

**BULACEROS, NEW GENUS, AND TYTTHOSOCEROS,
NEW GENUS, (PLATYHELMINTHES: POLYCLADIDA)
FROM THE GREAT BARRIER REEF, AUSTRALIA
AND PAPUA NEW GUINEA**

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ABSTRACT. - Two new genera of pseudocerotid flatworms are described from the Great Barrier Reef, Australia and Madang, Papua New Guinea. *Bulaceros*, new genus, and *Tytthosoceros*, new genus, resemble *Pseudoceros* Lang, 1884 in having a single reproductive system, however, their overall morphology resembles *Pseudobiceros* Faubel, 1984, which possesses paired male systems. *Bulaceros*, new genus can be distinguished from other pseudocerotid genera by its knobbed pseudotentacles, arrangement of the dorsal eyes and small, narrow penial stylet. *Tytthosoceros*, new genus, can be distinguished by its small ear-like pseudotentacles, arrangement of the dorsal eyes, and short, wide penial stylet.

INTRODUCTION

The most common and conspicuous polyclad flatworms occurring on coral reefs belong to the family Pseudocerotidae. In 1984, Faubel reviewed the systematics of the pseudocerotids on the basis of the male reproductive anatomy and divided the large genus *Pseudoceros* Lang, 1884 into five (four new) genera. Newman & Cannon (1994a, b; 1995a; in press) further re-defined the criteria needed for recognition of the most speciose genera, *Pseudoceros* and *Pseudobiceros* Faubel, 1984 and introduced new characters, some only clearly seen in living animals. These characters include the shape of 1) the body, 2) pseudotentacles, 3) pharynx and 4) pharyngeal lobes and also the number of male pores and the arrangement of the dorsal and cerebral eyes.

Newman & Cannon (1994a; 1995a; in press) showed that while clear morphological and anatomical differences exist between pseudocerotid genera there were no apparent interspecific anatomical differences in the details of the male reproductive anatomy. Recent species diagnoses in *Maiazoön* (Newman & Cannon, in press), *Phrikoceros* (Newman & Cannon, in press), *Pseudoceros* and *Pseudobiceros* have been based primarily on colour

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pattern. Since these polyclads use hypodermic insemination, physical isolating mechanisms based on differentiated anatomy of their copulatory structures cannot function. Isolating mechanisms based on behaviour, physiology and chemistry may exist but to date no reliable morphological variations associated with reproductive structures have been discerned.

The new genera, *Bulaceros* and *Tytthosoceros* from the Great Barrier Reef Australia and Madang, Papua New Guinea are described. These genera are morphologically distinct and can be differentiated from other pseudocerotid genera on the basis of the shape of the pseudotentacles, pharynx, arrangement of the dorsal eyes (cerebral and pseudotentacular) and details of their reproductive anatomy.

MATERIALS AND METHODS

Polyclads were hand collected from under coral rubble at the reef crest or from the reef slope by SCUBA from the Great Barrier Reef (GBR) [including Lizard Island (14° 40' S, 145° 28' E), One Tree Island (23° 30' S, 152° 05' E) and Heron Island (23° 27' S, 151° 55' E)] and Madang (5° 14' S, 145° 45' E), Papua New Guinea. Animals were photographed *in situ* and fixed by coaxing them onto filter paper which was then transferred to frozen polyclad fixative (Newman & Cannon, 1995b). After fixation, specimens were preserved in 70% ethanol for histological preparation. Whole mounts were stained with Mayer's Haemalum, then dehydrated in graded alcohols and mounted in Canada balsam. Longitudinal serial sections of the reproductive region were obtained from specimens embedded in Paraplast (56° C), sectioned at 5 - 7 µm, and stained with haematoxylin and eosin.

Body measurements were taken from live animals in a relaxed state and are expressed in mm (length x width). Due to the plasticity of these animals and the changes caused by fixation measurements are only used as a guide. Measurements of the reproductive organs are taken from the paratypes. Reconstructions of the reproductive systems are diagrammatic and have been derived from the sections with minimal interpretation.

Colour descriptions are based on living animals and colour numbers in brackets refer to Pantone Colors by Letraset, 1989, Series U. Colour groups and definitions of colour terms are given in Newman & Cannon (1994a). Drawings were made with the aid of a camera lucida by L.J.N. Specimens were collected and photographed by L.J.N. and A.E. Flowers and all material is lodged at the Queensland Museum (QM) as wholemounts (WM), serial sections (LS) and wet specimens (S).

DESCRIPTION

FAMILY PSEUDOCEROTIDAE LANG, 1884

Bulaceros, new genus

(Figs. 1 A-D; 2; 3 A,B; 8 A,B)

Diagnosis. - Size ranging from 8 x 3 mm up to 34 x 16 mm. Body soft, oval, flat medially, with crenulated margin, tapering slightly posteriorly (Figs. 1 A,B; 3 A,B; 8 A,B). Pseudotentacles formed from the anterior margin, well developed, ear-like with distal knobs, held erect and together (Figs. 1 C,D). Cerebral eyespot in two clusters with about 30 eyes

per cluster. Dorsal pseudotentacular eyes few, about 30 - 40, scattered between the pseudotentacles (not in clusters); ventral pseudotentacular eyes more numerous, extending medially to the pseudotentacular tips in two clusters, more concentrated at the pseudotentacular tips. Pharynx small, rounded, anterior, about 1/5 body length, with about 5 to 6 pairs of simple pharyngeal folds, mouth central (Figs. 1 B; 3 B). Main intestine narrow, extending posteriorly but ending prior to the posterior margin, lateral branches not evident. One male pore posterior to pharynx. Female pore extremely small, just posterior to the male pore. Sucker distinct, mid-body.

