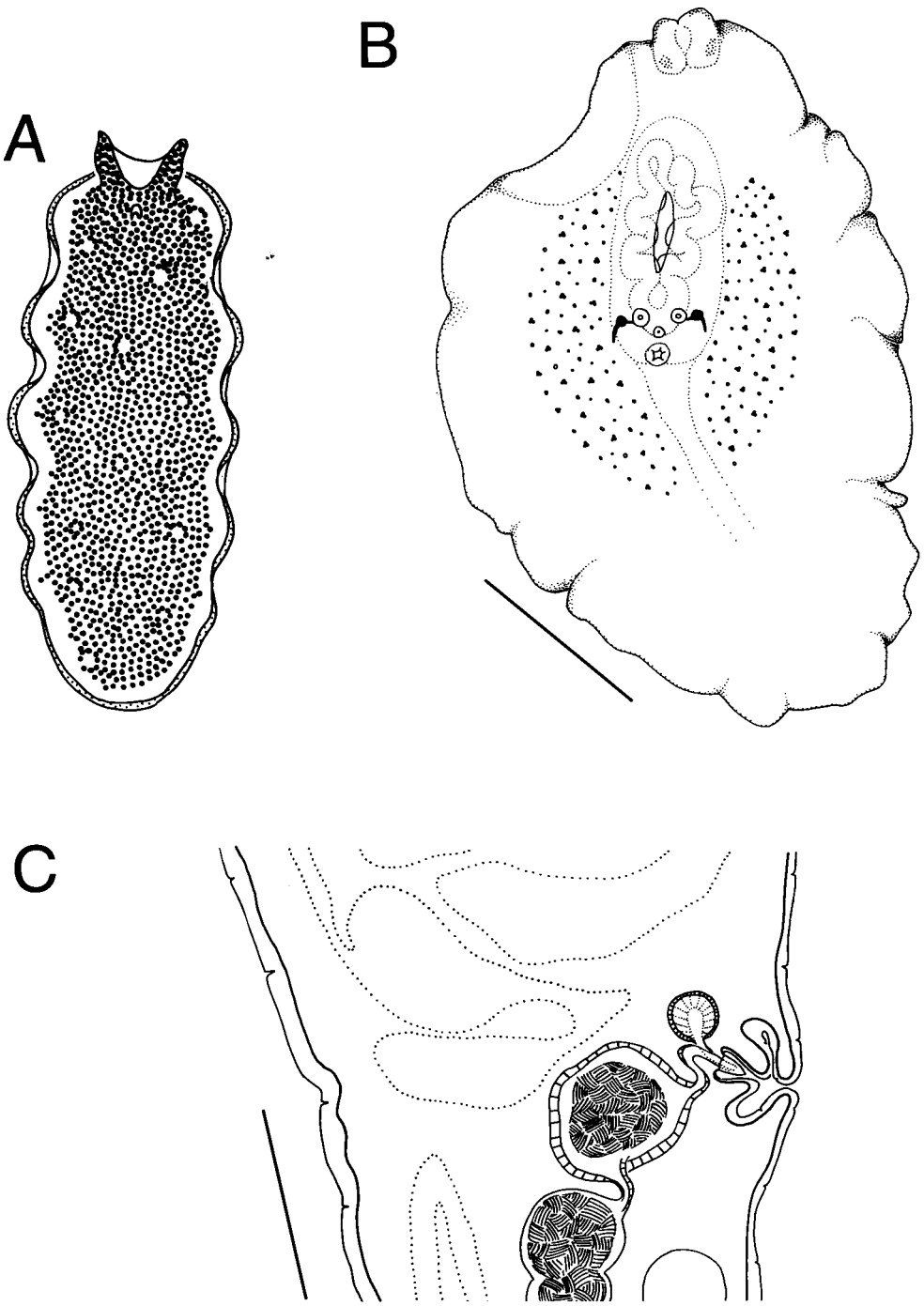

Fig. 7. *Pseudobiceros mikros*, new species, A) diagram of the dorsal surface, B) wholemount from the ventral side, C) reconstruction of one side of the male structures. Scales: B= 2 mm, C= 500 µm.

with white spots (composed of opaque dots) in round clusters; margin wide, formed of white spots becoming a solid white band marginally; narrow bright yellow (115U) rim (Figs. 7 A, 12 F). White triangle between the pseudotentacles, dorsally and ventrally. Ventrally transparent pink-red. Long, pointed ear-like pseudotentacles, held erect (Fig. 7 A). Cerebral eyespot in clear area with 20-30 eyes. Size range: 7 x 3 mm (immature) to 18 x 9 mm (mature).

Male pores well separated (Fig. 7 B). Vas deferens not branching. In one system: seminal vesicle rounded oblong (410 µm long); prostate round (140 µm wide); stylet 70 µm long x 40 µm wide; length: width ratio = 1: 0.6 (Fig. 7 C). Male antrum deep and wide.

Diagnosis. - Mottled brown and white, wide white margin and yellow rim.

