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## Four New Cestode Species from the Spiral Intestine of the Round Stingray, *Urobatis halleri*, in the Northern Gulf of California, Mexico

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**ABSTRACT:** The spiral intestines of 40 specimens of *Urobatis halleri* from the northern Gulf of California, Mexico, were examined for cestodes. Four new species, *Rhinebothrium chollaensis* n. sp., *Rhinebothrium gravidum* n. sp., *Eutetrarhynchus cortezensis* n. sp., and *Prochristianella minima* n. sp., are described. This is the first record of these 3 genera in the Gulf of California and the first report of *Eutetrarhynchus* in *U. halleri*.

**KEY WORDS:** Cestode, Trypanorhyncha, Tetraphyllidea, *Rhinebothrium*, *Prochristianella*, *Eutetrarhynchus*, Elasmobranch, *Urobatis halleri*, Sea of Cortez, Stingray.

During October of 1994 and 1995, 40 round stingrays, *Urobatis halleri* (Cooper, 1863), were collected from the northern Gulf of California near Puerto Peñasco, Sonora, Mexico. This article describes 4 new species of cestodes from the spiral intestine of *U. halleri*. *Urobatis halleri* (Rajiformes: Urolophidae) is a small marine elasmobranch (=56.0 cm length) inhabiting the benthos of beaches and bays (Eschmeyer et al., 1998). The order Rajiformes, to which *Urobatis* belongs, includes the skates (Rajidae and Anacanthobatidae), guitarfish (Rhinoobatidae), stingrays (Dasyatidae, Plesiobatidae, Hexatrygonidae, Urolophidae, and Potamotrygonidae), and rays (Myliobatidae) (Eschmeyer et al., 1998). There are 4 genera and 44 species within Urolophidae: *Urobatis* comprise 6 species (Eschmeyer et al., 1998). *Urobatis halleri* has a conical–spiral intestine (Compagno, 1988), an organ unique to elasmobranchs. This type of spiral intestine consists of a flap of tissue attached in a continuous spiral down its outer edge, creating whorls and increasing the absorptive surface of the organ (McVicar, 1979). Within *U. halleri*, these whorls form 13 distinct chambers. In this article, we report the results of our survey of the cestodes inhabiting *Urobatis* in the Northern Gulf of California, adding a new location to the previous cestode records for Urolophidae.

### MATERIALS AND METHODS

Forty specimens of *U. halleri* were obtained from 2 localities in the northern Gulf of California near El Centro de Estudio de Desiertos y Océanos (CEDO) in Puerto Peñasco, Sonora, Mexico, during October 1994 and 1995. One site

was located in the intertidal zone off CEDO and the other, Cholla Bay, was located 23 km north of CEDO. Working from Cholla Bay, 31 *U. halleri* were captured using a beach seine. Nine *U. halleri* were collected with a Hawaiian sling behind the CEDO field station. All hosts were brought back to CEDO and either killed for immediate dissection or maintained in an aerated tank for later dissection. Each host was measured, weighed, and its sex determined before dissection. Only cestodes recovered from freshly killed hosts are considered in this study.

An incision was made on the ventral side of each animal and the digestive track was tied off with a thread anterior and posterior to the stomach and spiral intestine to prevent loss or migration of worms. The stomach and spiral intestine were removed, injected with AFA (5 part glacial acetic acid, 10 parts formalin, and 85 parts 85% ethanol) to fix the worms in situ and placed in a dish containing AFA for examination. Individual chambers of the spiral intestine were defined by using the dorsal blood vessel of the spiral intestine as a point of reference to determine the beginning and end of each valve. The contents of the spiral valve were examined with a stereomicroscope. Worms from each chamber of the spiral intestine were recovered and transferred to an appropriately labeled vial containing 10% formalin for storage.

Initially, cestodes were hydrated, stained with Semichon carmine, dehydrated in a graded ethanol series, cleared in HistoClear, and mounted in Canada balsam for examination with light microscopy. When work resumed on the remaining preserved cestodes 4 yr later, many worms were brittle and unresponsive to stain. To remove residual fixatives, these worms were washed 2–3 times through a hydration series to water and dehydrated to 70% ethanol. Following the technique outlined by Pritchard and Kruse (1982) for straightening worms fixed in situ, worms were left in 70% ethanol and glycerin for at least 2 mo (Pritchard and Kruse [1982] suggest 48 hr). Finally, cestodes were hydrated, stained with Semichon carmine or Van Cleave hematoxylin, dehydrated in a graded ethanol series, cleared in toluene, and mounted in Canada balsam or resin TM 90 (Bjørn Berland, Zoologisk Institutt, Bergen, Norway).

Cestodes reserved for scanning electron microscopy (SEM) were hydrated, postfixed in 1% buffered (pH 7.2)

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osmium tetroxide (OsO<sub>4</sub>) for 1 hr, dehydrated in a graded ethanol series to absolute ethanol, critical-point dried in liquid CO<sub>2</sub>, mounted on aluminum stubs with double-sided tape and silver paint, coated with gold, and examined with a Hitachi S530 scanning electron microscope.