Vas deferens forming a prominent network (Figs. 1B, 3B). Male copulatory apparatus single with oblong seminal vesicle (Fig. 2). Prostate oval, orientated antero-dorsally. Small penis papilla with small, narrow, slightly sclerotised stylet. Female antrum extremely narrow and deep.

Type-Species.- *Bulaceros porcellanus*, new species, Great Barrier Reef, Australia.

Etymology.- Named for its knobbed pseudotentacles: *bula* = knobbed and *ceros* = horn. Gender: masculine

Remarks.- *Bulaceros*, new genus, can be distinguished from *Pseudoceros* which also possesses one male reproductive system and sclerotised stylet by its 1) well developed knobbed pseudotentacles (not simple folds), 2) arrangement of the cerebral eyes in two clusters (not a horseshoe shaped cluster), 3) scattered dorsal pseudotentacular eyes (not in rows along the anterior margin), 4) simple pharyngeal folds (not complex) and the reduced sclerotisation of the stylet (Table 1). *Bulaceros* also superficially resembles *Pseudobiceros* in the shape of its pseudotentacles (ear-like) and pharyngeal folds (simple). However, in *Bulaceros* the cerebral eyes are arranged in two clusters (not horseshoe shaped), the dorsal pseudotentacular eyes are scattered (not in four clusters) and there is only one male reproductive system (not two).

***Bulaceros porcellanus*, new species**

(Figs. 1 A-D, 2, 8 A)

Material examined.- Holotype - WM (QM G210662), under rubble, reef crest, Lizard Island Lagoon, northern GBR, Australia, 5 Apr.1995.

Paratypes - WM (QM G210666), under rubble, reef crest, Heron Island, southern GBR, 7 Aug. 1992; LS (QM G210665), under rubble, reef crest, One Tree Island, southern GBR, 16 Aug.1993; WM (QM G210664), 19 Aug.1993; LS (QM G210663), under rubble, Lizard Island Lagoon, northern GBR, 7 Apr.1995.

Description.- Background translucent white with opaque white mottling forming distinct spots towards the margin; entire dorsal surface covered with opaque white microdots and black evenly spaced spots which are absent near the margin; small, irregular orange-brown blotch just posterior to the cerebral eyespot (Figs. 1 A,B; 8 A). Narrow orange-brown marginal band and small white spots at rim. Ventrally translucent white. Size range from 8 x 3 mm (mature) to 22 x 12 mm (mature).

Seminal vesicle rounded, oblong, 520 µm long (Fig. 2). Ejaculatory duct not coiled. Prostatic vesicle small, oval, 160 µm long. Penial stylet small and narrow, 80 µm long and 20 µm wide, slightly sclerotised.

Diagnosis.- Translucent white, mottled with opaque white spots, covered in white microdots and evenly spaced black spots, narrow orange-brown marginal band.

Etymology.- Named for its delicate porcelain-like appearance.

Remarks.- From the colour pattern this species belongs in Group 4 (Newman & Cannon, 1994a). It is sexually mature at an extremely small size; 8 x 3 mm.