Etymology. - Named from the Latin (masculine), *mikros* = small, for its relatively small size.

Remarks. - This species belongs in Group 3 (Table 1) and no other species is brown with white dots.

Habitat & distribution. - Found on similarly coloured colonial ascidians (appeared to be feeding) under rubble. Rare from Madang, PNG.

Pseudobiceros murinus, new species

(Figs. 8 A-C, 13 A)

Material examined. - Holotype - WM (QM G210764), 3 m, under rubble, N Madang, PNG, 12 Apr.1994.

Other material - LS (QM G210765), 2 m, under rubble, between Lizard Is. Lagoon, N GBR, 5 Apr.1995.

Description. - Background transparent mottled grey-green (5575U) with evenly spaced small black and white dots in irregular, scattered clusters dorsally; darker medially with red or brown tinge (Figs. 8 A, 13 A). Margin with a narrow yellow-orange (121U) band; extremely narrow, clear rim. White dots forming a triangle between pseudotentacles, pseudotentacles with red tinge and white tips. Ventrally whitish-grey with opaque white dots. Pseudotentacles long, pointed, ear-like and held erect (Fig. 8 A). Cerebral eyespot with about 40 eyes in a clear area. Size range: 15 x 8 mm (immature) to 24 x 12 mm (mature).

Male pores well separated (Fig. 8 B). Vas deferens unbranched. In one system: seminal vesicle rounded oblong (300 µm long); prostate round (150 µm wide); stylet short and wide (90 µm long x 50 µm wide), length: width ratio = 1: 0.6 (Fig. 8 C). Male antrum deep.

Diagnosis. - Transparent grey-green with black and white dots, narrow yellow-orange marginal band and clear rim.

Etymology. - Named from the Latin (masculine), *murinus* = mouse grey, from its relatively small size and greyish colour.

Remarks. - This species belongs in Group 4 (Table 1) where three other species, *P. gardineri, P. damawan* and *Pseudobiceros* sp. 1 are also mottled grey. Only two other species,

