



Five new species of cotylean flatworms (Platyhelminthes: Polycladida) from the wider Caribbean

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Abstract

Five new species of cotylean flatworms belonging to the genera *Pseudoceros* Lang, 1884, *Thysanozoon* Grube, 1840, *Pseudobiceros* Faubel, 1984 and *Maritigrella* Newman & Cannon, 2000, are described from the wider Caribbean. Specific determinations are based primarily on color and color pattern. Diagrammatic reconstructions of the reproductive systems derived from serial histological sections and whole mounts are presented. In addition, a re-description of *Pseudoceros pardalis* Verrill, 1900 resulted in the new combination, *Pseudobiceros pardalis*.

Key words: Cotylea, *Pseudoceros*, *Pseudobiceros*, *Thysanozoon*, *Maritigrella*, Caribbean, color pattern, systematics

Resumen

Cinco nuevas especies de gusanos planos marinos de vida libre pertenecientes a los géneros *Pseudoceros* Lang, 1884, *Thysanozoon* Grube, 1840, *Pseudobiceros* Faubel, 1984 y *Maritigrella*, Newman & Cannon, 2000, son descritos para el mar Caribe. La determinación de especies esta basada principalmente en el color y patrones de coloración y también se presenta para cada especie, los diagramas reconstructivos de la anatomía del sistema reproductivo derivados de las secciones histológicas y de los montajes completos. Adicionalmente, la re-descripción de la especie *Pseudoceros pardalis* Verrill, 1900 resulta en la nueva combinación, *Pseudobiceros pardalis*.

Palabras clave: Cotylea, *Pseudoceros*, *Pseudobiceros*, *Thysanozoon*, *Maritigrella*, Caribe, patrón de coloración, sistemática

Introduction

The polyclad family Pseudocerotidae includes some of the most conspicuously colored and extraordinarily diverse marine flatworms. They have been found throughout tropical and subtropical waters and are prominent members of coral reef communities. Currently, 13 genera are included in the family, with *Pseudoceros* and *Pseudobiceros* contributing the majority of species. In general, polyclad species are distinguished by characters of their reproductive systems (Faubel 1983, 1984). However, many pseudocerotids are known for their remarkably uniform reproductive anatomy and hence, species diagnoses are based primarily on coloration and color pattern (Hyman 1954, 1955a, b, 1959a, b; Prudhoe 1989; Newman & Cannon 1994, 1996, 1997, 1998).

Faubel (1984) recognized that some species of *Pseudoceros* had two complete sets of male reproductive systems. This led him to erect the new genus *Pseudobiceros* and to transfer all *Pseudoceros* species with a double male system into this new genus (Faubel 1984). Since then, *Pseudobiceros* has been further validated by characters of pharynx type, arrangement of cerebral eyes, body margin ruffling, and molecular data (Newman & Cannon 1994, Litvaitis & Newman 2001, Rawlinson & Litvaitis, in press).

The genus *Thysanozoon* also belongs to the family Pseudocerotidae, and occasionally, species determinations can be made using coloration and color pattern as well. Additionally, two external features such as a papillated dorsal surface and the presence of two male gonopores allow for an easy placement of animals into this genus. Although species of *Acanthozoon* also show papillae on their dorsal surface, they only have one male gonopore and thus, can be readily distinguished from members of *Thysanozoon*. *Thysanozoon* is a circum-globally distributed and poorly studied genus. Risso (1818) was the first to describe two species but erroneously placed them into the molluscan genus *Tergipes*. Grube (1840) recognized Risso's two species as synonyms and established the genus *Thysanozoon* in the Pseudocerotidae.

An equally diverse and colorful family, the Euryleptidae also is an inhabitant of coral reefs and can easily be confused with the pseudocerotids, especially with species of *Pseudoceros*. A major distinction, though, is the presence of a tubular rather than a ruffled pharynx. Many of the genera in this family are very similar to each other and only few external and internal characters are distinct. The most recently described genus within the family is *Maritigrella* (Newman & Cannon 2000). The diagnosis for the genus includes an elongated body, marginal tentacles that are long and held erect, two elongated clusters of cerebral eyes, a small, muscular and tubular pharynx, a short, pointed and sclerotized stylet, no uterine vesicles, and an especially distinct striped color pattern (Newman & Cannon 2000).

Here we describe five new cotylean species collected from different localities in the Caribbean; four belonging to the Pseudocerotidae and one to the Euryleptidae. Additionally, we are re-describing *Pseudoceros pardalis*, Verrill 1900 and propose the new combination *Pseudobiceros pardalis*.

Material and Methods

Field Collection

Specimens were hand collected using a fine paint brush either in the littoral zone from under rocks and from under coral rubble or subtidally from coral reefs in Panama, Curaçao, Jamaica, the Florida Keys, Honduras, and the US Virgin Islands. Specific locations, habitat information, and georeferences are given with each species. Animals were measured (measurements given as length mm x width mm) and photographed *in vivo* in the lab.

Histology

Specimens were fixed on frozen 10% buffered formalin following the protocol developed by Newman & Cannon (1995). After fixation, animals were preserved in 70% ethanol for histological preparation. The portion of the animal containing the reproductive structures was dissected. This segment was embedded in paraffin, sagittally sectioned at 5–7 μm , and stained with Gill's hematoxylin and eosin. Sections were mounted in Permount on glass slides. For whole mounts, animals were dehydrated, cleared in Histoclear, and mounted in Histomount. Diagrammatic reconstructions of the reproductive system were derived from the sectioned material and from whole mounts. Taxonomic identifications of *Pseudoceros*, *Pseudobiceros*, and *Maritigrella* were based on the descriptions of color and color patterns and for each species we include the color pattern grouping as defined by Newman & Cannon (1994, 2000). Further information from the classification system of

Faubel (1984), which is based on characteristics of the male reproductive system, was used for the determination of *Thysanozoon*. Most type material has been deposited at the US Natural History Museum (USNM) in Washington, DC, USA. Specimens collected on St. John, US Virgin Islands have been deposited in the VIIS collection at the Biosphere Reserve Center on St. John.

Generation of Molecular Tags

From each specimen, we excised a small piece of tissue for DNA analysis. If the tissue piece was large enough, only part of it was used for DNA extraction. The remaining tissue samples can serve as future vouchers. High molecular weight DNA was extracted using Genomic Tips (Qiagen Inc., Valencia, CA). The target nucleotide sequence was the D1–D2 expansion segment of the 28S rDNA gene. Primer sequences (LSU D1, D2 fw1 and LSU D1, D2 rev2) can be found in Sonnenberg et al (2007). DNA amplifications followed the protocol outlined in Litvaitis & Newman (2001). Amplicons were gel-purified and sent to a commercial lab for sequencing (Geneway Research LLC, Hayward, CA). Sequencing occurred in both directions. Trace files were edited using FinchTV (vers. 1. 4; Geospiza Inc) and sequences were deposited in GenBank. Accession numbers are provided with individual species descriptions.

Systematics

Superfamily: Pseudocerotoidea Faubel, 1984

Family: Pseudocerotidae Lang, 1884

***Pseudobiceros pardalis* (Verrill, 1900) n. comb.**

(Figs. 1, 2)

Material Examined

Three specimens collected subtidally, Panama, Bocas del Toro, Salt Creek (N⁹ 16.806'; W82° 06.137') in July 2004.

a) One specimen (UNH-PAN 028, 40mm x 25mm) sagittally sectioned (18 slides); USNM 1104638. Collected 18 June, 2005 under *Acropora palmata* coral rubble, from the reef crest, 1.5 m depth.

b) One specimen (UNH-PAN 029, 38mm x 22mm) as whole mount (1 slide); USNM 1104639; GenBank Accession EF514807. Collected 18 June, 2005 under *Acropora palmata* coral rubble, from the reef crest, 2 m depth.

c) One specimen (UNH-PAN 056, 25mm x 14mm) as whole mount (1 slide); USNM 1104685; GenBank Accession EF514808. Collected 28 June, 2005 under *Acropora palmata* coral rubble, from the reef crest, 1.5 m depth.

Synonyms

Pseudoceros pardalis Verrill, 1900 (p. 596; plate LXX, Fig. 6a), see taxonomic remarks below.

Distribution

This species has been reported for Bermuda (Verrill 1900), the Bahamas, and southern Florida (Humann & DeLoach 1992); it was common in Bocas del Toro, Panama.

Diagnosis

Purple-brownish background blending into black towards the margin. Dorsal surface with large orange and smaller yellow dots outlined by a black shadow. Numerous, small white spots along the margin around the entire body. Light purple-violet ventral surface, more translucent towards the margin.