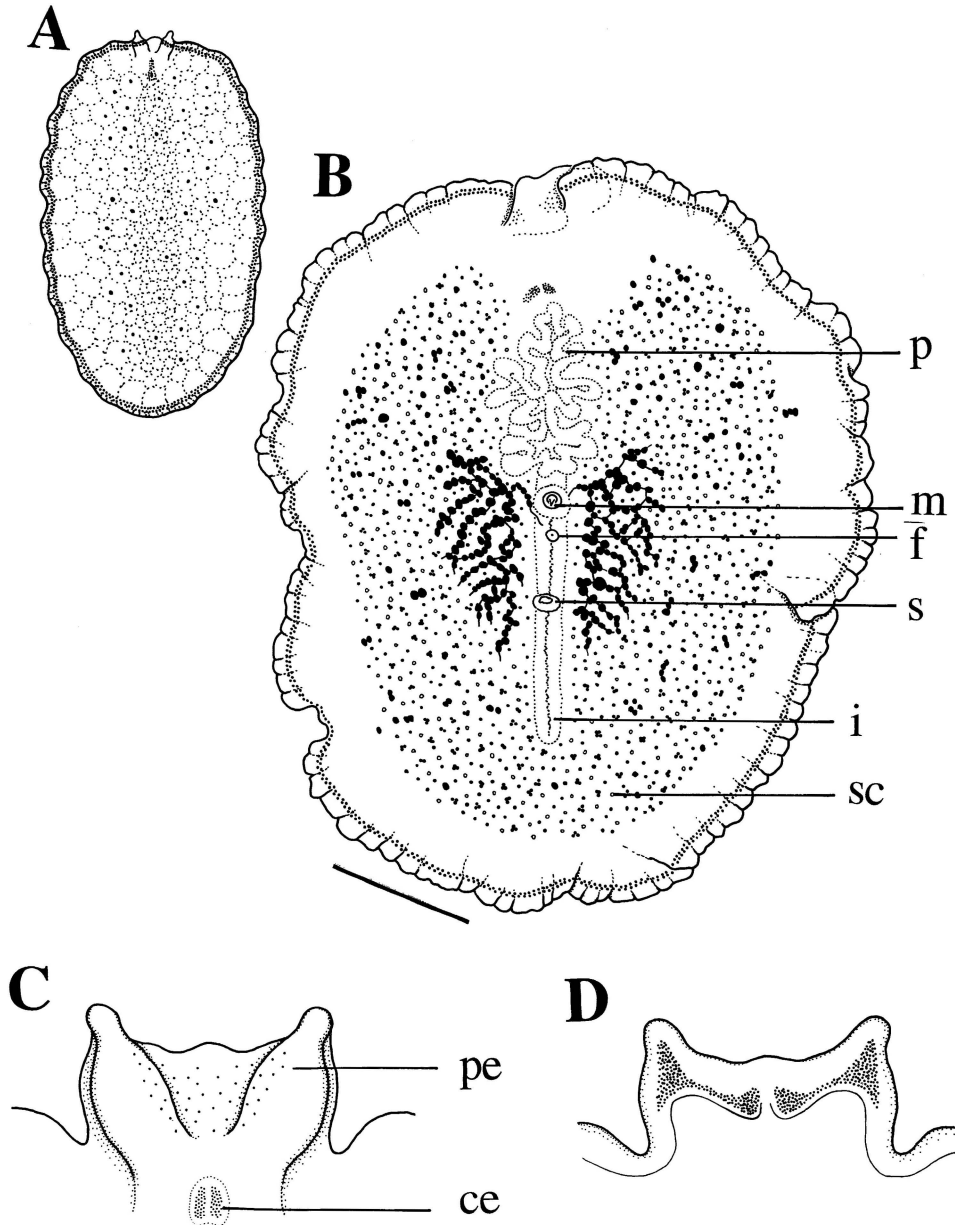


Fig. 1. *Bulaceros porcellanus*, new genus and species. A, diagram from the dorsal side; B, wholemount from the ventral side, QM G210662, scale: 1 mm; C,D, diagram of the eye arrangement. C, dorsal eyes; D, ventral eyes (ce - cerebral eyes, i -intestine, f -female pore, m -male pore, p -pharynx, pe - pseudotentacular eyes, s -sucker, sc -scattered ovaries and testes).

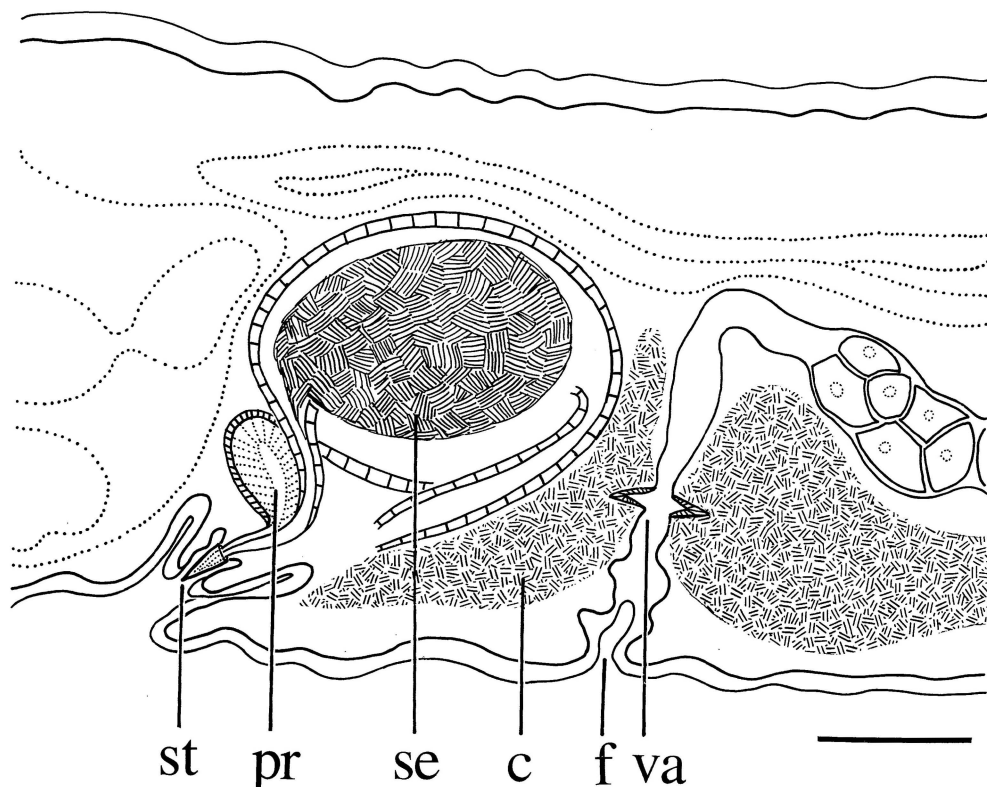


Fig. 2. *Bulaceros porcellanus*, new genus and species, reconstruction of the reproductive anatomy, QM G210655. Scale: 250 μ m (c - cement glands, f -female pore, pr -prostate, se -seminal vesicle, st -stylet, va -vagina).

Distribution.- Rare from under coral rubble, reef crest, northern and southern GBR, Australia.

Bulaceros, species 1

(Figs. 3 A,B; 8 B)

Material examined.- WM (QM G210734), 3m, under rubble, reef crest, Depilik tabub, Madang, Papua New Guinea, T. Gosliner, 8 Jun.1992; LS (QM G210735), incomplete, 10m, south Pig Island, Madang, 28 Mar.1994; WM (QM G210736), 3m, under rubble, reef crest, Yazi tinan, Madang, 12 Apr.1994.

Record - Colour transparency, Ikuren Island, Enewetak, S. Johnson, no date.

Description.-Transparent grey, gut diverticula light brown, irregular white spots over the entire surface, medially darker with mottling extending for about 3/4 body length, ending before posterior margin (Figs. 3 A, 8 B). Margin wide, transparent with opaque white spots, submargin discontinuous, narrow, black or brown. Pseudotentacles transparent dark grey with white tips, small white spot between. Cerebral eyespot with about 50 eyes (Fig. 3 B). Sizes ranged from 18 x 9 mm (immature) to 34 x 16 mm (mature).

No details of the reproductive anatomy are available.