Friggens and Brown (2005) present a comprehensive description of the cestode community within *U. halleri*, including species list and infection characteristics. Cestodes were identified using the study of Khalil et al. (1990) in combination with reference to primary literature. The following type specimens were borrowed from the United States National Parasite Collection (USNPC), Beltsville, Maryland, for comparison: *Acanthobothrium bajaensis* Appy and Dailey, 1973 (paratype 72568), *Acanthobothrium olseni* Dailey and Mudry, 1968 (holotype 71216), *Anthobothrium oligorchidum* Young, 1954 (type 49096), *Acanthobothrium parviuncinatum* Young, 1954 (type 49095), *Eutetrarhynchus geraschmidti* Dollfus, 1974 (paratype 72513), *Eutetrarhynchus schmidti* Heinz and Dailey, 1974 (paratype 72669), *Eutetrarhynchus thalassius* Kovacs and Schmidt, 1980 (paratype 75229), *Mecistobothrium myliobati* Heinz and Dailey, 1974 (holotype 72673), *Oncomegas paulinae* Toth, Campbell, and Schmidt, 1992 (paratype 82187), *Prochristianella fragilis* Heinz and Dailey, 1974 (holotype 72676), *Prochristianella minima* Heinz and Dailey, 1974 (paratype 72678), *Rhinebothrium flexile* Linton, 1890 (voucher 07662), *Rhinebothrium lintoni* Campbell, 1970 (paratype 70560), *Rhinebothrium minimum* van Benenden, 1850 (voucher 07334; note specimen possesses a myzorhynchus), and *Rhinebothrium urobati-dium* (Young, 1955) Appy and Dailey, 1977 (voucher 74599). Measurements are presented in micrometers as ranges, followed parenthetically by mean, standard deviation, and sample size, unless otherwise noted. Voucher specimens of *R. urobati-dium* (92202–92205), *A. parviuncinatum* (92206, 92207), *A. olseni* (92208), *O. paulinae* (92209), *M. myliobati* (92210), *P. minima* (92211) and holotypes and paratypes of the new species were deposited in the USNPC.

***Rhinebothrium chollaensis* n. sp.**  
(Figs. 1–3)

**Description**

With the characteristics of the genus. Based on 10 whole and 7 partial mounted specimens and 4 specimens examined by SEM. Worms 1.3–5.1 mm (3.0 ± 1.6 mm, 9) long, acraspidote ( $n = 11$ ), apolytic, consisting of 32–84 (61.1 ± 15.2, 9) proglottids. Scolex with 4 bothridia on short pedicles, spinose. Cephalic peduncle absent. Bothridia leaf-like, with lobulated muscular rims, asymmetrically set upon pedicle; posterior of bothridium is considerably wider and slightly longer than anterior. Pedicles 37.5–125 (91.5 ± 33.1, 5) long, 40–92.5 (66.5 ± 20, 5) wide. A slight constriction exists where the bothridia meet the pedicle. Each bothridium with a single median longitudinal septum and numerous transverse septa forming 2 rows of loculi along the length of bothridium and a single loculus at

each bothridial terminus. Loculi number 40–49 (45 ± 2.8, 9).

Immature proglottids 15–35 (24.3 ± 6.2, 11) long, 52.5–127.5 (88.6 ± 24.6, 11) wide; mature proglottids 80–272.5 (140.9 ± 60.5, 11) long, 47.5–155 (118.1 ± 30.6, 11) wide. Terminal proglottids longer than wide, 130–452.5 (327.3 ± 97, 11) long, 55–142.5 (98 ± 33, 11) wide. Conspicuous indentation at genital pore. Four testes 15–55 (37.2 ± 12.9, 8) long, 15–27.5 (20.7 ± 4.5, 8) wide, in 2 rows in anterior half of mature proglottids. Cirrus armed; cirrus sac centrally located and angled posteriorly, 57.5–75 (68.1 ± 8.5, 4) long, 40–50 (44.7 ± 4.4, 4) wide in mature proglottids, 37.5–72.5 (57.6 ± 13, 8) long, 32.5–50 (42.1 ± 5.7, 8) wide in gravid proglottids. Genital pore 60% of proglottid length from posterior end, irregularly alternating. Vagina anterior to cirrus sac, thick walled, widening distally to form atrium before winding posteriorly (in some specimens winding laterally then posteriorly) toward ovary. Ovary in posterior third to half of proglottid, U-shaped in dorsal–ventral view with symmetrical lobes that just reach the posterior margin of the cirrus sac. Ovarian lobes 87.5–258 (159.6 ± 48.3, 11) long, 12.5–50 (32 ± 14.4, 11) wide. Vitelline follicles small, in compact rows along length of proglottid.

**Taxonomic summary**

*Type host*: Haller's round ray, *Urobatis halleri* (Cooper, 1863).

*Type locality*: Puerto Peñasco, Sonora, Mexico (31°18'27"N; 113°32'5"W).

*Site of infection*: Spiral intestine, chambers 1–7.