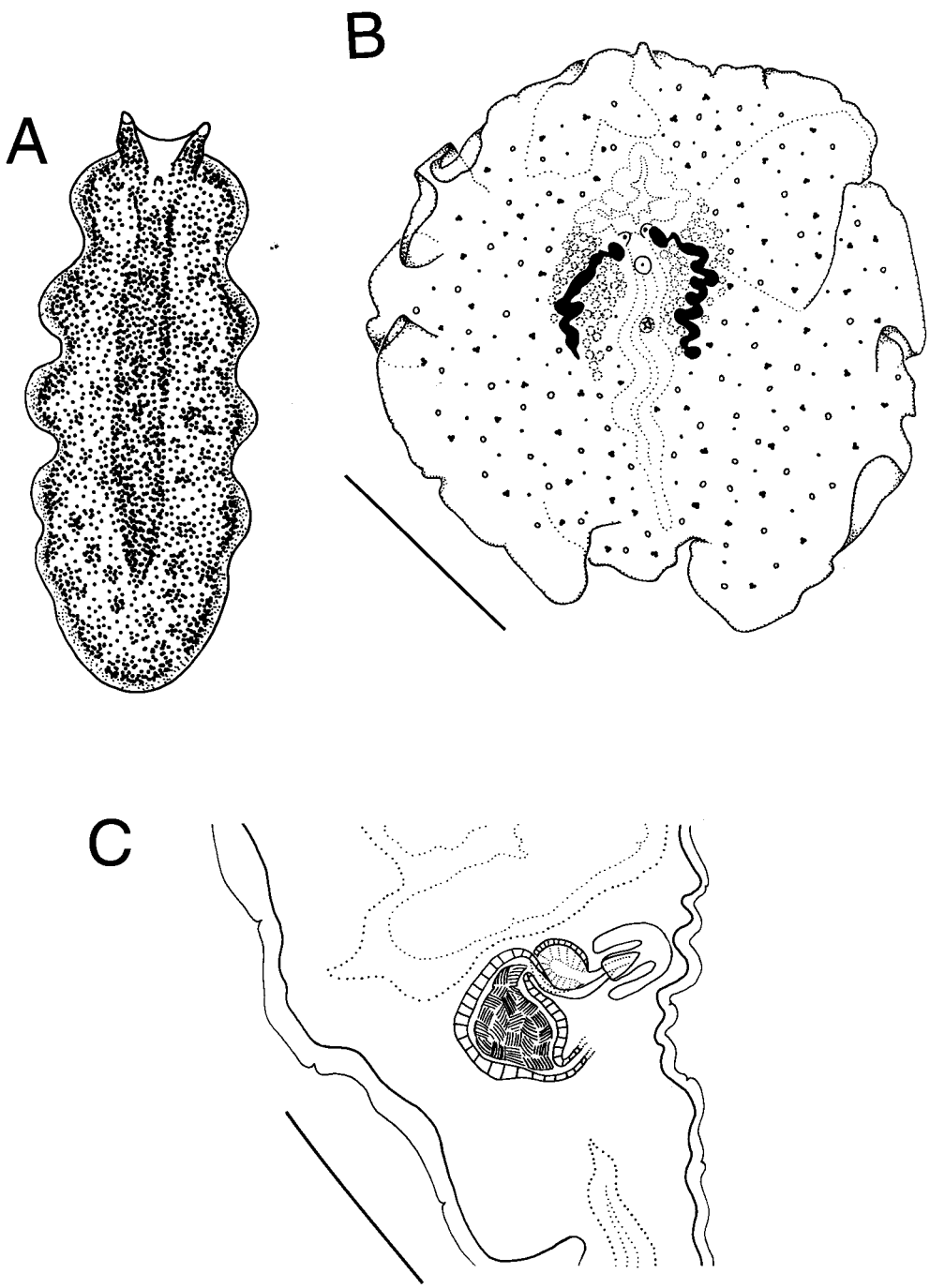

Fig. 8. *Pseudobiceros murinus*, new species, A) diagram of the dorsal surface, B) wholemount from the ventral side, C) reconstruction of one side of the male structures. Scales: B= 5 mm, C= 500 µm.

P. damawan and *Pseudobiceros* sp. 1 also possess an orange marginal band. However, this species has an orange submargin and clear rim, whereas *P. damawan* has an indistinct broken margin and *Pseudobiceros* sp. 1 has a continuous narrow, orange margin.

Both this species and *P. mikros* are not typical of the genus as they are relatively small when sexually mature and have long erect pseudotentacles. However, their double male systems and simple pharynx are typical of the genus.

Habitat & distribution. - Found under rubble in shallow waters. Rare from Lizard Is, N GBR and Madang, PNG.

Pseudobiceros sharroni, **new species**
(Figs. 9 A-C, 13 B)

Material examined. - Holotype - WM (QM G210905), 1 m, under algal mats, sea grass beds, Ngermutidech, Koror, Palau, coll. L. Sharron, 3 Dec.1996.

Paratypes - LS (QM G210879), same data as holotype, 24 Jun.1996; S (QM G210903), S (QM G210904).

Description. - Background opaque green-grey (573U), lighter medially and marginally, extremely narrow orange (150U) rim (Figs. 9 A, 13 B). Pseudotentacles with orange tips. Ventrally light green with a wide, dark grey band near the margin, then lighter green and narrow orange rim. Pseudotentacles pointed and ear-like (Fig. 9 A). Size range: 50 x 25 mm (mature) to 80 x 35 mm (mature).

Male pores close together (Fig. 9 B). Vas deferens branching. In one system: seminal vesicle rounded, oblong (380 µm long); prostate elongate oval (260 µm long); stylet 95 µm long x 25 µm wide, length: width ratio = 1: 0.3 (Fig. 9 C). Male antrum wide and deep.

Diagnosis. - Grey-green; extremely narrow orange rim.

Etymology. - Named in honour of Mr Larry Sharron who first collected this species.

Remarks. - This species belongs in Group 1 (Table 1). The majority of species in this group are velvety black with conspicuously coloured marginal bands and are likely to be displaying aposematic colouration (Newman & Cannon, 1994a; 1995a; Newman & Ang, 1996). This species is the only member of the group with a grey-green background.

Pseudobiceros sharroni was commonly found under algal mats or coral rubble and appears to be cryptically coloured to match its habitat. Often this species was found in pairs and when disturbed tended to curl up into frilly balls which resembled an algal turf (Sharron, pers. obs.).

Habitat & distribution. - Found in shallow waters under algal mats. Common from one site, Koror, Palau, Micronesia.