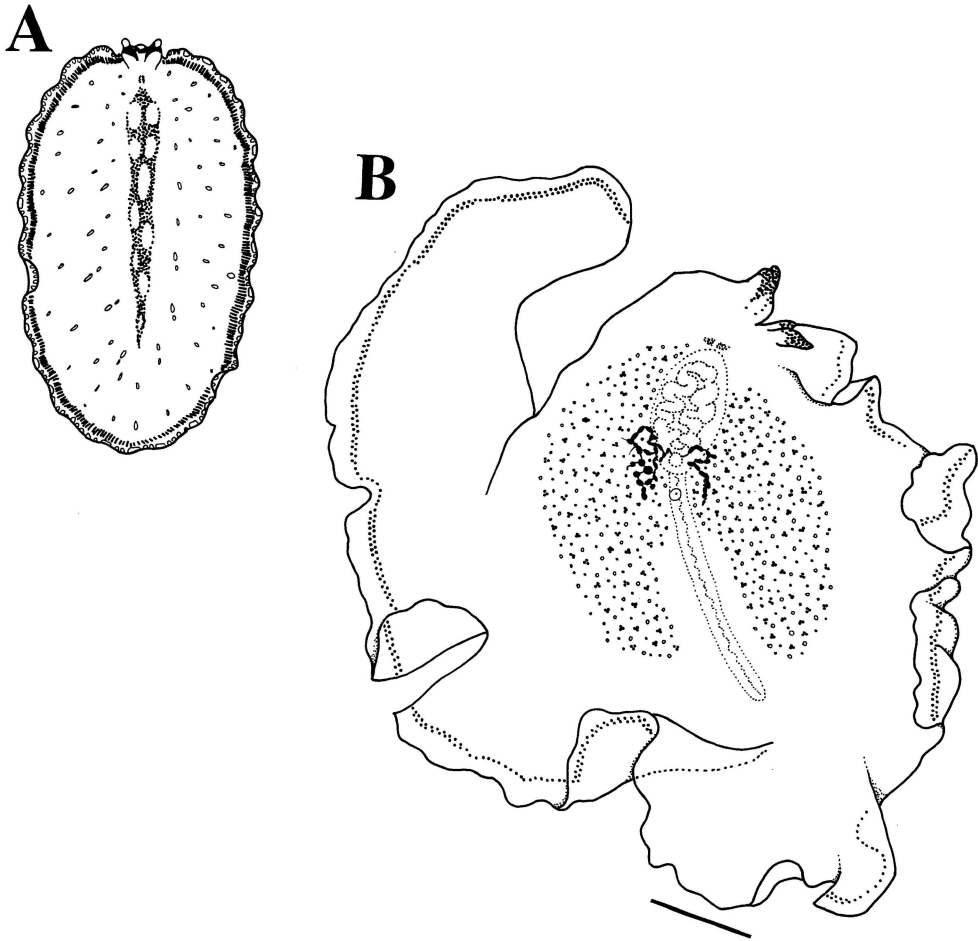


Fig. 3. *Bulaceros*, new species 1. A, diagram from the dorsal side; B, wholemount from the ventral surface side, QM 210743, scale: 2mm.

Remarks.- From the colour pattern this species belongs in Group 4 (Newman & Cannon, 1994a). It is an extremely fragile species and difficult to fix intact. Longitudinal serial sections are incomplete. Although we are confident this is a new species, we are reluctant to formally describe it solely from its colour pattern without any examination of its internal anatomy.

Distribution.- Rare from under coral rubble, reef slope, Madang and The Republic of the Marshall Islands.

***Tytthosoceros*, new genus**
(Figs. 4 A-C; 5; 6; 7; 8 C-D)

Diagnosis.- Averaged sized pseudocerotids ranging from 10 x 6 mm to 70 x 40 mm. Body elongate and oval, extremely soft and delicate, raised medially with deeply crenulated marginal ruffles, tapering slightly posteriorly (Figs. 4 A,B; 8 C,D). Pseudotentacles relatively small, formed from the anterior margin, ear-like, held erect (Fig. 4 C). Cerebral eyespot horseshoe shaped with about 60-100 eyes in clear oval area. Dorsal pseudotentacular eyes

few, about 30-40, scattered between the pseudotentacles (not in clusters); ventral pseudotentacular eyes more numerous, extending medially to the pseudotentacular tips in two clusters, more concentrated at the pseudotentacular tips as in *Bulaceros* (Fig. 1 D). Pharynx large, anterior, about 1/5 body length, with about 5 pairs of simple pharyngeal folds, mouth central. Main intestine wide, extending posteriorly but ending prior to the posterior margin, lateral branches not evident. One male pore posterior to pharynx. Female pore posterior and close to the male pore. Small, inconspicuous sucker well separated from gonopores, distinct, mid-body.

Vas deferens forming a prominent network (Fig. 4 B). Male copulatory apparatus single with rounded-oblong seminal vesicle (Figs. 5, 7). Prostate oval, orientated antero-dorsally. Distinct penis papilla with wide, short sclerotised stylet. Female antrum wide and deep, vaginal walls muscular.

Type-species.-*Tytthosoceros lizardensis*, new species, northern and southern Great Barrier Reef, Australia.

Etymology.- Named for its relatively small pseudotentacles: *Tytthos*= small and *ceros* = horn. Gender: masculine.

Remarks.-*Tytthosoceros* can be distinguished from *Pseudoceros* and *Bulaceros* which also possess one male reproductive system by its combination of 1) small ear-like pseudotentacles (*Pseudoceros* - simple folds, *Bulaceros* - knobbed), 2) horseshoe shaped cerebral eyespot (*Bulaceros* - 2 clusters), 3) scattered dorsal pseudotentacular eyes (*Pseudoceros* - in lines along the anterior margin), 4) short, simple pharyngeal folds (*Pseudoceros* - complex folds) and 5) short, wide stylet (*Pseudoceros* - long & narrow, *Bulaceros* - weakly sclerotised small & narrow) (Table 1).