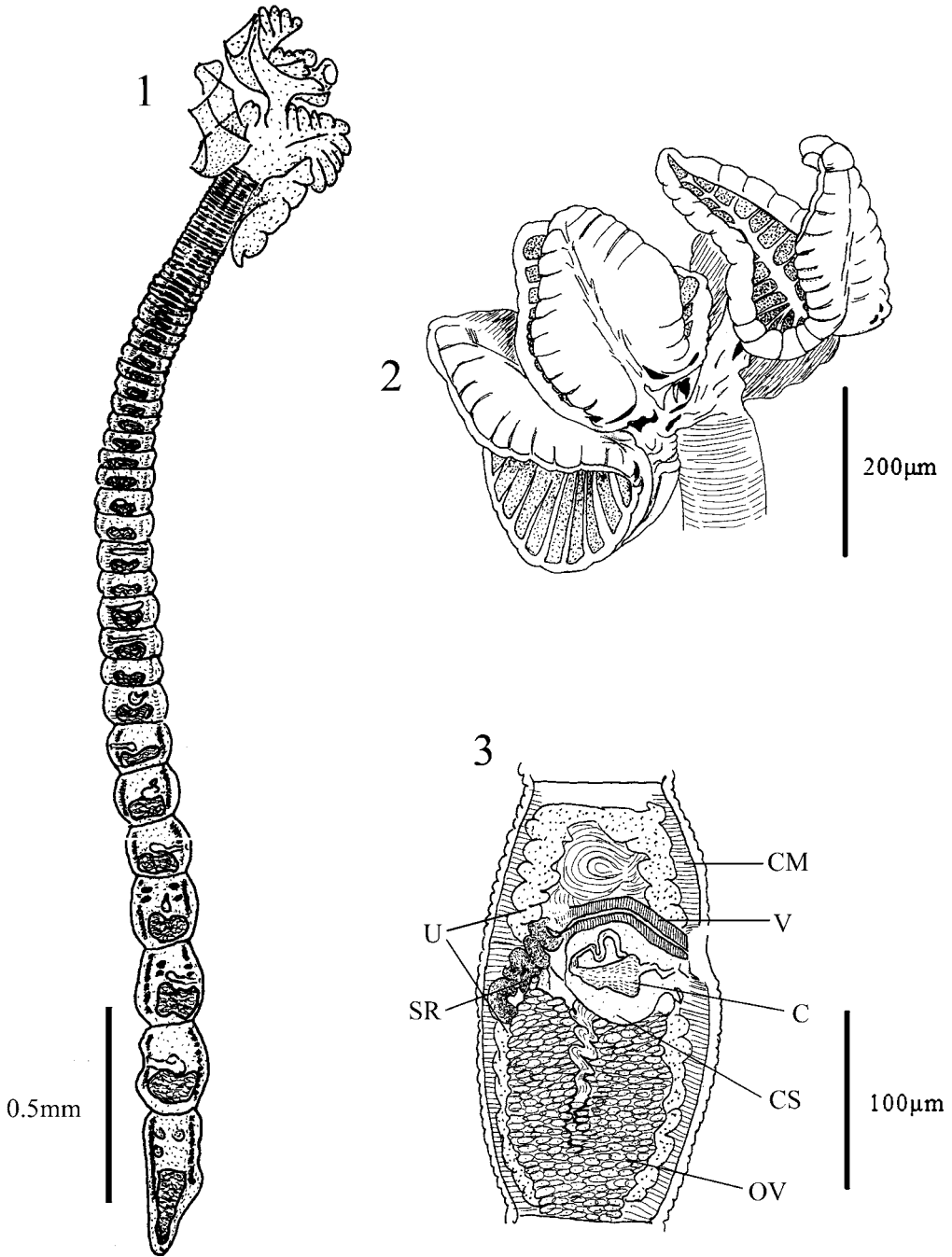
*Prevalence, mean intensity, abundance, and range of infection*: 7%, 21.0, 3.8 (±28.3), and 1–41.

*Species deposited*: United States National Parasite Collection, Beltsville, Maryland, holotype (USNPC 92213) and paratype (USNPC 92214).

*Etymology*: The specific epithet, *chollaensis*, refers to Cholla Bay in which the host of the holotype specimen was collected.

**Remarks**

Seventeen *Rhinebothrium* species possess a median longitudinal septum and are similar in size (~1–6 mm) to *R. chollaensis*: *Rhinebothrium biorchidum* Huber and Schmidt, 1985, *Rhinebothrium rhinobati* Dailey and Carvajal, 1976, *Rhinebothrium paratrygoni* Rego and Dias, 1976, *Rhinebothrium xiamensis* Yanhai



**Figures 1–3.** *Rhinebothrium chollaensis* n. sp. **1.** Entire worm. **2.** Scolex. **3.** Early gravid proglottid. (C, cirrus; CM, circular muscle; CS, cirrus sac; OV, ovary; SR, seminal receptacle; U, uterus; V, vagina.)

and Wenchuan, 2001, *Rhinebothrium longicolle* Linton, 1890, *R. urobatidium*, *Rhinebothrium scobinae* Euzet and Carvajal, 1973, *Rhinebothrium himatura* Williams, 1964, *Rhinebothrium hawaiiensis*