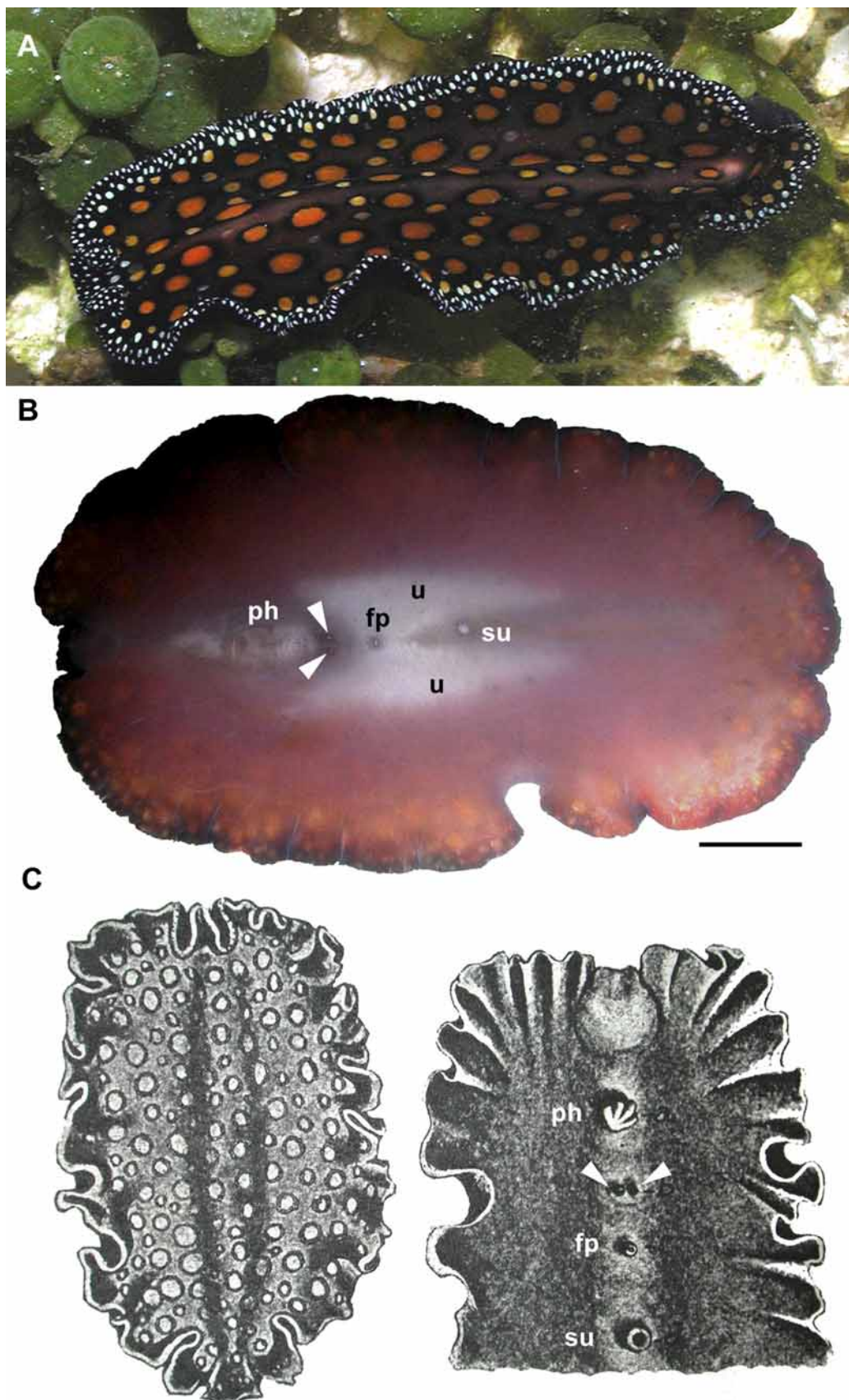


FIGURE 1. *Pseudobiceros pardalis* n. comb. A. Dorsal view of live animal in its natural habitat. Scale bar 5 mm. B. Ventral view of live animal showing pharynx, two male gonopores, female gonopore, uteri and sucker. Scale bar 5 mm. C. Original diagram of Verrill, 1900 of dorsal (left) and ventral view (right); ventral view clearly shows two male gonopores and pharynx, female gonopore and sucker. fp, female gonopore; ph, pharynx; su, sucker; u, uteri; arrowheads, male gonopores.

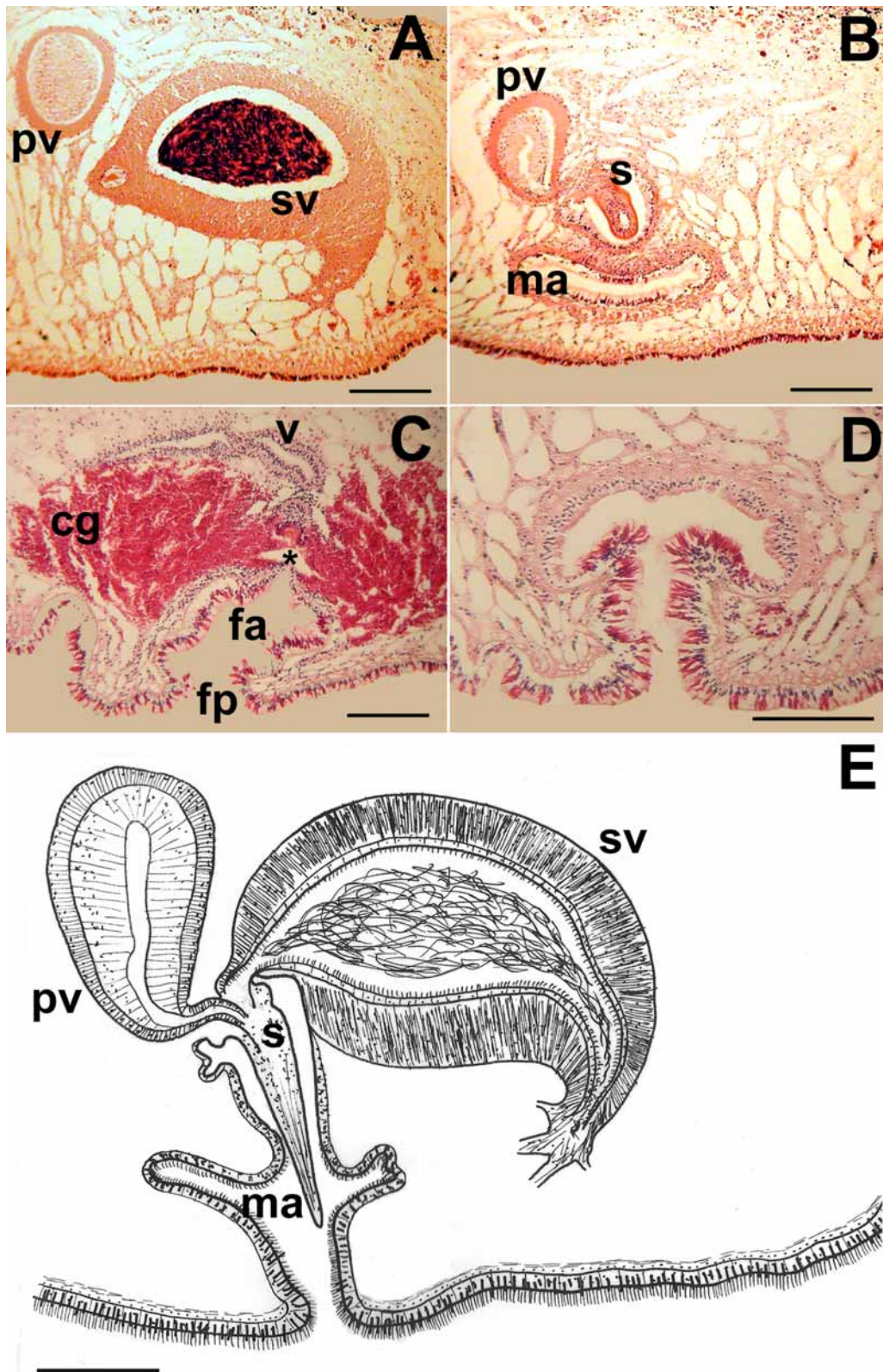


FIGURE 2. *Pseudobiceros pardalis* n. comb. A. Sagittal section of one male copulatory system, showing seminal and prostatic vesicles. B. Sagittal section of one male copulatory system, showing prostatic vesicle, stylet, and male atrium. C. Sagittal section of female copulatory system, showing female pore, atrium, cement glands, cement pouch and vagina. D. Sagittal section through the sucker. E. Diagrammatic representation of one male copulatory apparatus. All scale bars 250 μ m. cg, cement glands; fa, female atrium; fp, female pore; ma, male atrium; s, stylet; pv, prostatic vesicle; sv, seminal vesicle; v, vagina; asterisk, cement pouch.

Re-description

External Features: Coloration as described above for diagnosis (Fig. 1A). In preserved specimens, the coloration is “brownish-black, covered with numerous round, pale yellow spots” (Verrill 1900). According to the color pattern groups established for *Pseudobiceros* (Newman & Cannon 1994), the species belongs to Group 4 (spots, dots and mottling). The body is large, oval shaped, and fleshy. Prominent pseudotentacles are formed by simple folds of the anterior margin (Fig. 1A). The cerebral eyespot is oval with about 90–100 eyes. A slightly ruffled pharynx is located in the anterior one-third of the body and the mouth is a large opening located at the anterior end of the pharynx. The sucker is conspicuous and centrally located (Fig. 2D).

Body Wall: The epidermis is of uniform thickness dorsally and ventrally. It consists of a simple, ciliated epithelium that surrounds the entire body. Epithelial cells are closely aggregated, making it difficult to differentiate the nuclei. Rhabdite glands are more abundant on the dorsal side. However, they are very numerous around the sucker and gonopores on the ventral side. Loose connective tissue is irregularly distributed dorsally but forms a fine network with considerable extracellular spaces ventrally, supporting the seminal and prostatic vesicles and the sucker. The basement membrane is extremely thin. The body wall musculature is weakly developed with thin muscle fibers. Color is imparted endogenously (i. e., not due to ingested food) by dark pigment granules located in dense, oval clusters beneath the dorsal epidermis. Additional small spherical pigment granules are found scattered in the epidermis, muscle layers, and connective tissue.

Reproductive Anatomy: Externally, two male gonopores are evident, one on either side of the posterior end of the pharynx (Fig. 1B). The female gonopore is located on the midventral line between the male gonopores and the sucker. In mature animals, the uteri are triangular white masses on either side of the female gonopore; in preserved specimens they are tan colored (Fig. 1B). Ovaries are located dorsally and testes are found ventrally. Two large, oblong, and highly muscularized seminal vesicles (925µm x 600µm) are present (Figs. 2A, 2E), as are two large and elongated prostatic vesicles (550µm x 350µm) (Figs. 2A, 2B, 2E). Seminal and prostatic vesicles are oriented perpendicularly to each other. The prostatic and seminal vesicles are enwrapped by thick layers of circular muscles. The interiors of the prostatic vesicles are lined with columnar, glandular epithelia whose nuclei are located basally in the cells. The seminal vesicles are lined by thin ciliated epithelia. Two wide male atria house conical stylets (350µm x 100µm) (Figs. 2B, 2E). The superficial female gonopore leads into a wide female atrium, which continues interiorly into a short and very narrow vagina. Cement pouches are well defined and surrounded by cement glands typical of pseudocerotids (Fig. 2C).

Taxonomic Remarks

Pseudoceros pardalis was first described by Verrill (1900) from a single, large (60 mm x 40 mm), alcohol-preserved specimen collected in Bermuda by Dr. C. H. Merriam. The description was based on external features of body shape, size and a brownish-black dorsal color pattern covered with numerous, round, pale-yellow spots (Fig. 1G). No information regarding the reproductive system was included in the original description (Verrill 1900). A second specimen, also collected in Bermuda by Dr. O. Giere in 1982, has been identified as *P. pardalis* Verrill, 1900 by Faubel (1984) and is described by having a single male copulatory apparatus.