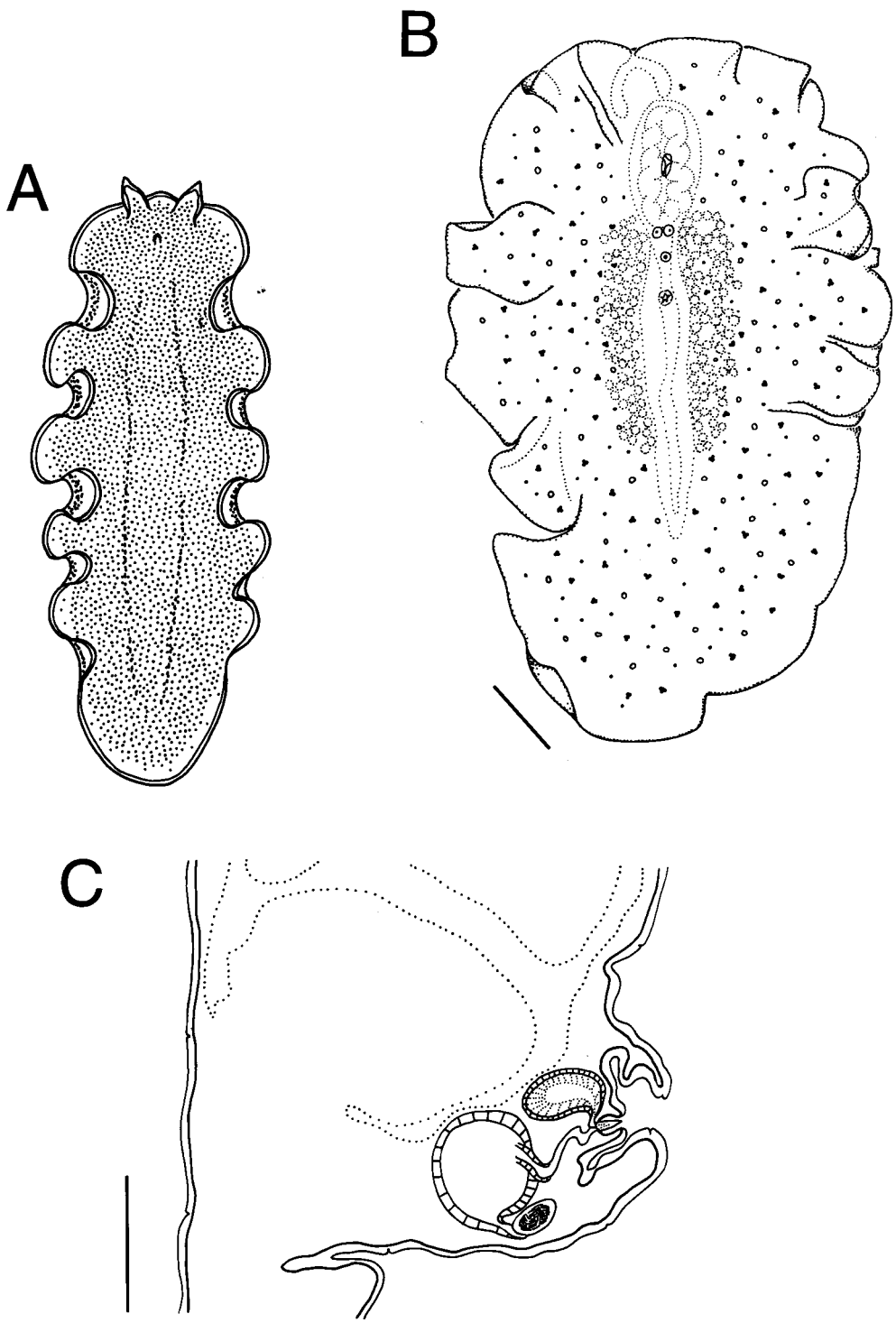

Fig. 9. *Pseudobiceros sharroni*, new species, A) diagram of the dorsal surface, B) wholemount from the ventral side, C) reconstruction of one side of the male structures. Scales: B= 5 mm, C= 500 μm.

Pseudobiceros stellae Newman & Cannon, 1994

Pseudobiceros stellae Newman & Cannon, 1994a: 252; figs. 41a-d, 51e.

Material Examined. - S (QM G210830), out at night, reef crest, Heron Is., S GBR, 18 Mar.1996; S (QM G210825), 2 ex., 10 m, reef slope, 20 Mar.1996; S (WAM 182-96), 2 ex., under rubble, 6 m, S Coral Bay, WA, 28 Apr.1996; S (QM G210810), under rocks, 2 m, N Coral Bay, 29 Apr.1996. Records: CT, under rubble, 2 m, Lizard Is. Lagoon, N GBR, 7 Apr.1995; CT, under rubble, 6 m, N Coral Bay, WA, 29 Apr.1996.

Remarks. - This species belongs in Group 3 (Table 1) and only one other species, *P. bajae,* is black with white dots, however, *P. stellae* has regular white dots forming a regular pattern (vs. irregular white dots) (Newman & Cannon, 1994a).

Habitat & distribution. - Found under boulders and out on the rubble at night from the reef crest. Common from Heron Is. and rare from One Tree Is., S GBR; Madang, PNG and Hawaii, USA (Newman & Cannon, 1994a). New records: Lizard Island, N GBR and Coral Bay, WA.

Pseudobiceros uniarborensis Newman & Cannon, 1994
(Figs. 13 C, D)

Pseudobiceros uniarborensis Newman & Cannon, 1994: 252 - 254; figs. 42a-d, 51f.
Pseudobiceros sp. 5 Gosliner et al., 1996: 103, fig. 343.

Material Examined. - WM (QM G210912), under rubble, reef crest, Heron Is., S GBR, 19 Feb.1992; WM (QM G210910); WM (QM G210914), 21 Feb.1992; WM (QM G210913), 3 m under rubble, N Madang, PNG, 16 Jun.1992; WM (QM G210911), 26 Jun.1992; S (QM G210888), reef crest, Heron Is., S GBR, 8 Feb.1993; LS (QM G210826), 2 m, under rubble, Lizard Is. Lagoon, N GBR, 7 Apr.1995; WM (QM G210908), 10 Apr.1995; S (QM G210824), under rubble, crest, Heron Is., 14 Mar.1996; S (QM G210886), 15 m, under rubble, S Tantabiddi, outside Ningaloo Reef, WA, 25 Apr.1996; S (QM G210887), 6 m, under rubble, Coral Bay, WA, 28 Apr.1996; S (QM G210814), coll. P. & S. Morrison, 29 Apr.1996; WM (QM G210862), 2 m, under rocks; S (QM G210861); LS (QM G210856), 5 m, under rubble, 8 May.1996.