***Tytthosoceros lizardensis*, new species**
(Figs. 4A-D; 5; 8C)

Material examined.- Holotype - WM (QM G210716), inshore, under rocks, South Island, Lizard Island Lagoon, northern GBR, Australia, 31 Mar.1995.

Paratypes - WM (QM G210721), under rubble, reef crest, Heron Island, 20 June 1991; LS (QM G210724) 20 Jun.1991; WM (QM G210717), 7 Feb.1992; WM (QM G210730); LS (QM G210726); S (QM G210737); WM (QM G210719), 14 Feb.1992; WM (QM G210718), 16 Feb.1992; LS (QM G210723), 10m, reef slope at night, 25 Feb.1992; WM (QM G210729), under rubble, 12 Aug.1992.

Other material - LS (QM G210725), under rubble, reef crest, Heron Island, 8 Feb.1993; LS (QM G210722), reef crest, One Tree Island, 16 Aug.1993; S, 2 ex. (QM G210759) reef crest, Heron Island, 2 Feb.1993; LS (QM G210728), inshore, under rocks, South Island, Lizard Island Lagoon, 31 Mar.1995; LS (QM G210727); WM (QM G210720), under rubble, reef crest, Heron Island, 10 Jun.1995.

Description.- Background colour variable [mottled chocolate brown (159U, 142U) or caramel brown (1385U) or olive green (103U) or light brown] with cream mottling composed of dots forming loose transverse streaks medially and laterally, darker medially, sometimes with a tinge of red laterally near the margin and on pseudotentacles (Figs. 4 A, 8 C). Extremely narrow marginal band, black then grey interrupted with short white transverse streaks of microdots at rim, submargin narrow, either bright yellow or transparent grey band. Pseudotentacles with white tips and cream mottling between. Ventrally cream, light brown

toward the margin, yellow submargin and black rim.

Male antrum small and deep, penis papilla small, stylet short (110 μm long and 70 μm wide)(Fig. 5). Stylet length to width ratio is 1: 2 (Table 1). Prostatic vesicle small and oval (130 μm long). Seminal vesicle oblong (280 μm long) and muscular. Large cement glands and wide cement pouch, vaginal wall thick and muscular. Oviducts full of eggs.