Although our own specimens exhibit the colorations and color patterns of *Pseudoceros pardalis* Verrill, 1900, all are characterized by double male copulatory complexes. Each complex opens into an independent male gonopore, each has a seminal and a prostatic vesicle and each is armed with a penis papilla. Faubel (1984) erected the genus *Pseudobiceros* to distinguish species of *Pseudoceros* with double male copulatory systems, which allows us to establish *Pseudobiceros pardalis* n. comb. Furthermore, a closer examination of Verrill's drawing of his specimen shows the presence of two distinct male gonopores (Verrill, 1900; plate LXX, Fig. 6a) (Fig. 1G). Thus, we synonymize the single specimen of *Pseudoceros pardalis* Verrill, 1900 with *Pseudobiceros pardalis* n. comb.

It is noteworthy that the specimen of *Pseudoceros pardalis* re-described by Faubel (1984) is not the same species as the one described by Verrill (1900) despite similarities in coloration. With only one male copulatory complex, Faubel's (1984) specimen clearly belongs to *Pseudoceros*, not *Pseudobiceros*. We therefore accept *Pseudoceros pardalis* Verrill, 1900 *sensu* Faubel, 1984 as a separate, distinct species, different from *Pseudobiceros pardalis* n. comb.

***Pseudobiceros caribbensis* n. sp.**

(Figs. 3, 4)

Type Material

a) Holotype, one mature specimen (UNH-CUR 065, 17mm X 10mm) as serial sagittal sections (9 slides); USNM 1104640. Collected 21 June, 2005, subtidally under coral rubble in Curaçao, Carmabi Beach, Piscad-
era Baai (N12° 07.367'; W68° 68.165').

b) Paratype, one mature specimen (UNH-JAM 089, 12mm X 8mm) as serial sagittal sections (6 slides), the remaining part of the body as a whole mount (1 slide); USNM 1104686. Collected 2 June, 2006, subtidally from 6 m depth in Jamaica, St. Ann's Bay, Bull Reef (N18° 44.070'; W77° 17.355'). GenBank Accession EF514806.

Other Material Examined

c) One mature specimen (UNH-USFL 041, 20mm X 11mm) as serial sagittal sections (12 slides) USNM 1104688. Collected 2 June, 2005, subtidally from 4.5 m depth in Florida, 11-foot Mount (N24° 43.371'; W80° 51.700'). GenBank Accession EF514804.

d) One juvenile specimen (UNH-USFL 044, 16mm X 8mm) as whole mount (1 slide) USNM 1104687. Collected 2 June, 2005, subtidally from 4.5 m depth, in Florida, 11-foot Mount (N24° 43.371'; W80° 51.700'). GenBank Accession EF514805.

e) One mature specimen (UNH-CUR 069, 13mm X 7mm) as a whole mount (1 slide) USNM 1104641. Collected 23 June, 2005, subtidally in Curaçao, Playa Kalki (N12° 22.529'; W69° 09.470').

f) One immature specimen (UNH-HON 014, 4mm X 2mm) for molecular analysis only; collected 27 August, 2006, subtidally under coral rubble of a patch reef at 5 m depth in Honduras, Cayos Cochinos, Cayo Timon (N15° 56.134'; W86° 31.234').

Etymology

The name indicates the widespread distribution of this species in the Caribbean.

Synonyms

It is likely that it corresponds to *Pseudobiceros* sp. 11 Newman & Cannon (2003, p. 84), but see taxonomic remarks below.

Distribution

Known from the type locality in Curaçao. Also found in Jamaica, Florida, and Honduras. *Pseudobiceros* sp. 11 has been reported from the French Mediterranean (Newman & Cannon 2003).

Diagnosis

Background transparent brown, darker medially; raised line over the main intestine with irregular patches lacking brown pigment. Instead, numerous and densely concentrated white dots are substituting the pigment. In some cases, a fine medial dorsal white line is present. Dorsal surface covered with dark brown and white

dots irregularly scattered. Larger white spots unevenly distributed around the margin. Intestinal branches visible through the skin as yellow net-like ramifications. Tentacle tips white with a dark brown submarginal band.

Description

External Features: Coloration as described above in diagnosis (Fig. 3A). According to the color pattern groups established for *Pseudobiceros* (Newman & Cannon 1994), the species belongs to Group 4 (spots, dots and mottling). Prominently raised medial ridge of dark brown coloration. Ventral surface brownish milky-white with bright white scattered dots (Fig. 3B). Pointed, ear-like pseudotentacles with 87–100 eyes on each one (Figs. 3A, 3C). Cerebral eyespot horseshoe shaped with 32–34 eyes. Two additional eyes are present anterior to the brain immersed more deeply into the parenchyma than the eyes of the cerebral cluster (Fig. 3C inset). Small ruffled pharynx located anteriorly with 8–10 pharyngeal folds.

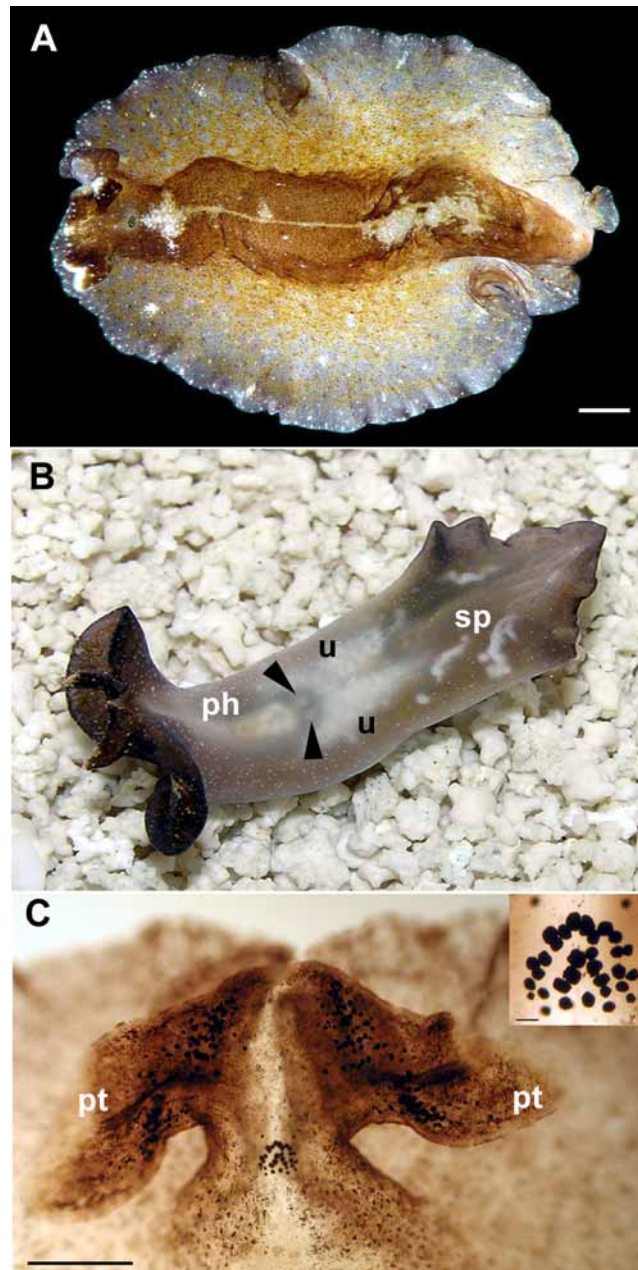


FIGURE 3. *Pseudobiceros caribbensis* n. sp. A. Dorsal view of live animal, showing coloration. Scale bar 1mm. B. Ventral view of live animal, showing pharynx, male gonopores, uteri, and patches of sperm from hypodermic insemination. Scale bar 5 mm. C. Cleared whole mount of the anterior end showing pseudotentacles and pseudotentacular eyes. Scale bar 0.5 mm. Inset: Higher magnification of cerebral eye cluster. Scale bar 300 μ m. ph, pharynx; pt, pseudotentacles; sp, sperm; u, uteri; arrowheads, male gonopores.

Body Wall: A simple, densely ciliated epithelium surrounds the entire body. Dorsally, the epithelial cells are somewhat taller than ventrally. Numerous glands containing slender rhabdites are found dorsally. A thin but conspicuous basement membrane is located below the epithelium. Coloration is primarily due to the contents in the intestinal branches, although small brown pigment granules are found in the dorsal epidermis and in the parenchyma. The parenchyma is coarsely granular. Individual muscle layers could not be differentiated.