Remarks. - *Pseudoceros uniarborensis* as originally described is opaque black with three extremely narrow marginal bands Group 1 (Table 1). However, this species now appears to show a range of colour patterns; i.e. black with irregular white spots (WA specimens), or semi-transparent brown, semi-transparent brown with irregular white spots (PNG specimens) (Figs. 13 C, D). The specimen illustrated in Gosliner et al. (1996) from the Philippines shows an extreme colour variation where the dorsal surface is semi-transparent and light brown. We believe all these animals belong to *P. uniarborensis* since the marginal banding remains the same.

Habitat & distribution. - Found under boulders at the reef crest and slope. Abundant from Heron and One Tree Is., S GBR; common from Madang, PNG (Newman & Cannon, 1994a). New records: rare from Lizard Island, N GBR, Coral Bay, WA and the Philippines.

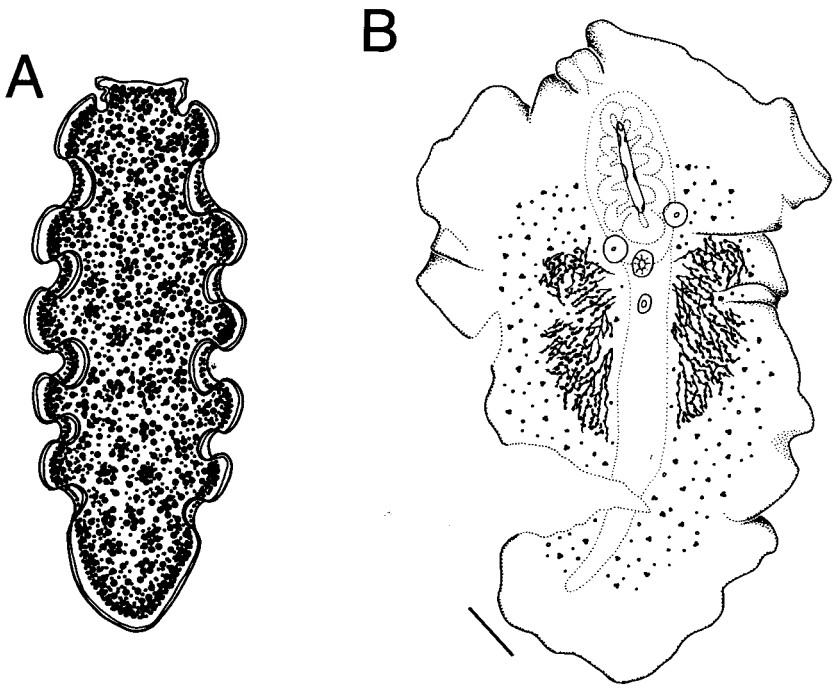

Fig. 10. *Pseudobiceros* species 1, A) diagram of the dorsal surface, B) wholemount from the ventral side, scale= 5 mm.

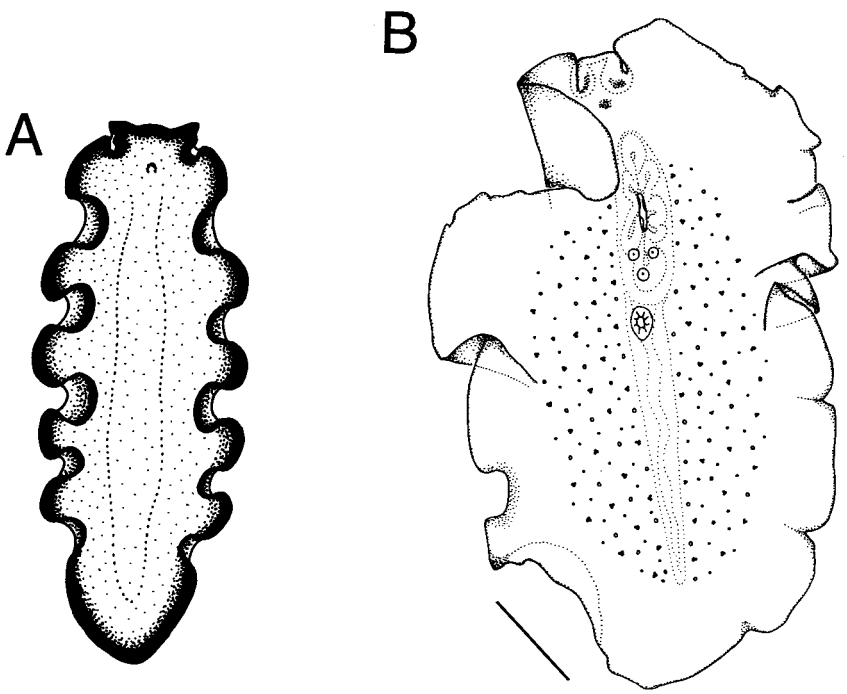

Fig. 11. *Pseudobiceros* species 2, A) diagram of the dorsal surface, B) wholemount from the ventral side, scale= 2 mm.