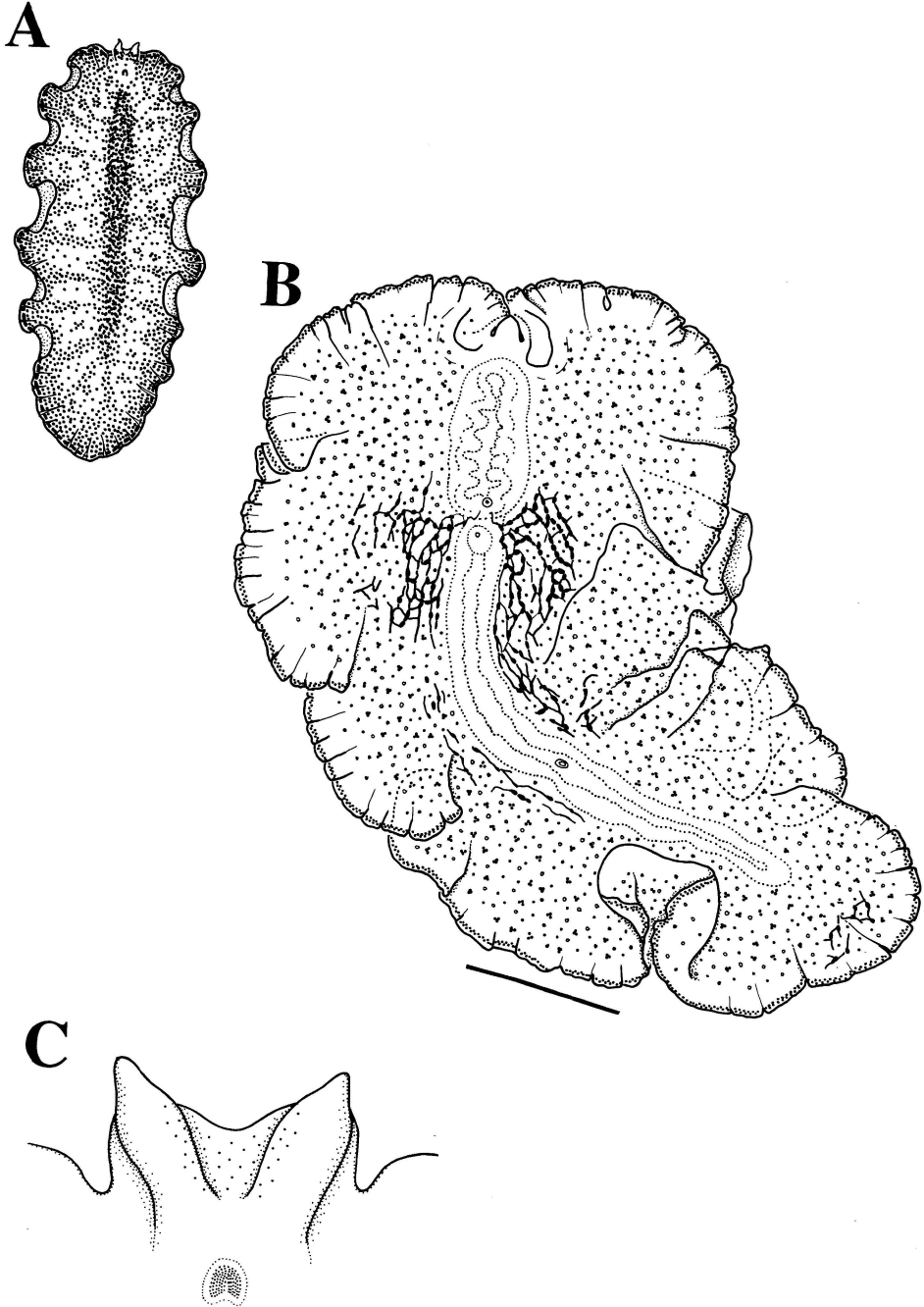


Fig. 4. *Tythosoceros lizardensis*, new genus and species. A, diagram from the dorsal side; B, wholemound from the ventral side, QM G210717, scale: 5 mm; C, diagram of the dorsal eyes.

Diagnosis.- Mottled brown or olive green or light brown with cream mottling composed of dots and forming streaks medially and laterally towards the margin; darker medially. Extremely narrow marginal band, black then grey interrupted with short white transverse streaks of microdots at rim, submargin narrow, either bright yellow or transparent grey. Pseudotentacles with white tips and cream mottling between.

Etymology.- Named in honour of the Lizard Island Research Station.

Remarks.- With regard to the colour pattern this species belongs in Group 4 (Newman & Cannon, 1994a) and appears to be cryptic in colouration. At Lizard Island, groups of up to 20 animals were found under rocks or in pools in the sand. Pairs of animals were observed simultaneously copulating by everting their penes and stabbing each other apparently anywhere (hypodermic insemination). A pair of unidentified small copepods were found on one specimen and are assumed to be symbiotic.

Distribution.- Rare from reef crest and reef slope, Heron Island and abundant from under rocks, inshore, Lizard Island Lagoon, northern GBR, Australia.

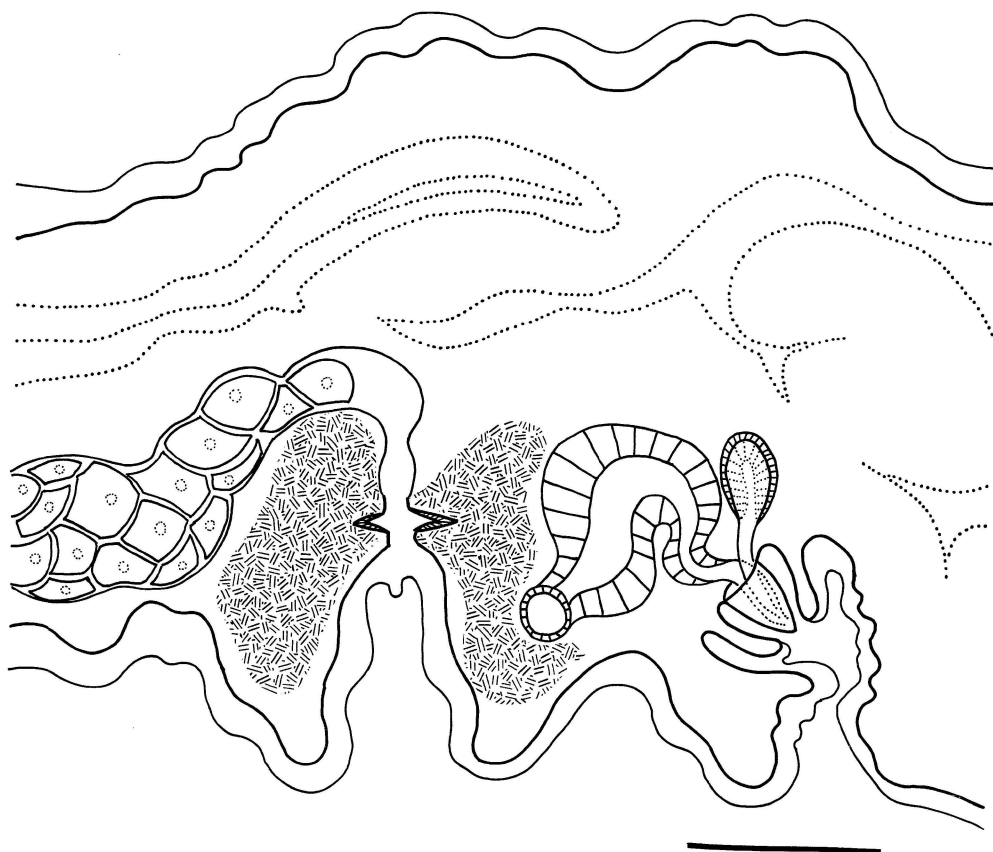


Fig. 5. *Tythosoceros lizardensis*, new genus and species, reconstruction of the reproductive anatomy, QM G210727. Scale: 250 μ m.

***Tytthosoceros nocturnus*, new species**

(Figs. 6 A,B; 7; 8D)

Material examined.- Holotype - WM (QM G210732), 15m, reef slope, under rubble, reef crest, Heron Island, southern GBR, Australia, 1 Jan.1993.

Paratypes - WM (QM G210731), same data, 28 Feb.1990; WM (QM G210733), swimming inshore, night, 3 Feb.1993; LS (QM G210752), 10m, 31 Mar.1996.

Description.- Velvety black or dark brown (sometimes with a red tinge), no markings (Figs. 6 A, 8 D). Pseudotentacles with white or grey tips. Ventrally light brown, darker medially. Cerebral eyespot with about 60 eyes in a clear, round grey area. Due to the dark pigmentation the number and arrangement of the pseudotentacular eyes could not be determined.