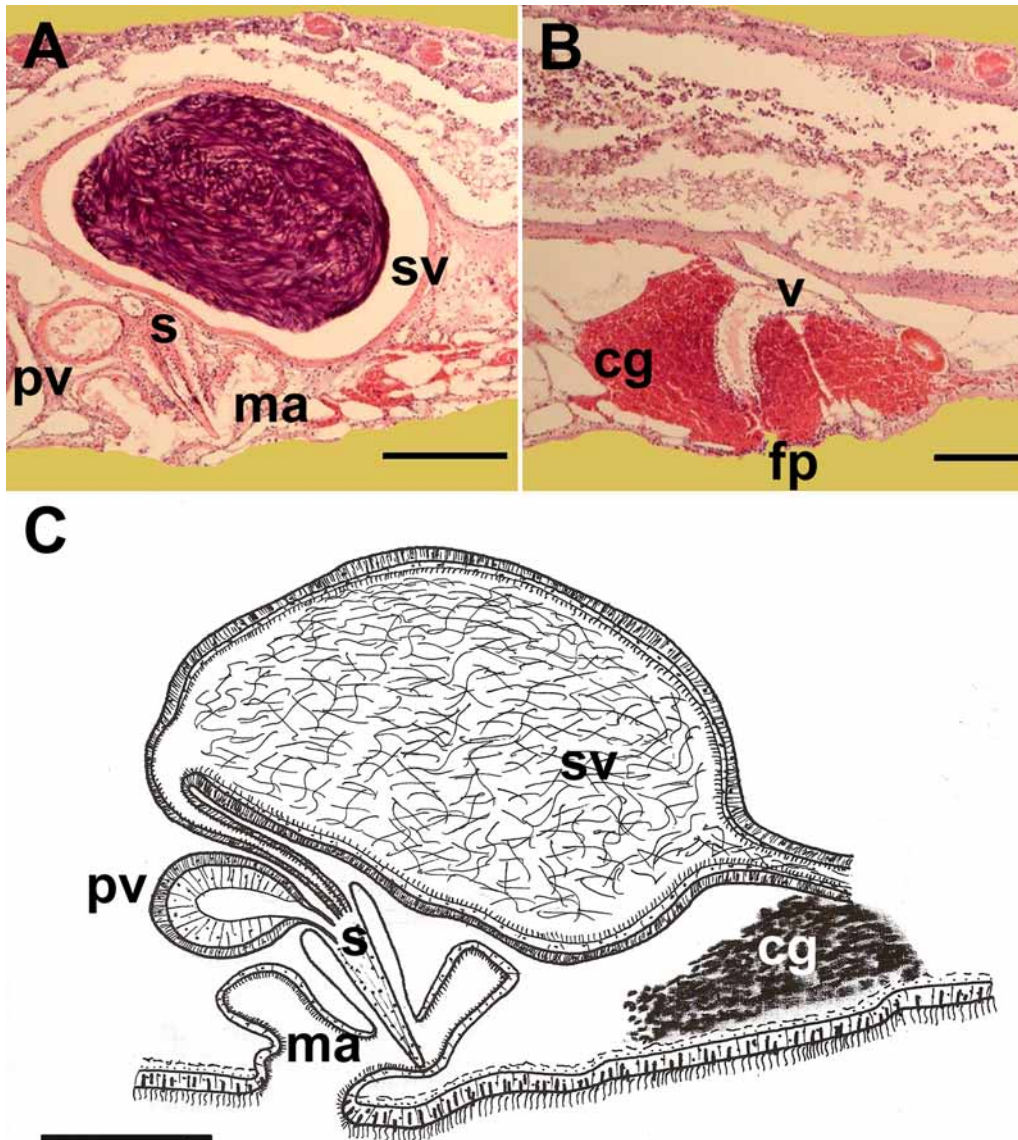


FIGURE 4. *Pseudobiceros caribbensis* n. sp. A. Sagittal histological sections of one male copulatory system showing seminal and prostatic vesicles, stylet, and male atrium. B. Sagittal histological section of the female copulatory system showing cement glands, vagina, and female pore. C. Diagrammatic representation of one male reproductive system. All scale bars 250 μm . cg, cement glands; fp, female pore; ma, male atrium; s, stylet; pv, prostatic vesicle; sv, seminal vesicle; v, vagina.

Reproductive Anatomy: Externally, two separate male gonopores are evident one on either side of the posterior end of the pharynx (Fig. 3B). The midventrally located female gonopore is well separated from the male gonopores. In mature animals, the uteri appear as triangular white masses on either side of the female gonopore (Fig. 3B). Ovaries are located dorsally, testes are found ventrally. The following measurements are representative of one male copulatory system only. Measurements of the second male system are comparable. The male reproductive system consists of a large, rounded seminal vesicle ($800\mu\text{m} \times 600\mu\text{m}$) with a thin wall

composed of circular muscles and lined by a thin ciliated epithelium. Each seminal vesicle connects to an expanded vas deferens (Figs. 4A, 4C). The expansion of the vas deferens only occurs in mature animals. The prostatic vesicle is small and narrow (300µm X 200µm) (Figs. 4A, 4C) surrounded by a thin muscular wall composed of circular fibers and lined by columnar, glandular cells that fill almost the entire lumen. There is no evidence of exterior glandular cells emptying into the prostatic vesicle. The shallow male atrium houses a long conical stylet (275µm). The female atrium is small and narrow (Fig. 4B) and connects to a short and slender vagina, which is directed posteriorly. Cement glands completely surround the vagina and the small, inconspicuous cement pouches (Fig. 4B).

Taxonomic Remarks

This species was well represented in several localities in the Caribbean, and it is hard to imagine that it has not been reported previously. It is possible that due to the delicate nature of pseudocerotids and their ability to autolyse, specimens of this species had been impossible to collect and preserve in the past. Furthermore, in some specimens of *Pseudobiceros caribbensis*, the dorsal surface appears evenly dark brown in coloration, obscuring the yellow net-like ramifications of the intestinal branches and the scattered brown and white spots. As outlined above, these characteristics are important in the determination of this new species.

The general coloration and body shape of *Pseudobiceros caribbensis* are very similar those of *Pseudoceros maximus*, a species described by Lang (1884). Lang (1884) described three mature specimens of *P. maximus*, and although they differed in their male reproductive anatomy, he considered them to be the same species. With only one male reproductive complex, the first specimen clearly belongs to the genus *Pseudoceros*. Faubel (1984) designated this as *P. maximus* (type A) and it corresponds to specimens found by Novell (2001, unpublished thesis) in the western Mediterranean. Lang's second specimen contains two complete male reproductive complexes arranged perpendicular to the long axis of the animal and opening into a single large male atrium. Faubel (1984) designated this as type B and erected the monotypic *Monobiceros langi* for it. Finally, the third specimen also is characterized by double male reproductive systems opening into a single male pore, but their arrangement is in an anterior-posterior orientation. Our specimens differ from either *Monobiceros langi* or *Pseudoceros maximus* because their double male reproductive structures open into two separate male gonopores, thus validating their placement into the genus *Pseudobiceros*.

Newman & Cannon (2003) record an unidentified species of *Pseudobiceros* (sp. 11, p. 84) from the French Mediterranean, which bears a striking resemblance to *P. maximus* (type A). However, because the authors list the specimen as *Pseudobiceros*, we have to assume that it is characterized by double male reproductive systems opening into two separate male gonopores. Hence, it may be a possible synonym of *P. caribbensis*. Final determination of this synonymy and a resolution of Lang's (1884) *P. maximus* specimens as separate species most likely will require data from nucleotide sequences.

***Pseudoceros rawlinsonae* n. sp. (Figs. 5, 6)**

Type Material

a) Holotype, one mature specimen (UNH-USVI 029, 17mm X 7mm) as serial sections (3 slides), the remaining part of the body as a whole mount (1 slide), VIIS 41977. Collected 26 May, 2006, from coral rubble at 6 m, in the US Virgin Islands, Great Lameshur Bay, St. John (N18° 18.870'; W64° 43.361'). GenBank Accession EF514803.

Etymology

Named in honor of Dr. Kate A. Rawlinson.

Distribution

To date, found in the US Virgin Islands, Great Lameshur Bay, St. John (N18° 18.870'; W64° 43.361') and Bonaire, Netherlands Antilles (Ellen Muller, image #512, *Pseudoceros* sp. posted at <http://www.rzuser.uni-heidelberg.de/~bu6/flat0512.html> and at <http://www.pbase.com/imageine/image/36592827>). To assure stable access to both web images, their URL's have been archived at <http://www.webcitation.org/5NsXWpejC> and at <http://www.webcitation.org/5NsXwnb60>, respectively via WebCite.

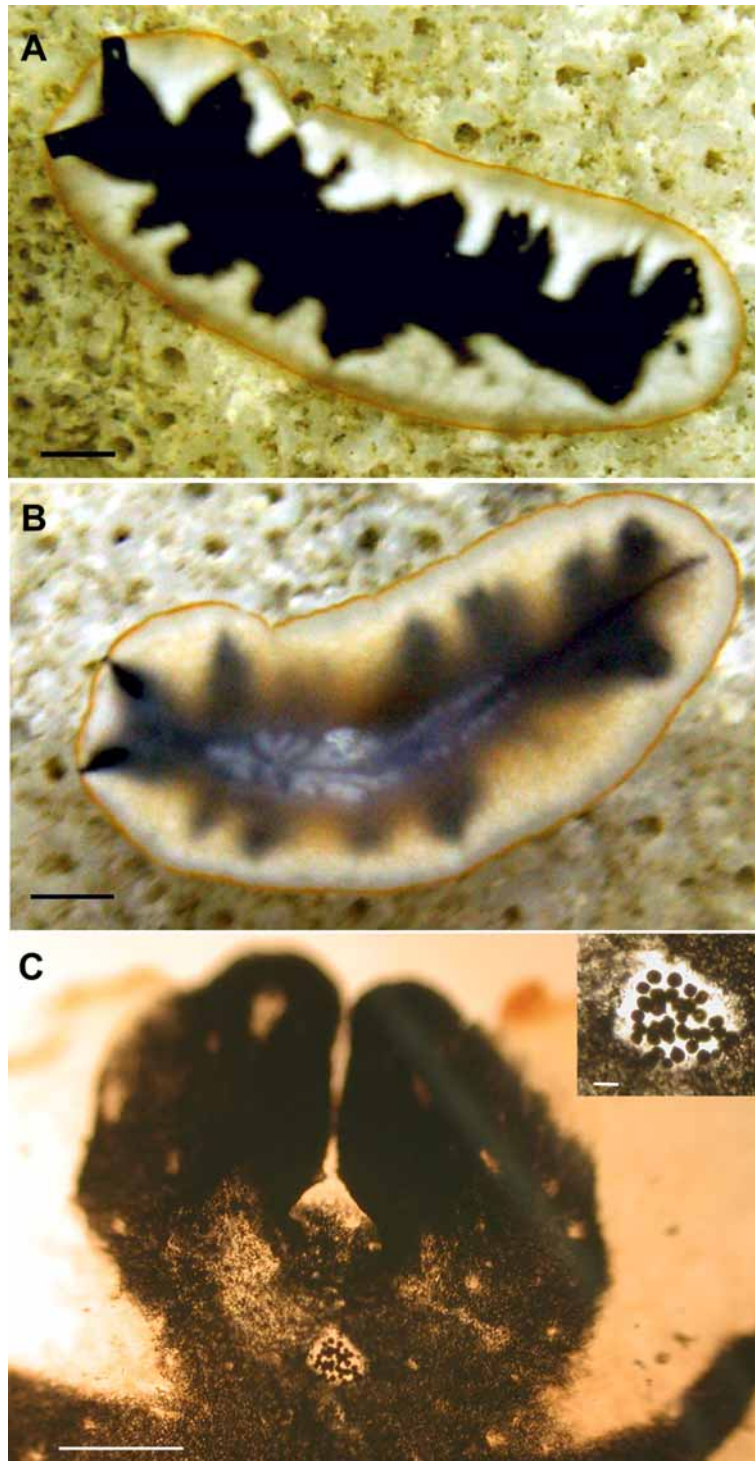


FIGURE 5. *Pseudoceros rawlinsonae* n. sp. A. Dorsal view of live animal in its natural habitat showing coloration and color pattern. Scale bar 2 mm. B. Ventral view of live animal, showing pharynx and uteri. Scale bar 2 mm. C. Cleared whole mount of the anterior end, showing pseudotentacles and cerebral eye cluster. Scale bar 0.5 mm. Inset: Higher magnification to show detail of cerebral eye cluster. Scale bar 500 μ m.