Cornford, 1974, *R. lintoni* Campbell, 1970, *Rhinebothrium devaneyi* Brooks and Deardorff, 1988, *Rhinebothrium corymbum* Campbell, 1975, *Rhinebothrium euzeti* Williams, 1958, *Rhinebothrium*

*cadenati* Euzet 1954, *Rhinebothrium tumidulum* (Rudolphi 1819) Joyeux and Baer, 1936, *Rhinebothrium margeritense* Mayes and Brooks, 1981, and *Rhinebothrium walga* (Shiple and Hornel, 1905) Euzet, 1956. Testes number distinguishes *R. chollaensis* (4) from *R. xiamensensis* (10–14), *R. longicolle* (20–32), *R. urobatidium* (6–12), *R. scobinae* (19), *R. himatura* (19–20), *R. hawaiiensis* (11–13), *R. lintoni* (5–8), *R. devaneyi* (30–43), *R. corymbum* (25), and *R. euzeti* (12). Furthermore, *R. chollaensis* possesses fewer loculi (40–49) than the latter 4 species, *R. lintoni* (54–56), *R. devaneyi* (128), *R. corymbum* (58), and *R. euzeti* (78); a greater number of loculi (40–49) than *R. cadenati* (4) and *R. tumidulum* (23); and, both a greater number of testes (4) and loculi (40–49) than *R. biorchidum* (2 and 22–30, respectively) and *R. rhinobati* (2 and 23, respectively). *Rhinebothrium biorchidum* is further distinguished from *R. chollaensis* by distinctly hinged bothridia. *Rhinebothrium chollaensis* has fewer loculi than *R. paratrygoni* (40–49 vs. 72–76, respectively) and lacks the long cephalic peduncle of *R. paratrygoni*. *Rhinebothrium margeritense*, *R. walga*, and *R. chollaensis* possess a similar number of testes and loculi. The acraspidote segments of *R. chollaensis* distinguish it from *R. margeritense* and proglottid number distinguishes *R. chollaensis* from *R. walga* (32–80 vs. 15–25, respectively).

***Rhinebothrium gravidum* n. sp.**  
(Figs. 4–8)

**Description**

With the characteristics of the genus. Based on 8 mounted specimens and 1 specimen examined by SEM. Worms 1.8–5.3 mm ( $3.1 \pm 1.4$  mm, 5) long, acraspidote, apolytic, consisting of 9–21 ( $14.8 \pm 3.6$ , 8) proglottids. Scolex with 4 bothridia on short pedicles, spinose. Cephalic peduncle short or absent, 25–37.5 ( $30.8 \pm 6.3$ , 3) long, 87.5–105 ( $96.3 \pm 12.4$ , 3) wide. Bothridia leaf-like, with lobulate muscular rims, asymmetrically set on pedicles; posterior of bothridium considerably wider and slightly longer than anterior. A slight constriction present where bothridium meets pedicle. Each bothridium possesses a single median longitudinal septum and numerous transverse septa forming 2 rows of loculi along length of bothridium and a single loculus at each terminus. Loculi number 46–56 ( $50.7 \pm 5$ , 3).

Immature proglottids 25–67.5 ( $45.6 \pm 16.56$ , 7) long, 47.5–176 ( $106.2 \pm 42.8$ , 7) wide; mature proglottids 132–354 ( $222.4 \pm 81.8$ , 11) long, 72.5–

223 ( $157.5 \pm 45$ , 11) wide. Gravid proglottids elongate, 551–1,547 ( $909.8 \pm 412.1$ , 5) long, 117.5–180 ( $156 \pm 23.7$ , 5) wide. Testes 8–10 ( $8.7 \pm 0.95$ , 7) in number, forming 2 rows in anterior half of mature proglottids, 23–44 ( $35.7 \pm 6.3$ , 11) long, 10–22.5 ( $14.9 \pm 4.2$ , 11) wide; atrophied in gravid proglottids. Cirrus armed, cirrus sac round, centrally located, 52.5–79 ( $69.1 \pm 13.4$ , 8) long, 27.5–69 ( $49.1 \pm 17$ , 8) wide in mature proglottids; 80–130 ( $108.1 \pm 21.3$ , 4) long, 60–82.5 ( $70 \pm 9.4$ , 4) wide in gravid proglottids. Genital pore 50–60% of proglottid length from end, irregularly alternating. Vagina opening into the genital atrium anterior to cirrus sac and coiling posteriorly toward ovary along midline of proglottids. Ovary located in posterior third of proglottid, U shaped in dorsal–ventral view with symmetrical lobes that just reach posterior margin of cirrus sac. Ovarian lobes measure 50–135  $\times$  25–70 ( $96.9 \times 43.1$ ). Uterus saccate, diverticulated in early gravid proglottids, occupying entire length of proglottid. Eggs spheroid with filament, 10–15 ( $13 \pm 2.5$ , 6) across. Vitellaria form compact lateral bands along entire length of proglottid.

**Taxonomic summary**

*Type host*: Haller's round ray, *Urobatis halleri* (Cooper, 1863).