Male antrum narrow and deep, penis papilla small, stylet short (60 μ m long and 30 μ m wide) (Fig. 7). Stylet length to width ratio is 1: 2 (Table 1). Seminal vesicle oblong (350 μ m long). Prostatic vesicle small and round (70 μ m diameter) about the same size as the stylet. Ejaculatory duct short not coiled. Female reproductive system not mature in the paratype.

Diagnosis.- Black with white or grey pseudotentacular tips.

Etymology.- Named from the Latin (masculine), *nocturnus* = of the night, for its black colour.

Remarks.- With regard to the colour pattern, this species belongs to Group 1 (Newman & Cannon, 1994a) and can be easily confused with *Pseudoceros bolool* Newman & Cannon, 1994a which is also evenly black and possesses one male pore. However, *Tytthosoceros nocturnus* is raised medially (not flat), has white tips on its ear-like pseudotentacles (not simple pseudotentacles and evenly coloured) and simple pharyngeal folds (not complex folds).

Table 1. Summary of generic diagnostic characteristics for *Pseudoceros*, *Pseudobiceros*, *Bulaceros*, new genus and *Tytthosoceros*, new genus (see Newman & Cannon, 1994a).

Characters	<i>Pseudoceros</i>	<i>Pseudobiceros</i>	<i>Bulaceros</i>	<i>Tytthosoceros</i>
Body shape	flat	raised medially	flat	raised anteriorly
Pseudotentacle shape	simple	ear-like or square	knobbed	ear-like
Pharyngeal folds	complex	simple	simple	simple
Cerebral eye clusters	horseshoe shaped	horseshoe shaped	2 clusters	horseshoe shaped
Dorsal eyes	anterior lines	4 clusters	scattered	scattered
# Male pores	1	2	1	1
Stylet	sclerotised	small, sclerotised	weakly sclerotised small, narrow	sclerotised wide, short
Stylet length: width ratio	* <i>P. bifurcus</i> Prudhoe, 1989 1: 2	* <i>P. gratus</i> (Kato, 1937) 1: 4.2	<i>B. porcellanus</i> 1: 4	<i>T. lizardensis</i> 1: 2 <i>T. nocturnus</i> 1: 2

* unpublished data

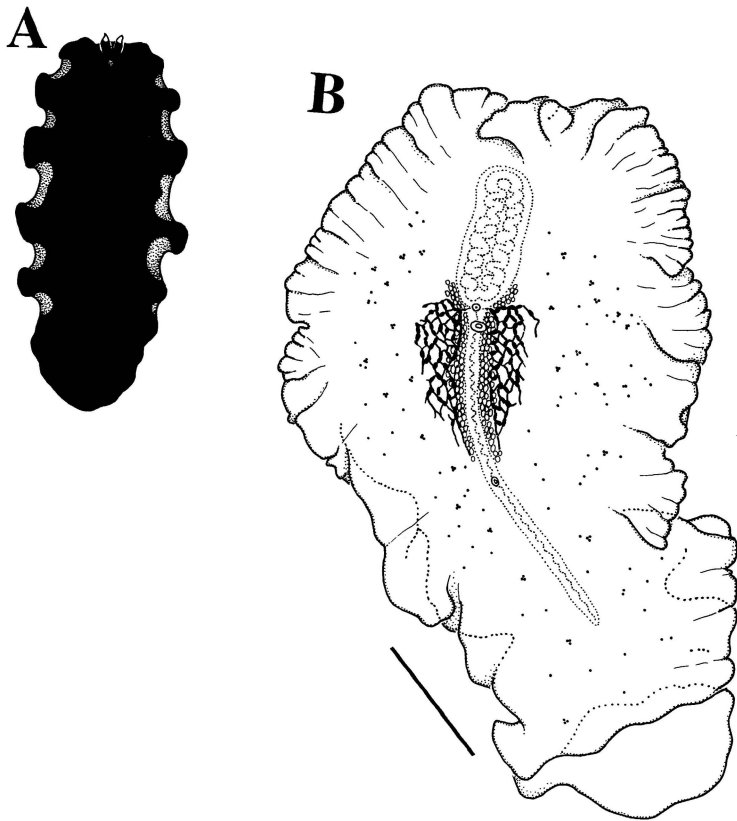


Fig. 6. *Tytthosoceros nocturnus*, new genus and species. A, diagram from the dorsal side; B, wholemount from the ventral side, QM G210731, scale: 5 mm.

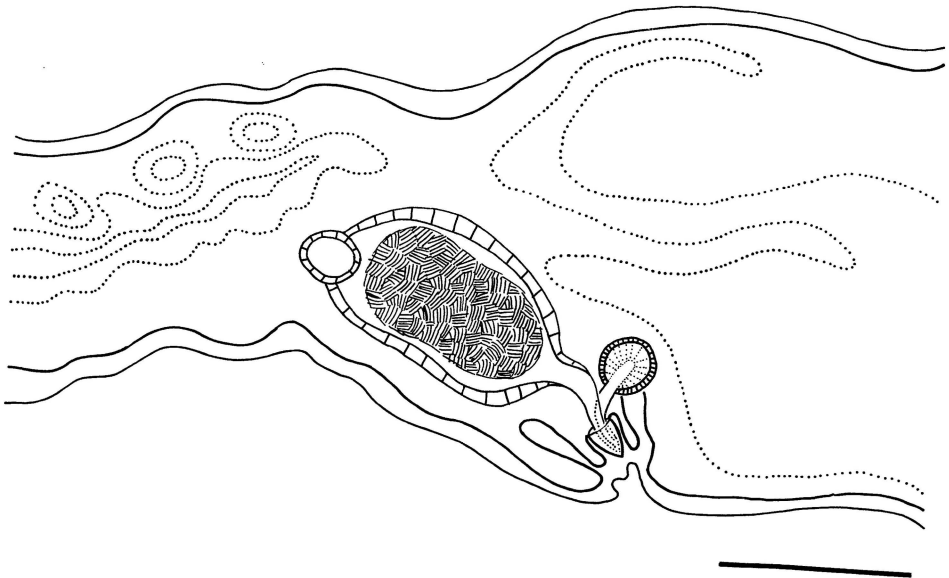


Fig. 7. *Tytthosoceros nocturnus*, new genus and species, reconstruction of the male reproductive anatomy, QM G210752, scale: 250 μ m.