Diagnosis

Body white, with a black, broad, branched stripe middorsally. Margin becomes translucent towards the periphery; thin, bright orange line surrounds the entire body. Tentacles entirely black; no evidence of white body color or orange line on the tentacles. Fusiform, elongated seminal vesicle drained by an ejaculatory duct; ejaculatory duct loops dorsal over prostatic vesicle and enters penis papilla anterior to the prostatic vesicle.

Description

External Features: Coloration as described above for diagnosis (Fig. 5A). Following the color pattern groupings of *Pseudoceros* (Newman & Cannon 1998), this new species belongs into Group 6 (transverse streaks and stripes). Pseudotentacles are formed by simple folds of the anterior margin and are dotted with a few scattered eyes (Figs. 5A, 5C). The cerebral eyespot is rounded and contains about 36 eyes (Figs. 5C inset). The pharynx is typical of the genus. The ventral surface is translucent (Fig. 5B). In preserved animals, the distance between the male and female gonopores is 500 μm , and between the latter and the sucker it is approximately 600 μm .

Body Wall: The dorsal epidermis consists of tall, columnar cells interspersed with clusters of elongate rhabdite glands. Rhabdite glands are less numerous ventrally. The basement membrane is distinct and the typical three layers of muscles (circular, diagonal, longitudinal) can be distinguished. Dark granular pigmentation is located beneath the dorsal epidermis and among the muscle layers.

Reproductive Anatomy: The ovaries are arranged dorsally, the testes ventrally. Numerous, large and conspicuous nuclei are scattered throughout the body, and are especially concentrated in the muscle layers and the glandular areas of the reproductive systems (e. g., male atria, prostatic and ejaculatory ducts, narrowing part of prostatic vesicle). The seminal vesicle (250 μm X 550 μm) is pear-shaped, narrowing as it joins the ejaculatory duct (Figs. 6A–C). It extends antero-dorsally beyond the prostatic vesicle. The seminal vesicle is surrounded by a thick layer of circular muscles and is lined by a ciliated epithelium. The ejaculatory duct loops to enter the penis papilla anteriorly to the prostatic vesicle (Figs. 6A, 6C). The prostatic vesicle is small and rounded (175 μm) and surrounded by a thin layer of circular muscles. Its interior is lined by columnar, glandular cells, whose nuclei are located basally in the cells (Fig. 6A). The deep male atrium houses a long, conical and blunt stylet (250 μm) (Figs. 6A, 6C). The female complex has a short and slender vagina that is surrounded by cement glands. Cement pouches are not well defined, and instead of eosinophilic cells, basophilic cells compose the cement glands, which stain not as strongly as is usual for pseudocerotids (Figs. 6A–C). The female atrium is lined by a ciliated epithelium, whereas the vagina is lined by a modified glandular epithelium.

Taxonomic Remarks

With perhaps as many as 75% of all pseudocerotid species, *Pseudoceros* represents the largest genus in the family Pseudocerotidae. Species determinations in *Pseudoceros* usually are based on coloration and color patterns (Hyman 1954, 1955a, b, 1959a, b; Prudhoe 1989; Newman & Cannon 1994, 1996, 1997, 1998) because of a lack of distinguishing characters in their reproductive anatomies. The newly described species *Pseudoceros rawlinsonae* exhibits a unique, and as of yet, undescribed color pattern (Fig. 6A). Other species exhibiting similar color patterns with a median, branched stripe include *Pseudoceros imperatus* and *P. zebra*. However, the body of *P. imperatus* is very dark brown to almost black, the middorsal stripe is yellow-green with only a few wide branches, and the marginal band is very broad, orange, and extends across the tentacles (Newman & Cannon 1998). In *P. zebra*, the body is black, the stripe is white with wide branches and the marginal band is yellow, very wide and extends across the tips of the tentacles.

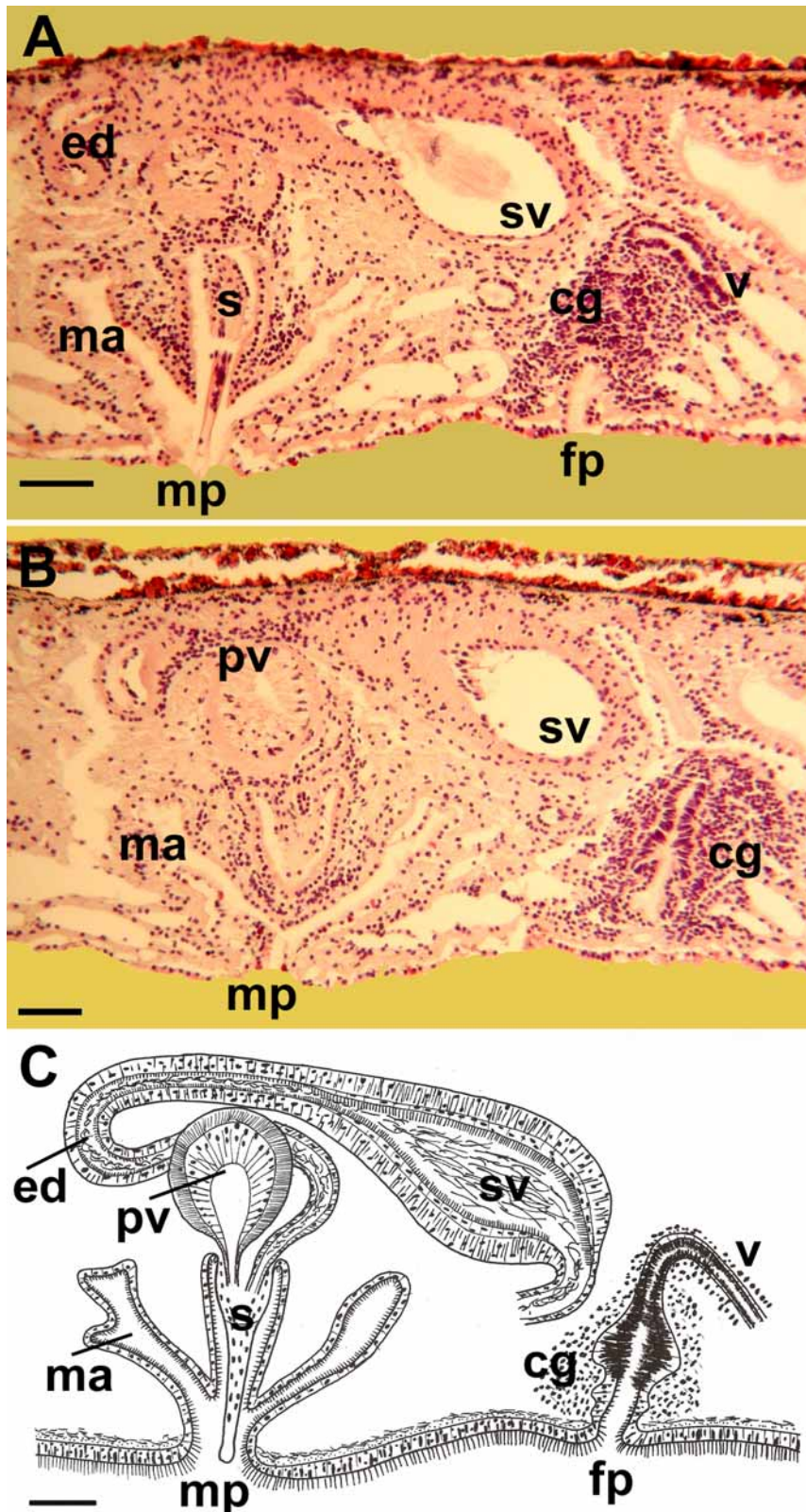


FIGURE 6. *Pseudoceros rawlinsonae* n. sp. A. Sagittal histological section of the male and female copulatory systems, showing loop of ejaculatory duct, seminal vesicle, long conical, blunt, cuticular stilet, male atrium, male and female pores, vagina, and cement glands. B. Sagittal histological section of the male and female copulatory systems, showing small, rounded prostatic vesicle, male atrium, male pore, and vagina surrounded by basophilic cement glands. C. Schematic sagittal representation of the male and female reproductive systems. All scale bars 100 μ m. cg, cement glands; ed, ejaculatory duct; fp, female pore; ma, male atrium; mp, male pore; s, stilet; pv, prostatic vesicle; sv, seminal vesicle; v, vagina.

***Pseudoceros harrisi* n. sp.**

(Fig. 7)

Type Material

a) Holotype, one mature specimen (UNH-PAN 036, 11mm X 7mm) as serial sections (4 slides) USNM 1104642. Collected 19 June, 2005, from coral rubble at 4.5 m depth by Dr. Larry Harris in Panama, Bocas del Toro, Isla de los Pájaros (N^o 27.156'; W28° 19.975'). GenBank Accession EF514802.

Etymology

Named after the collector, Dr. Larry Harris.

Distribution

To date, known only from the type locality.

Diagnosis

Transparent cream-pinkish background. Middle area of dorsal surface with a strong red coloration but absent towards the margin. Big white spots over the red pigment. Smaller and numerous white dots forming a conspicuous margin. Bright white tentacles. According to the coloration pattern groupings of Newman & Cannon (1998), this species fits into Group 5.

Description

External Features: Coloration as described above for diagnosis (Fig. 7A). The bright white pseudotentacles are formed by simple folds of the anterior margin. The cerebral eyespots are small (Fig. 7A). The pharynx is typical for the genus. Because only one specimen was found, the entire animal was sectioned. The distances given below were taken from the histological slides.

Body Wall: The entire animal is surrounded by a ciliated, columnar epithelium with interspersed rhabdite glands. No pigment granules are evident.