*Type locality*: Puerto Peñasco, Sonora, Mexico (31°18'27"N; 113°32'52"W).

*Infection site*: Spiral intestine, chambers 1–9.

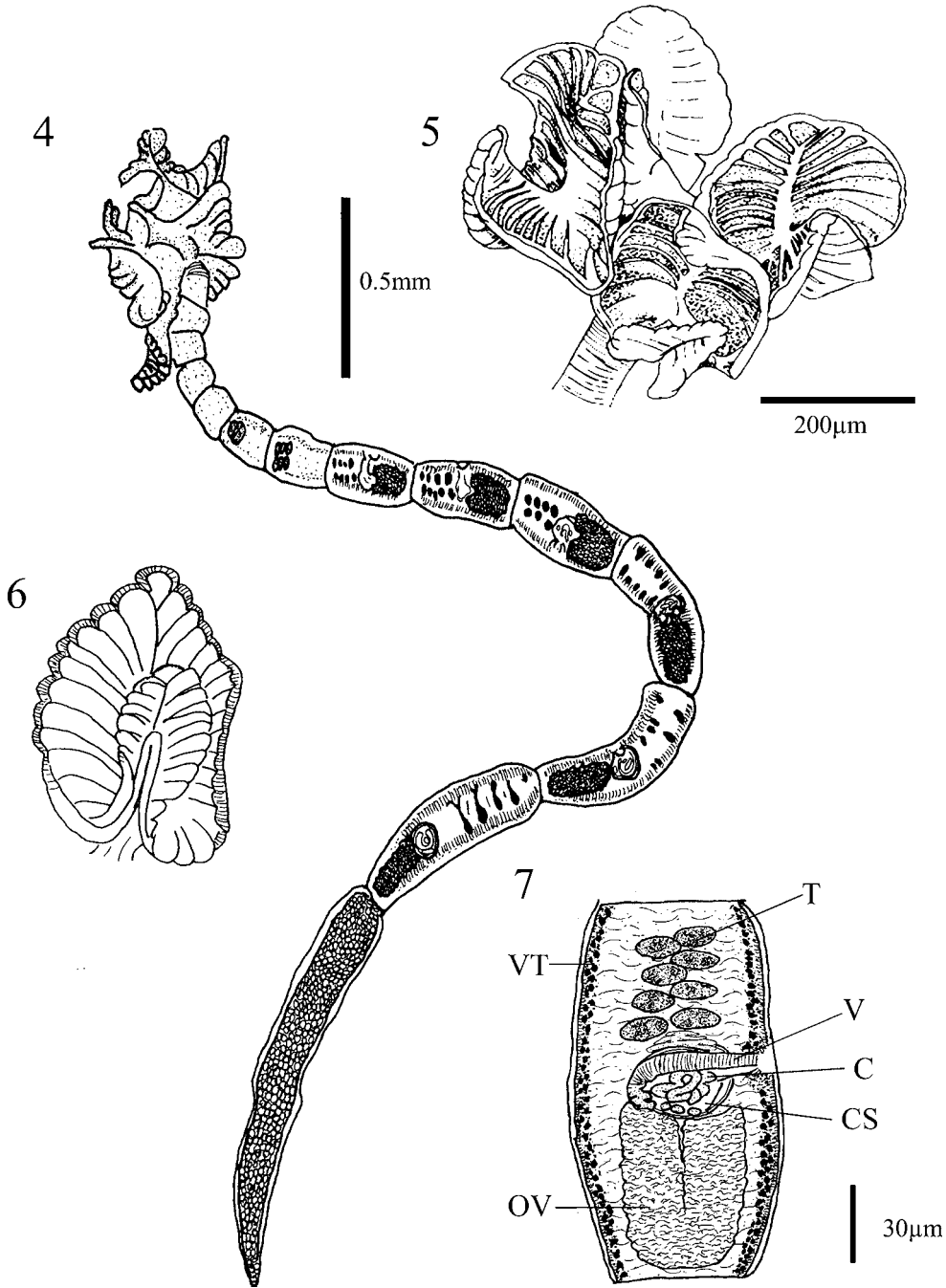
*Species deposited*: United States National Parasite Collection, Beltsville, Maryland, holotype (USNPC 92212).

*Prevalence, mean intensity, abundance, and range of infection*: 18%, 2.4, 0.9 ( $\pm 2.6$ ), and 1–7.

*Etymology*: The specific epithet, *gravidum*, refers to the typically gravid characteristic of the terminal proglottid of these specimens.