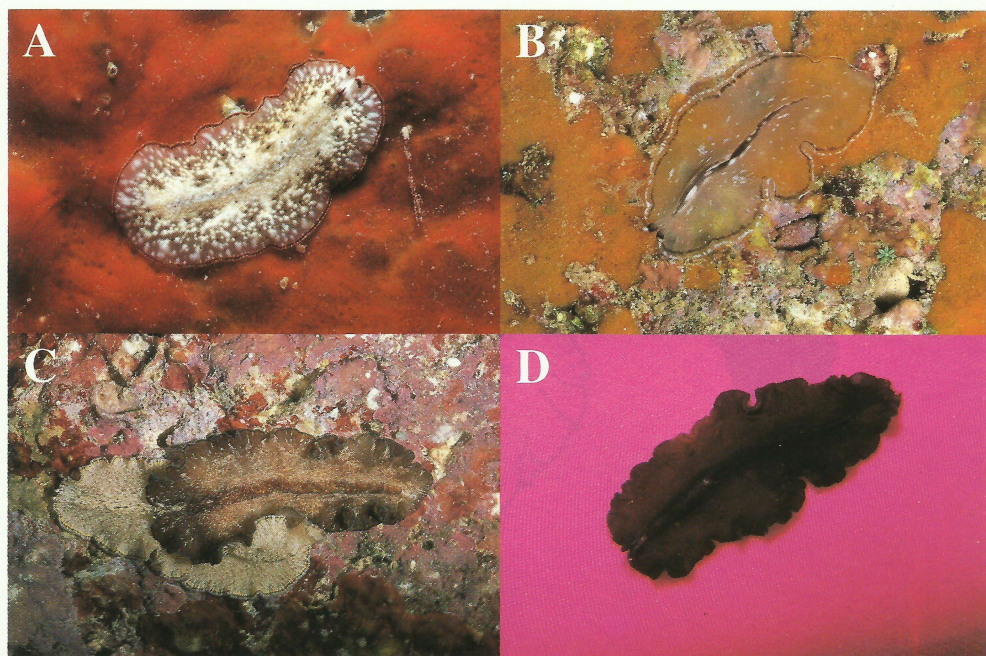


Fig. 8. A, *Bulaceros porcellanus*, new species and genus, Lizard Island; B, *Bulaceros* sp. 1, Madang; C, *Tythosoceros lizardensis*, new genus and species, Lizard Island, two colour forms; D, *Tythosoceros nocturnus*, new genus and species, Heron Island.

Hyman (1959) described *Pseudoceros ater* as uniformly dark greyish without any markings and possessing one male pore. After re-examination of the holotype, Newman & Cannon (1994a) determined that this species possesses simple pharyngeal folds and may belong to *Pseudobiceros*. It appears that more details, such as the shape of the pseudotentacles and details of the male reproductive anatomy would be needed to accurately determine the correct genus for '*Pseudoceros ater*' since other genera also possess simple pharyngeal folds and possess one male pore (Newman & Cannon, in press).

Distribution. - Rare from the reef crest and slope, Heron Island, southern GBR, Australia.

DISCUSSION

For over 100 years large colourful polyclads have been described from coral reefs, usually from very few specimens and rarely with attention to the live animals. Most were attributed to the genus *Pseudoceros* which grew very large with over 150 species. Anatomical details of the reproductive system, so useful with most flatworms, proved of limited value in describing new species and both Hyman (1959) and Prudhoe (1985, 1989) argued that colour patterns provided sufficient information to recognise species. Faubel (1984) placed more reliance on the reproductive anatomy and in an attempt to bring greater order to the genus *Pseudoceros*, he erected four new genera and made many species incerta sedis. Newman & Cannon (1994a) for the first time employed life observations and colour photography to the taxonomic study of these flatworms. Aided by a new fixation technique (Newman & Cannon, 1995b) they were able to re-examine Faubel's classification, as well as, the more traditional one of Prudhoe (1985). In accepting Faubel's genus *Pseudobiceros* they recognised that

anatomical features were important at the generic level. Their observation on hypodermic copulatory behaviour provided a rational explanation for the lack of physical isolating mechanisms within genera of Pseudocerotidae.

People are able to recognise differences in colour patterns of these flatworms, however, due to the lack of image forming eyes, worms clearly use behavioural, physical or chemical means to recognise each other. By careful observation of living animals subtle differences in the pseudotentacle shape (presumably of great significance for chemosensory stimuli) have been detected and found useful in combination with other morphological characters to determine groups of species. It is our contention that it is of greater heuristic value to recognise these groups as genera than to subsume the differences within species level taxa. That subtle morphological differences do have relevance has been confirmed by molecular studies (Goggin & Newman, 1996).

Careful observations on living animals has revealed new characteristics previously overlooked in preserved specimens which in turn has lead to documentation of new taxa. In the present state of knowledge of polyclads, we expect this process to continue. Other techniques (i.e. molecular biology) may eventually provide the best means to recognising species and their relationships. However, we believe that confirmation of live observations with colour photography and videography currently provides a most useful means of engaging the taxonomy and biology of these exquisitely beautiful creatures.

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