Reproductive Anatomy: The ovaries are located dorsally in the animal, the testes are ventral. The seminal vesicle (350µm X 225µm) is oval, with a strongly muscularized wall and a ciliated epithelium lining the lumen. A smaller, rounded prostatic vesicle (150µm X 112µm) is located ventral to the seminal vesicle and is surrounded by a thin layer of circular muscles and lined by tall, columnar glandular cells. A deep male atrium houses a long stylet (125µm) that is directed forwards (Figs. 7B–C). The female reproductive system has a long and slender vagina and well-defined cement pouches. Cement glands surround the proximal part of the vagina (Figs. 7B–C). The vagina is lined by a ciliated epithelium. The distance between gonopores is 500µm and from the female gonopore to the sucker 900µm.

Taxonomic Remarks

Unfortunately only one damaged specimen was found and therefore, comparisons of color variation within the species were not possible. This species does not resemble any other species of *Pseudoceros*. However, superficially *P. harrisi* may be confused with members of *Cycloporus* because of its body shape, the mottled coloration and the marginal dots around the body. But with a more carefully examination, *P. harrisi* can be distinguished easily from *Cycloporus* because these marginal dots are due to pigmentation only and not to the peripheral vesicles that open to the exterior as found in *Cycloporus*. Additionally, the pharynx is ruffled, only one cluster of cerebral eyes is present, and the pseudotentacles are well defined.

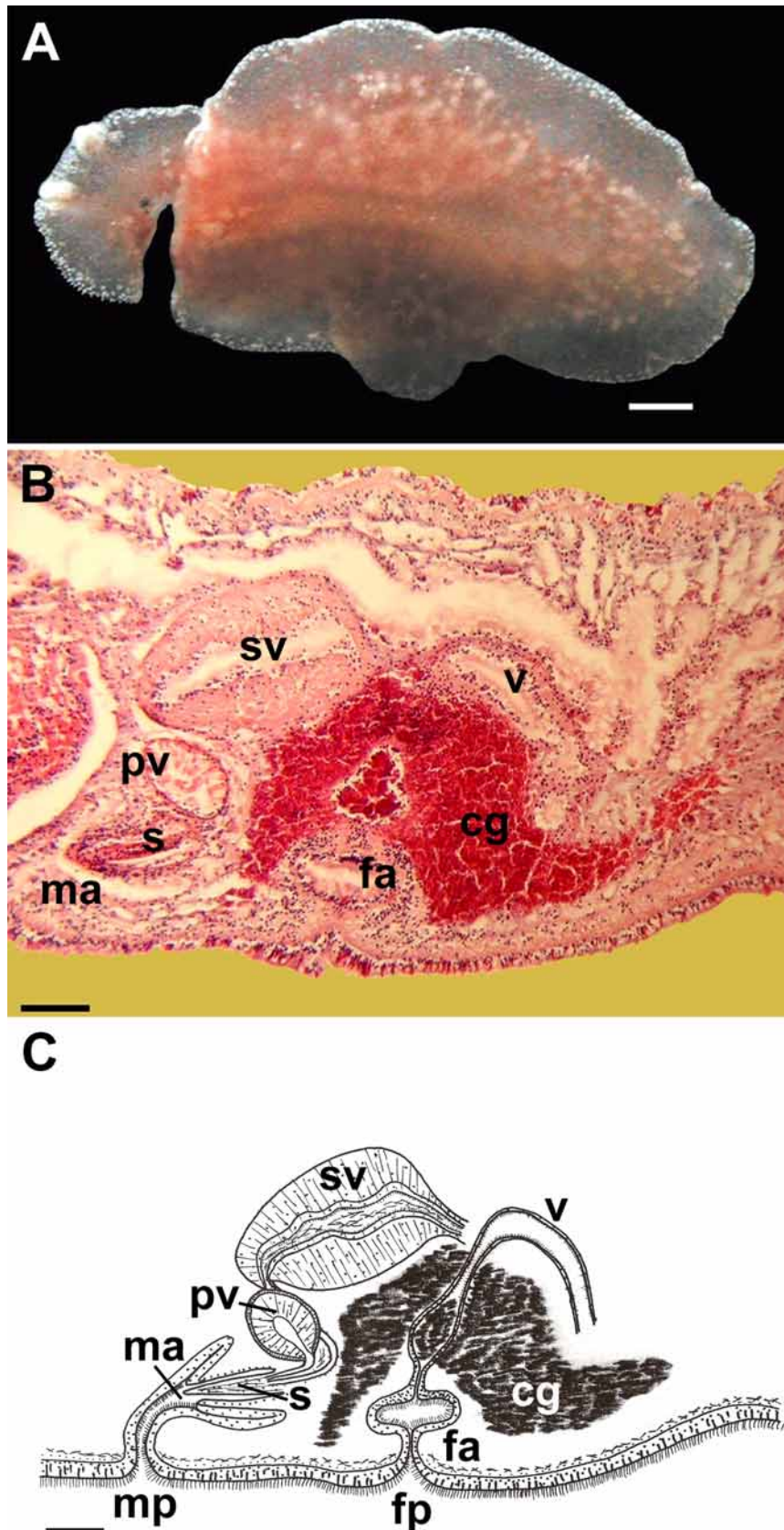


FIGURE 7. *Pseudoceros harrisi* n. sp. A. Dorsal view of live animal, showing tentacles and cerebral eye cluster (anterior end broken). B. Sagittal histological section of male and female copulatory systems, showing seminal and prostatic vesicles, stylet, male and female atria, cement glands, and vagina. C. Diagrammatic representation of male and female reproductive systems. All scale bars 100 μ m. cg, cement glands; fa, female atrium; fp, female pore; ma, male atrium; mp, male pore; s, stylet; pv, prostatic vesicle; sv, seminal vesicle; v, vagina.

***Thysanozoon raphaeli* n. sp.**
(Fig. 8)

Type Material

a) Holotype, one mature specimen (UNH-BLZ 057, 15mm X 10mm) as serial sagittal sections (8 slides), remaining part of the body as a whole mount (1 slide) USNM 1104643. Collected among mangroves in Belize, Twin Caye (N16° 49.46', W88° 06.068') in June 2006 by Raphael Ritson-Williams. GenBank Accession EF514810.

b) Paratype, one juvenile specimen (UNH-PAN 001, 8mm X 4mm) as whole mount; collected 12 June, 2005, among mangroves (0.5 m depth) in Panama, Bocas del Toro, Sunset Point (N9° 17.829'; W82° 15.848'). USNM 1104689.

c) Paratype, one juvenile specimen (UNH-PAN 049, 3.5mm X 3.0mm) as whole mount (1 slide) USNM 1104644. Collected 20 June, 2005, from the water column at 1.2 m depth in Panama, Bocas del Toro, Punta Coco (N9° 17.829'; W82° 15.848'). GenBank Accession EF514809.

Other Material Examined

d) One juvenile specimen (UNH-PAN 050, 6mm X 3mm) as whole mount; collected subtidally from 4.5 m depth on 21 June, 2005, in Panama, Bocas del Toro, Crawl Cay (N9° 14.563'; W82° 08.302').

Etymology

Named for Raphael Ritson-Williams who provided us with the type specimen.

Synonyms

It is possible that this species corresponds to *Thysanozoon* or *Acanthozoon* sp. 4 Newman & Cannon 2003 (p. 86) because of similarities in body shape, papillae, and coloration.

Distribution

This species was found in Belize, Panama and Colombia.

Diagnosis

Translucent brown-blackish background with numerous large bulbous yellow papillae over the entire dorsal surface. Small white slash-like marks, hardly visible, around the entire margin, sometimes giving the impression of an extremely thin white border. Darker pigment medially and darker black tentacles outlined by the white marks. Translucent white ventrally.

Description

External Features: Coloration as described above for the diagnosis (Figs. 8A–C). Short, bulbous papillae are dispersed over the dorsal surface; with long and pointed pseudotentacles (Figs. 8A–B). One oval cerebral eyespot is present (Fig. 8C inset), although because of the dark background pigment, the number of eyes in the cluster and on the pseudotentacles could not be determined.

Body Wall: A ciliated, columnar epithelium surrounds the entire specimen. In addition to rhabdite glands, a second type of glands is very common. The secretions within this second type are strongly acidophilic. These types of glands are conspicuous in the ventral epidermis and in the epithelium covering the papillae (Fig. 8E).

Reproductive Anatomy: All information is from only one specimen because the other collected specimens were immature juveniles. The seminal vesicle is large, oval in shape (450µm X 225µm) and close to the body wall (Figs. 8D–E). The small, oval prostatic vesicle (100µm X 75µm) is located ventrally (Fig. 8D). The male atrium is not well defined in the sections but a stylet is discernible (Fig. 8E). It was not possible to visualize the internal female reproductive system. The distance between the female gonopore and the sucker is 1200µm.

Taxonomic Remarks

In some juvenile specimens of *Thysanozoon raphaeli*, the dorsal papillae are less numerous but still about the same size as in the adults. We noted the shape and distribution of the papillae in *T. raphaeli* are similar to those of *Thysanozoon* or *Acanthozoon* sp. 4 (Newman & Cannon 2003, p. 86), although the color of the papillae in that species is white instead of yellow. Additional similarities include body shape and background coloration. Thus, it is possible that their undescribed species is *T. raphaeli*. The genera *Thysanozoon* and *Acanthozoon* are distinguished by two vs. one male gonopores, respectively. However, because Newman & Cannon (2003) did not indicate the number of male gonopores for their specimen, we cannot be absolutely certain that it is the same species as *T. raphaeli*, and therefore, will leave it as a possible synonym only.