**Remarks**

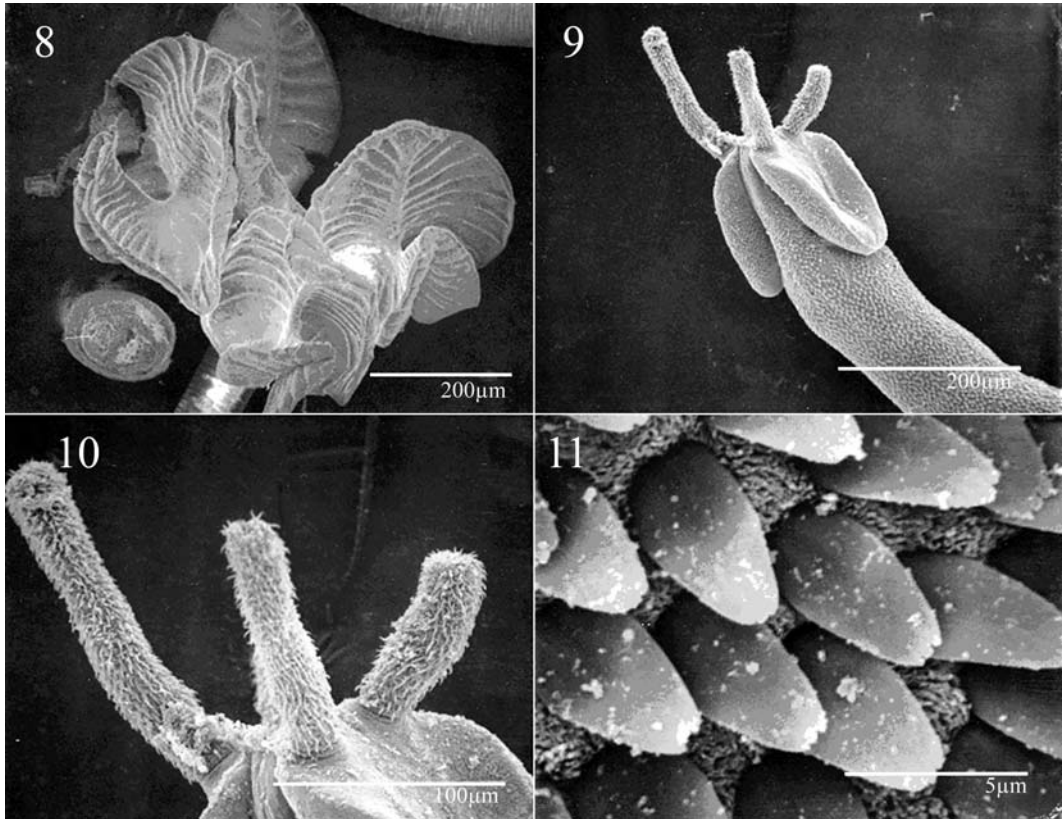
Eighteen *Rhinebothrium* species possess a median longitudinal septum and are similar in size (~1–6 mm) to *R. gravidum*: *R. biorchidum*, *R. rhinobati*, *R. paratrygoni*, *R. xiamensensis*, *R. longicolle*, *R. urobatidium*, *R. scobinae*, *R. himatura*, *R. hawaiiensis*, *R. lintoni*, *R. devaneyi*, *R. corymbum*, *R. euzeti*, *R. cadenati*, *R. tumidulum*, *R. margeritense*, *R. walga*, and *R. chollaensis*. Testes number distinguishes



**Figures 4–7.** *Rhinebothrium gravidum* n. sp. **4.** Entire worm. **5.** Scolex. **6.** Bothridium. **7.** Mature proglottid. (C, cirrus; CS, cirrus sac; OV, ovary; T, testes; V, vagina; VT, vitellaria.)

*R. gravidum* (8–10) from *R. biorchidum* (2), *R. rhinobati* (2), *R. margeritense* (3–6), *R. walga* (4–6), *R. longicolle* (20–32), *R. scobinae* (19), *R. himatura* (19–20), *R. hawaiiensis* (11–13),

*R. devaneyi* (30–43), *R. corymbum* (25), and *R. euzeti* (12). *Rhinebothrium gravidum* possesses a distinct number of loculi (46–56) as compared with *R. devaneyi* (128), *R. corymbum* (58), *R. euzeti* (78), *R. cadenati*