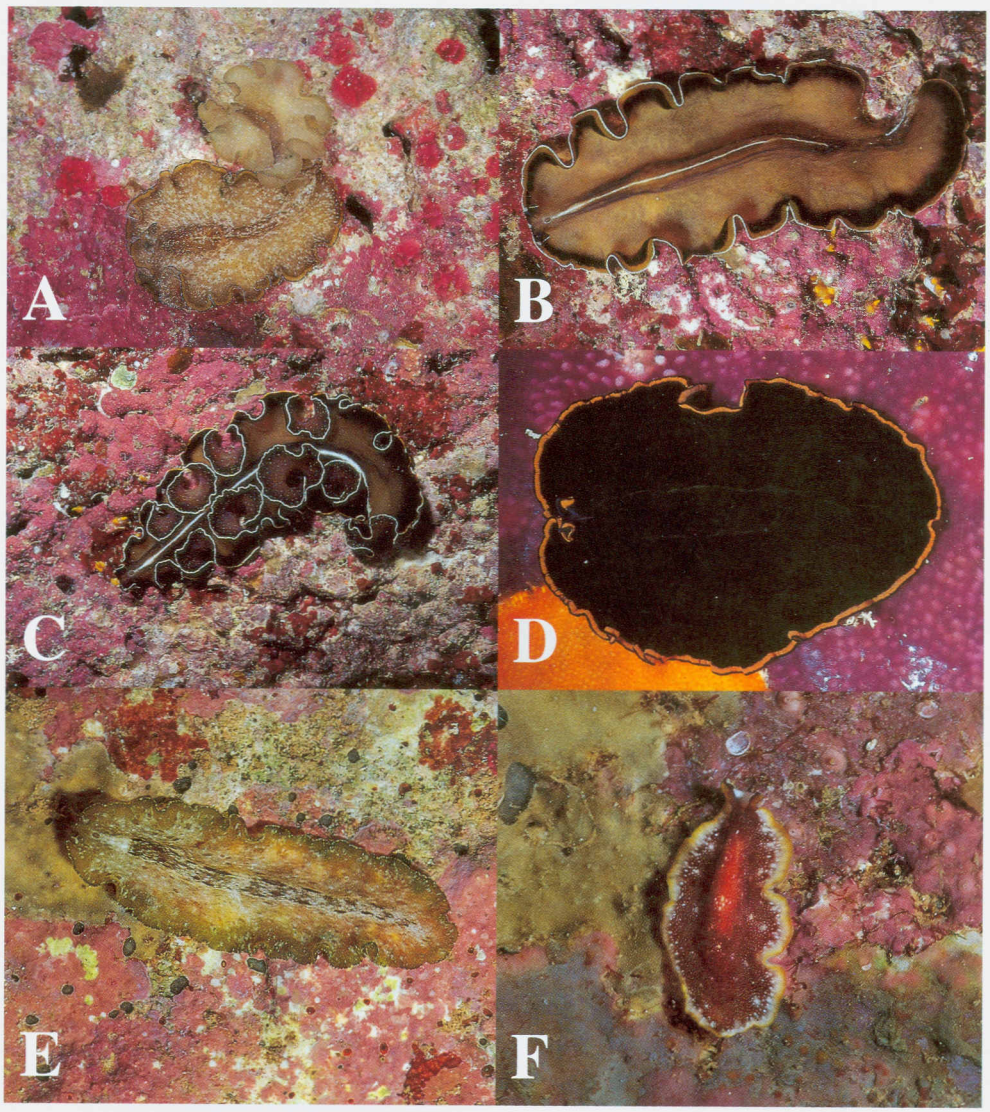

Fig. 12. A, *Pseudobiceros brogani*, new species, Coral Bay, WA: showing colour pattern variation; B, *Pseudobiceros flowersi*, new species, juvenile, Lizard Is., N GBR; C, *Pseudobiceros flowersi*, new species, mature animal, Lizard Is., N GBR; D, *Pseudobiceros hymanae*, new species, Heron Is., S GBR, E, *Pseudobiceros kryptos*, new species, Madang, PNG; F, *Pseudobiceros mikros*, new species, Madang, PNG.