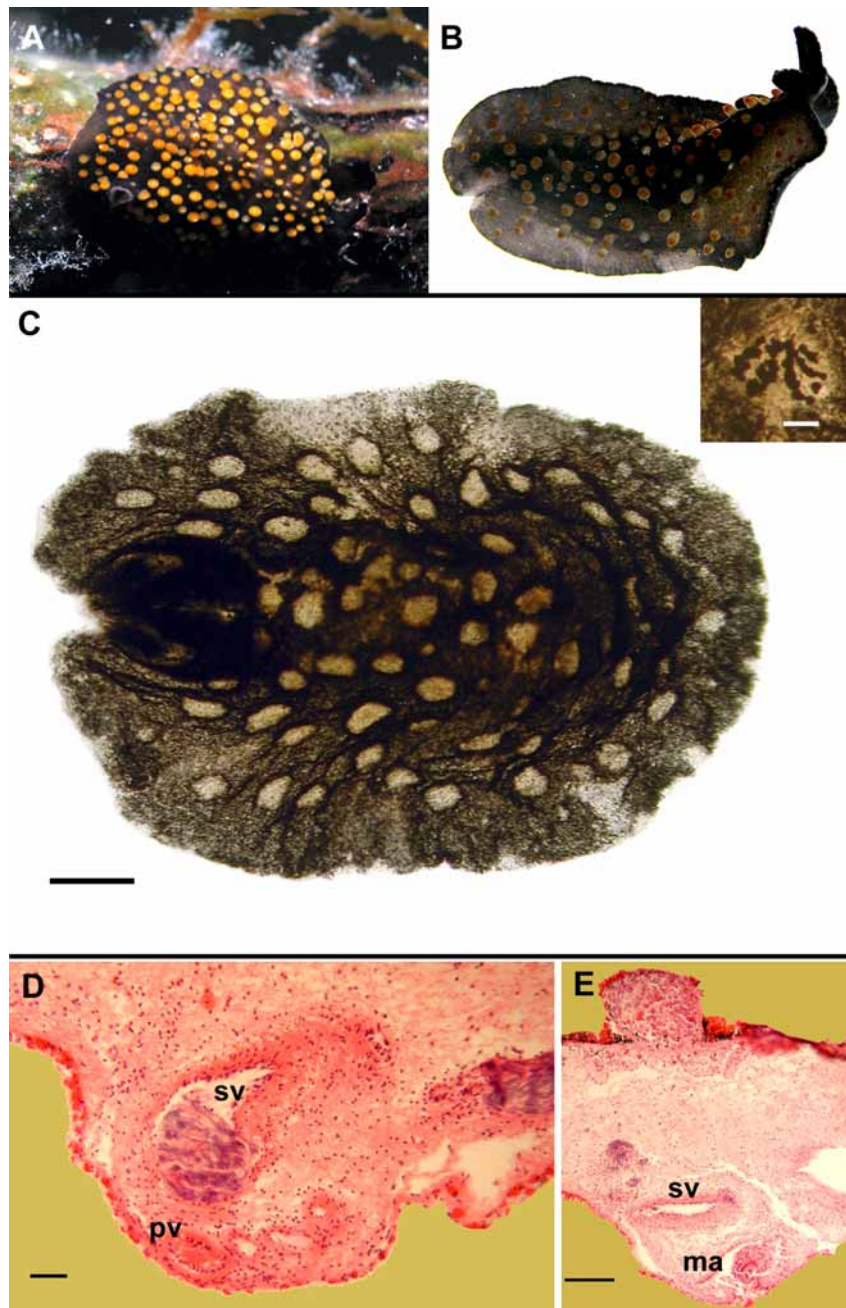


FIGURE 8. *Thysanozoon raphaeli* n. sp. A. Dorsal view of live animal in mangrove roots at Twin Caye, Belize. Photo credit, Raphael Ritson-Williams. B. Dorsal view of live animal found in Bocas del Toro, Panama. Photo credit, Dr. Arthur Anker. C. Dorsal view of cleared whole mount. Scale bar 1.5 mm. Inset: Higher magnification to show detail of cerebral eye cluster. Scale bar 500 μ m. D. Sagittal histological section of one male copulatory system, showing seminal and prostatic vesicles. Scale bar 100 μ m. E. Sagittal histological section of one male copulatory system, showing seminal vesicle and male atrium. Scale bar 200 μ m. ma, male atrium; pv, prostatic vesicle; sv, seminal vesicle.

Superfamily: Euryleptoidea Lang, 1884

Family: Euryleptidae Faubel, 1984

Maritigrella newmana n. sp.

(Figs. 9, 10)

Type Material

a) Holotype, one mature specimen (UNH-USVI 0100, 18mm X 7mm) as serial sagittal sections (4 slides), the remaining part of the body as a whole mount (1 slide) VIIS 41978. Collected 3 June, 2006, from the intertidal in coral rubble in the US Virgin Islands, Salt Pond Bay, St. John (N18° 18.454'; W64° 43.440'). GenBank Accession EF514801.

b) Paratype, one mature specimen (UNH-USVI 034, 20mm X 12mm) as a whole mount (1 slide) VIIS 41979. Collected 26 May, 2006, from coral rubble at 4.5 m depth in the US Virgin Islands, Great Lameshur Bay, St. John (N18° 18.870'; W64° 43.36'). GenBank Accession EF514800.

c) Paratype, one juvenile specimen (UNH-BLZ 032, 9mm X 4mm) as serial sagittal sections (4 slides), the remaining part of the body as a whole mount (1 slide) USNM 1104645. Collected 22 June, 2006, intertidally from coral rubble in Belize, Southwater Caye, North End (N16° 49.113'; W88° 04.818'). GenBank Accession EF514798.

Other Material Examined

d) One juvenile specimen (UNH-BLZ 040, 8mm X 3mm) preserved in ethanol; collected 22 June, 2006, intertidally from coral rubble in Belize, Southwater Caye, North End (N16° 49.113'; W88° 04.818'). GenBank Accession EF514799.

e) One mature specimen (UNH-HON 036, 15mm X 6mm) as serial sagittal sections, the remaining part of the body as a whole mount; collected 3 September, 2006, at 1.5 m from coral rubble in Honduras, Cayos Cochinos, Cayo Menor (N15° 57.793'; W86° 30.727').

f) One juvenile specimen (UNH-HON 004, 10mm X 4mm) as a whole mount; collected 25 August, 2006 from coral rubble, in Honduras, Cayos Cochinos, Pelicano 3 (N15° 58.431'; W86° 28.436').

Etymology

The species is named in honor of Dr. Leslie Newman who described the genus *Maritigrella*.

Synonyms

It is likely that it corresponds to euryleptid sp. 11 Newman & Cannon (2003, p. 67) based on coloration and color pattern.

Distribution

Common species, found at the type locality in the US Virgin Islands, and also found in Belize, Honduras, Colombia, and probably Dominica (Newman & Cannon 2003, p. 67).

Diagnosis

White background with brown pigment arranged in dense, anastomosing, scale-like outlines. Dense brown pigment covering entire dorsal surface but absent near the margins; white median area without pigment visible over the pharynx and extending posteriorly. Three to five conspicuous and continuous transverse black stripes, well-spaced across the dorsal surface (may vary with the size of the animal); series of finer, grayish-black, transverse stripes located between the five conspicuous transverse stripes and extending from the margins towards the midline of the animal but do not completely cross the dorsal surface. Narrow, orange, mar-

ginal line surrounding the body but anteriorly crossing over the dorsal side behind the tentacles. Tentacles black with white tips and white coloration of the anterior margin between the tentacles. Ventral side is translucent white.

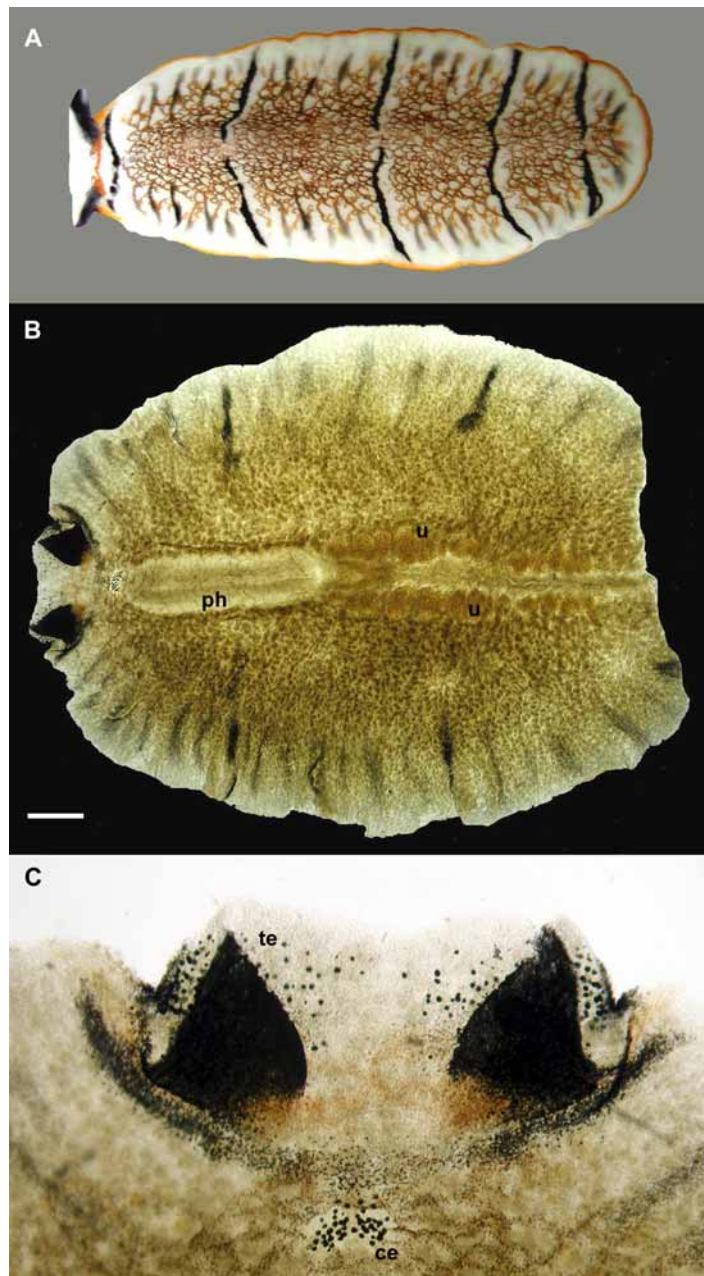


FIGURE 9. *Maritigrella newmanae* n. sp. A. Dorsal view of live animal, showing coloration and color pattern. Scale bar 2.5 mm. B. Cleared whole mount of animal showing tentacles, cerebral eye cluster, pharynx and uteri. Scale bar 1 mm. C. Cleared whole mount of the anterior end showing details of tentacles, cerebral eye cluster and tentacular eyes. Scale bar 0.5 mm. ce, cerebral eyes; ph, pharynx; te, tentacular eyes, u, uteri.