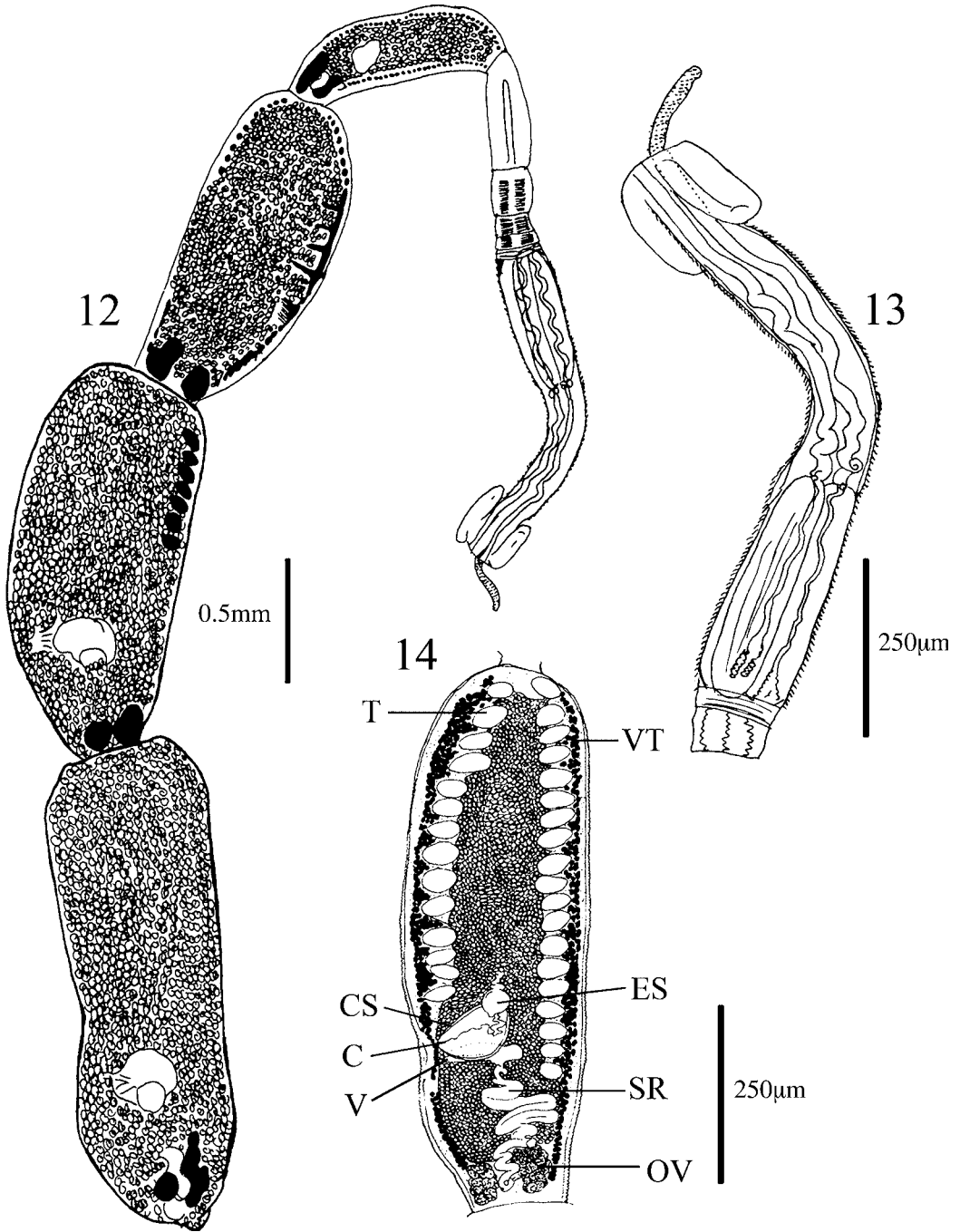
**Figures 8–11.** Scanning electron micrographs of *Rhinebothrium gravidum* n. sp. and *Eutetrarhynchus cortezensis* n. sp. **8.** Scolex of *R. gravidum*. **9.** Scolex of *E. cortezensis*. **10.** Tentacles of *E. cortezensis* showing homeoacanthous nature of the armature. **11.** Pectinate blade-like microtriches from proximate bothrial and pars bothridialis surfaces of the *E. cortezensis* scolex.

(4), *R. tumidulum* (23), *R. hawaiiensis* (48), *R. walga* (42), *R. scobinae* (19), *R. longicolle* (32–40), *R. urobatidium* (38–48), *Rhinebothrium spinicephalum* (32), *R. rhinobati* (23), and *R. biorchidum* (22–30). Differences in loculi number distinguish *R. gravidum* (46–56 loculi) from *R. devaneyi* (128), *R. corymbum* (58), *R. euzeti* (78), *R. cadenati* (4), *R. tumidulum* (23), *R. hawaiiensis* (48), *R. walga* (42), *R. scobinae* (19), *R. longicolle* (32–40), *R. urobatidium* (38–48), *R. spinicephalum* (32), *R. rhinobati* (23), and *R. biorchidum* (22–30). *Rhinebothrium gravidum* lacks the distinctly bilobed bothridia of *R. biorchidum* and *R. corymbum*, the long cephalic peduncle of *R. paratrygoni*, and the enlarged cirrus sac of *R. xiamensensis*. *Rhinebothrium gravidum* possesses markedly fewer segments (9–21) than *R. lintoni* (>250). *Rhinebothrium gravidum* is distinguished from *R. chollaensis* by proglottid number (14 vs. 61) and loculi number (45 vs. 50).