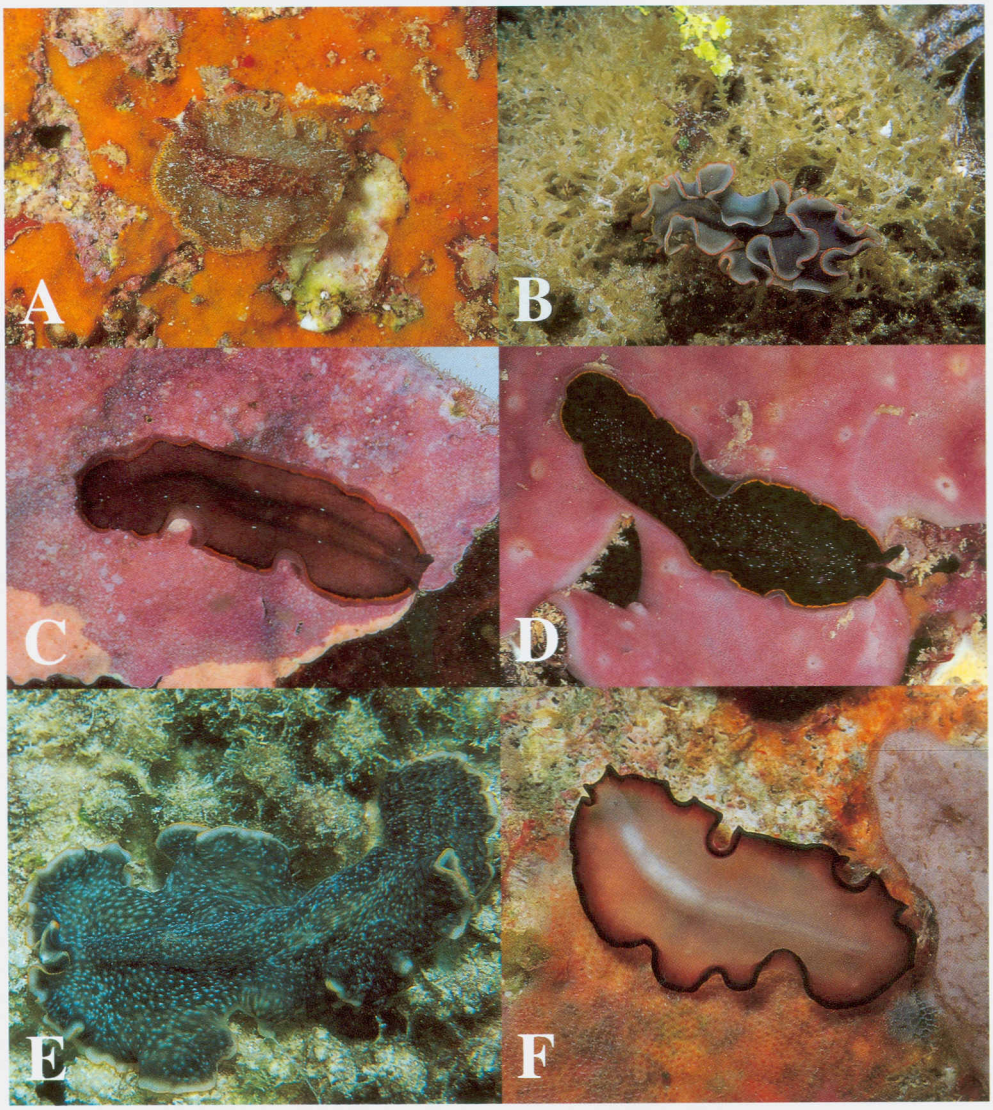

Fig. 13. A, *Pseudobiceros murinus*, new species, Lizard Is., N GBR; B, *Pseudobiceros sharroni*, new species, Palau, Micronesia (photo by L. Sharron); C, *Pseudobiceros uniarborensis*, Madang, PNG; D, *Pseudobiceros uniarborensis*, Coral Bay, WA; E, *Pseudobiceros* sp. 1, Heron Is, S GBR; F, *Pseudobiceros* sp. 2, Madang, PNG.

Table 1. Dorsal colour pattern groups for recognised and new species of *Pseudobiceros* (modified from Newman & Cannon, 1994a)

#	Colour Pattern Group	Recognised Species	New Species
1	Even Colour & Distinct Marginal Bands	*hancockanus* - black; orange & white margin *flavocanthus* - black; white & yellow margin *gloriosus* - black; orange & pink & purple margin *periculosus* - black; orange margin *uniarboretus* - black; orange, grey & white margin *evelinae* - red; orange & black margin	*hymanae* - black; orange & black margin *sharroni* - grey-green; orange margin *Pseudobiceros sp. 2* - cream; orange & black margin
2	Longitudinal Stripes	*cincereus* - black; 2 grey stripes, grey margin *gratus* - white; 3 or 4 black stripes *nigromarginatus* - black; 2 brown stripes, black margin *philippinensis* - black; 3 purple-grey stripes, orange margin	*flowersi* - green or brown; white stripe
3	Spots & Dots	*bajae* - black; sometimes white irregular dots *izuensis* - white; black dots; interrupted margin *apricus* - orange; white dots, black margin *splendidus* - black; orange & brown margin, white flecks* *stellae* - black; white regular dots	*mikros* - brown; white dots, white margin
4	Mottling	*fulvogriseus* - grey, yellow & brown *gardineri* - grey & black *damawan* - grey & white; black spots, orange margin	*brogani* - green or brown & cream; brown spots *kryptos* - green & white; yellow rim *murinus* - grey & white; white & black dots *Pseudobiceros* sp. 1 - grey &w hite; orange margin
5	Transverse Streaks	*bedfordi* - black; yellow dots, pink streaks	
6	Stripes	*flavolineatus* - brown; yellow stripes, black margin *fulgor* - brown; yellow & white stipes, black margin *dendricticus* - yellow; mottled brown, yellow long. stripes	

* Here greater emphasis is place on the flecks than the marginal bands.