Description

External Features: Coloration as described above in diagnosis (Fig. 9A). Pointed tentacles that are held erect (Figs. 9A–C), with a few scattered eyes between them (Figs. 9B–C). There are two cerebral eye clusters with about 26 eyes in each one (Fig. 9C). The pharynx (3.6mm X 1mm) is muscular and tubular (Fig. 9B). The paired uteri have no uterine glands. The distance between the gonopores is 400 μ m and 1200 μ m between the female gonopore and the sucker. The sucker is large and conspicuous (325 μ m in diameter).

Body Wall: A simple, ciliated epithelium surrounds the entire animal. There is no difference in the height of the cells between the dorsal and the ventral epidermis, although rhabdite glands are more abundant dorsally. Thick, distinct basement membrane separates the epithelium from the underlying muscle layers (outer circular, middle diagonal, inner longitudinal). Small clusters of cyanophilous pigment are located immediately below the dorsal epidermis.

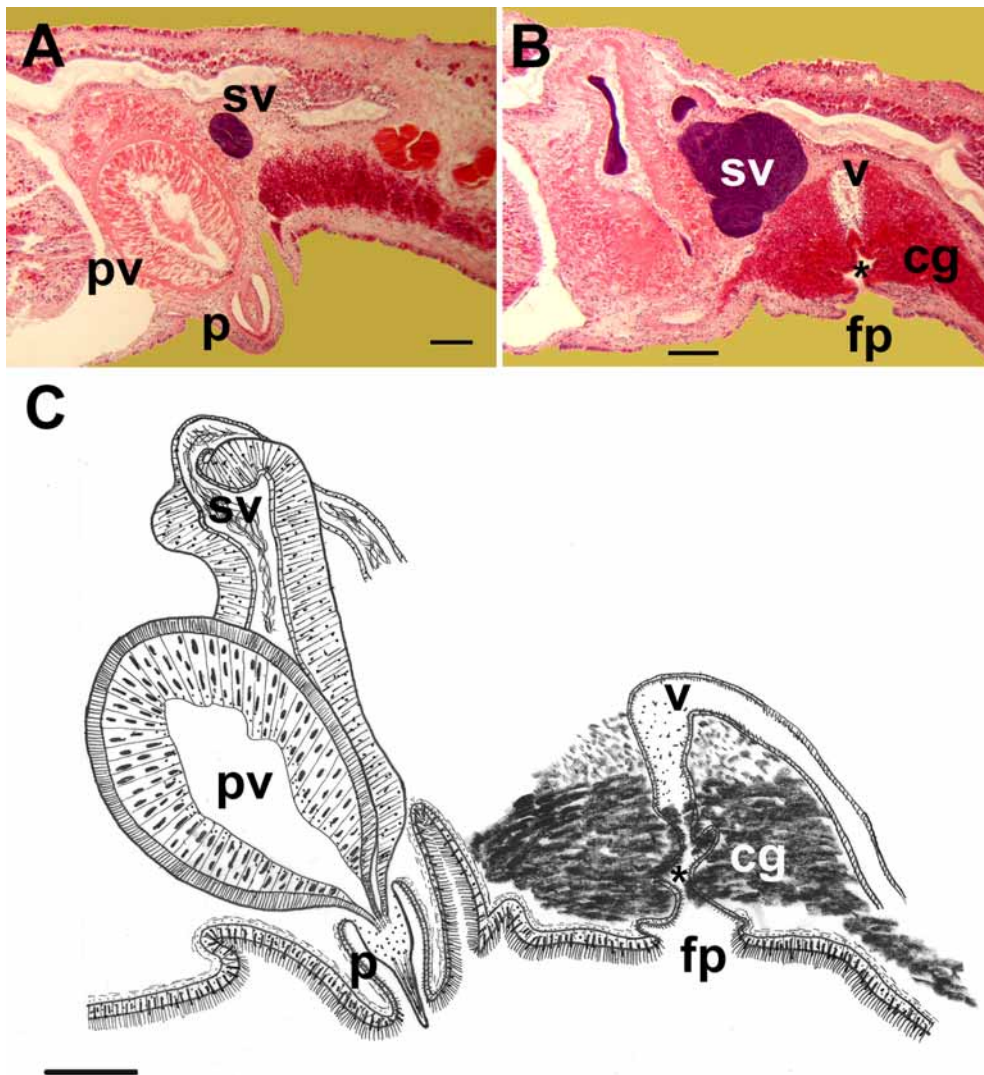


FIGURE 10. *Maritigrella newmana* n. sp. A. Sagittal histological section of male copulatory system, showing large, oval prostatic vesicle and penis papilla. B. Sagittal histological section of male and female copulatory systems, showing large, amorphous seminal vesicle, deep vagina, cement pouch, and well-developed cement glands. C. Diagrammatic representation of male and female reproductive systems. All scale bars 100 μ m. cg, cement glands; fp, female pore; p, penis papilla; pv, prostatic vesicle; sv, seminal vesicle; v, vagina; asterisks, cement pouch.

Reproductive Anatomy: The ovaries are located dorsally, the testes are scattered throughout the body ventrally. A large, irregularly shaped seminal vesicle (550 μ m X 200 μ m) with thickly muscularized walls is located adjacent to one side of the prostatic vesicle (Figs. 10A, 10C). Its lumen is lined by a ciliated epithelium. The prostatic vesicle is large and oval (400 μ m X 300 μ m) (Figs. 10B–C), surrounded by a thin layer of circular muscles and lined by a glandular epithelium that consists of tall cells and whose nuclei are located peripherally. Additionally, the prostatic vesicle is surrounded by glandular cells whose thin necks appear to penetrate the prostatic wall (Fig. 10B). The penis papilla is well developed and bears a short stylet (150 μ m) (Figs. 10B–C). In our sectioned specimen, the vasa deferentia are expanded and filled with sperm. The female

reproductive system is characterized by a deep vagina and well-developed cement pouches. The epithelium of the cement pouches is glandular. The female atrium and the vagina is lined by a ciliated epithelium. Strong cement glands extend dorsally along the side of the vagina (Figs. 10A, 10C).

Taxonomic Remarks

This species clearly belongs to *Maritigrella*. It exhibits the typical characteristics of the genus, such as an oval body shape, a small, muscular and tubular pharynx, long tentacles that are held erect, a short, pointed, and sclerotized stylet a lack of uterine vesicles, and especially, the distinct striped color pattern for which the genus is known (Newman & Cannon 2000). *M. newmanae* can be differentiated clearly from other species in the genus by the distinct brown pigment pattern on its dorsal surface, the discrete black transverse stripes extending completely across the dorsal surface, and the marginal orange line around the body. In juveniles, the dorsal pigment may take on a more reddish tint instead of being dark brown. The transverse stripes vary in number depending on the size of the animal, and in some cases, they can be interrupted at the midline. In some specimens, the transverse stripes are absent over the area of the brown pigment. In those cases, the stripes are limited to the margin only, with just their beginnings being visible.

Other species of *Maritigrella* that exhibit brown pigment patterns middorsally and black transverse stripes or lines include *M. fuscopunctata*, *M. marygarsonae*, and *M. virgulata* (Newman & Cannon 2000). *M. newmanae* is distinguished from *M. fuscopunctata* by the fact that the middorsal area of *M. fuscopunctata* contains orange-brown solid spots arranged in a honeycomb pattern and none of the marginal transverse black lines extend across the dorsal surface. In *M. marygarsonae*, the brown pigment is confined to a thin middorsal line and the black transverse markings consist of numerous, thin lines that extend from the margin to the middorsal line. Finally, our species is distinct from *M. virgulata* by its scale-like brown network middorsally, and by black transverse streaks that cross over the entire dorsal surface (Newman & Cannon 2000). Furthermore, none of the other describes species of *Maritigrella* have an orange marginal line.

Discussion

Some of the specimens were found associated with their prey items. Most *Maritigrella newmanae* from either the US Virgin Islands or Belize were found consistently within transparent ascidians, probably feeding on them but possibly also seeking refuge from their own predators. Some specimens of *Thysanozoon raphaeli* were found feeding on the fouling communities associated with mangrove roots. No prey items were found with *Pseudoceros rawlinsonae*, *P. harrisi*, or *Pseudobiceros caribbensis*.

Polyclad flatworms are almost exclusively marine and have been recorded from tropical, temperate and even arctic waters (Prudhoe 1989). They also are known from the deep-sea (Quiroga et al. 2006). Due to a focused and long-term sampling effort, some of the highest diversity of polyclads (more than 600 species) has been recorded from the Great Barrier Reef and the Indo-Pacific (see extensive references in Newman & Cannon 2003). In contrast, polyclad diversity in the Caribbean has received much less attention (Bolaños et al. 2006, Hyman 1939a, b 1955a, c, Marcus 1960, Marcus & Marcus 1968, Prudhoe 1944, Quiroga et al. 2004). The present study adds five new cotyleans to the known polyclad diversity of the Caribbean, increasing the total number to 128 species.

The new species descriptions presented here are the result of a survey of eight Caribbean localities over two field seasons and may be an indication that pseudocerotid and euryleptid flatworms are more common in the tropical waters of the Caribbean than anticipated from earlier reports (Hyman 1939a, b 1955a, c, Marcus 1960, Marcus & Marcus 1968, Prudhoe 1944). However, in comparison with the Indo-Pacific, cotylean diversity in the Caribbean is relatively low. This discrepancy may be explained in part by the deterioration of many Caribbean coral reefs, the difficulty in collecting these fragile animals, their cryptic nature, and until now, a

lack of focused surveys. Furthermore, only a few Caribbean cotyleans exhibit the flamboyant coloration and color patterns so characteristic of species from the tropical waters of the Indo-Pacific, making them more difficult to detect. An on-going survey in the Caribbean, combined with improved methods for collecting and preserving these delicate flatworms will hopefully help in elucidating their biodiversity and distribution.

Acknowledgements

We thank Kate Rawlinson, Marcin Liana, Anne DuPont and Joseph Dunn for their assistance in collecting the specimens and Raphael Ritson-Williams for providing us with the type specimen and an image of *Thysanozoon raphaeli* in its habitat (Fig. 8A). We also wish to thank Dr. Arthur Anker for another *in vivo* image of *T. raphaeli* (Fig. 8B), and Néstor Ardila for information regarding the distribution of this species in Colombia. This work was supported by NSF grant DEB-0412932, and is Scientific Contribution No. 2334 from the New Hampshire Agricultural Experiment Station.

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