Pseudobiceros sp. 1
(Figs. 10 A, B; 13 E)

Material examined. - WM (QM G210881), 8 m, reef slope, night, Heron Is., S GBR, 24 Feb.1992.

Description. - Background mottled dark grey and white forming a dense reticulate pattern, becoming black marginally. Margin wide, white with an extremely narrow orange (136U) rim (Figs. 10 A, 13 E). Ventral surface cream with a wide grey-black band, margin white and orange at the rim. Pseudotentacles wide and square (Fig. 10 B). Size 70 x 35 mm (mature).

Diagnosis. - Mottled grey and white, narrow white and orange rim.

Remarks. - This species belongs in Group 4 (Table 1) where the majority of species are mottled grey (see Remarks for *P. murinus*). We are reluctant to name this species without further material, though on the basis of current knowledge it is new.

Habitat & distribution. - Found under rubble. Rare from Heron Is., S GBR.

Pseudobiceros sp. 2
(Figs. 11 A, B; 13 F)

Material examined. - WM (QM G210882), 3 m, under rubble, Madang, PNG, T. Gosliner, 4 Jun.1992.

Description. - Background semi-transparent cream, intensifying to orange (172U) marginally; lighter medially (Fig. 11 A, 13 F). Margin wide black. Ventral surface same. Pseudotentacles square and ruffled (Fig. 11 B). Size: 20 x 10 mm (immature).

Diagnosis. - Semi-transparent cream intensifying to orange; wide, black margin.

Remarks. - This species belongs in Group 1 (Table 1) and no other species in this group has a light background colour and we are reluctant to name this species without further material, though on the basis of current knowledge it is new.

Habitat & distribution. - Found on the reef slope. Rare from Madang, PNG.

DISCUSSION

As records and observations on these large and colourful flatworms increase we are able to affirm the clear distinctions between genera within the Pseudocerotidae, especially *Pseudoceros* and *Pseudobiceros*, which we have outlined previously (Newman & Cannon, 1994a; 1996 a,b). As we predicted, however, there has been a need to modify our heuristic tabulation of colour patterns. We also note that the earlier observation that *Pseudobiceros* were, in the main, more flamboyantly coloured than *Pseudoceros* may not be true. Many of the species described here are spotted or flecked producing broken and cryptic patterns.

There seems little doubt too, that the species we recognise are found well beyond the Great Barrier Reef and Papua New Guinea - the fauna is clearly Indo-Pacific with only minor colour variations, or at least variations within circumscribed limits. To what extent

this may be a truly cosmopolitan fauna we reserve judgement until comparable studies have been undertaken in tropical Atlantic waters. Certainly, convergence of colours and patterns between genera or even families has already been noted (Newman & Cannon, 1994a). The limited data available, however, support the concept of species recognition from colour and pattern (Goggin & Newman, 1996).

It is well recognised that sedentary marine organisms (sponges, corals, bryozoans, ascidians) are replete with chemical defences against predation. As major predators on these organisms flatworms have clearly evolved to accommodate to these chemical defences - while developing defences of their own. These appear to have taken two paths, towards camouflage by mimicking the colourful and broken patterns created by their sedentary prey or towards aposematism to warn off predators. These flatworms clearly offer intriguing questions for the marine chemist.

ACKNOWLEDGMENTS

We wish to thank the following people who helped with collecting tropical polyclads; Andrew Flowers, Terry Gosliner, Hugh & Carolyn Peterken, Vivien Matson-Larkin and Peter & Sue Morrison and Bill Brogan. Histological preparations were expertly provided by Zeinab Khalil and all specimens were curated by Kim Sewell. Kylie Jennings prepared many of the drawings and plates. Andrew Flowers greatly assisted with the underwater and laboratory photography. We are indebted to Terry Gosliner, Julie Marshall, Charles Anderson, Scott Johnson, Clay Bryce and Neville Coleman providing colour transparencies and new records. Special thanks are given to Bill Brogan for his support at Coral Bay, the Directors and staff of the Heron and Lizard Island Research Stations and Christensen Research Station, the Managers of the One Tree Island Research Station and Pat & Lori Colin and Larry Sharron, Coral Reef Research Foundation through a contract with the US National Cancer Institute. Financial support was generously provided to L.N. by the Australian Biological Resource Study, Canberra and the Christensen Fund, Palto Alto, California. This is Contribution No. 152 from the Christensen Research Institute, Madang, Papua New Guinea.

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Received 14 Apr 1997
Accepted 23 May 1997