#### *Eutetrarhynchus cortezensis* n. sp. (Figs. 11–20)

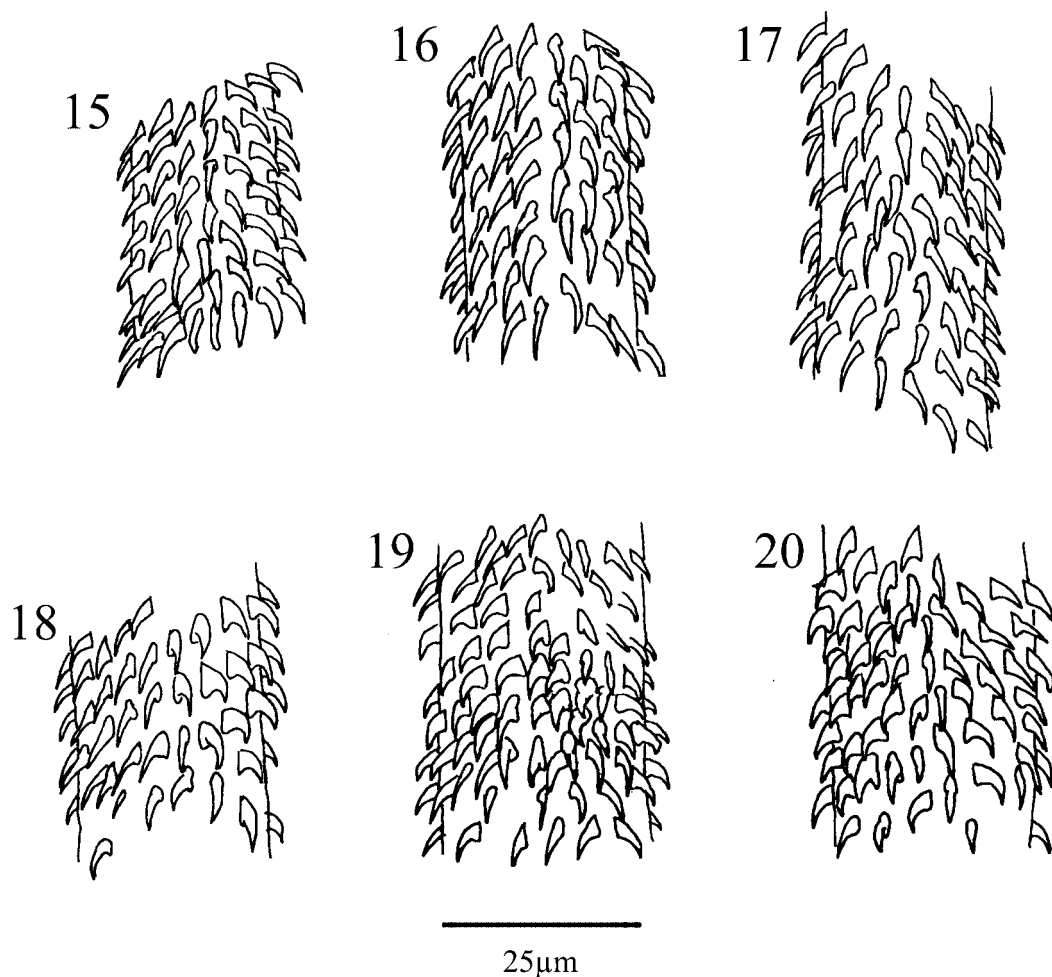
##### Description

With the characteristics of the genus. Based on 9 whole mounted specimens and 2 specimens examined with SEM. Worms small, length 2.5–6.8 mm ( $3.7 \pm 1.3$  mm, 8), acraspidote, apolytic, consisting of 3–9 ( $6.2 \pm 1.8$ , 8) proglottids. Scolex, acraspidote with 2 patelliform bothria; pars bulbosa, pars vaginalis, and proximal surface of bothria covered by pectinate microtriches. Distal surface of bothria with no microtriches. Bothrial margins free; rims often notably thickened. Pars bothridialis 176–232 ( $204.6 \pm 12.9$ , 11) long; pars bulbosa 240–487.5 ( $412.6 \pm 83.5$ , 8) long, bulb width 54.5–90 ( $75.8 \pm 12.6$ , 8); pars vaginalis 422–742.5 ( $574.9 \pm 129.4$ , 9) long. Ratio pars bothridialis:par bulbosa:pars vaginalis, 1.0:2.8:2.0. Tentacle sheaths slightly sinuous.



**Figures 12–14.** *Eutetrarhynchus cortezensis* n. sp. **12.** Entire worm. **13.** Scolex. **14.** Early gravid proglottid. (C, cirrus; CS, cirrus sac; ES, external seminal vesicle; OV, ovary; SR, seminal receptacle; V, vagina; VT, vitellaria; T, testes.)





**Figures 15–20.** Tentacle armature of *Eutetrarhynchus cortezensis* n. sp. **15.** Metabasal bothrial surface. **16.** Metabasal external surface. **17.** Metabasal antibothrial surface. **18.** Basal bothrial surface. **19.** Basal external surface. **20.** Basal antibothrial surface.

Retractor muscles originate at base of bulbs. Prebulbar organs present.

Hooks hollow, heteromorphous, heteroacanthous typical. Slight swelling at basal region. No area of enlarged hooks. Basal armature consists of 2 half rows of 10 hooks ascending from the internal face of tentacle. Hooks 1 (1') falciform 6.8 long; hooks 2 (2')–6 (6') hastate 6.0 long, 7 (7')–8 (8') falciform 4.5 long, and 9 (9')–10 (10') uncinat and 3.8 long. Metabasal and distal armature is characterized by less densely packed rows of 10 falciform- and spiniform-type hooks.

Terminal gravid proglottid 992–1,700 ( $1,353 \pm 259.8$ , 7) long by 272–828 ( $428.5 \pm 206$ , 7) wide. Indentation at genital pore; genital pore postequatorial, 30% of proglottid length from posterior end, irregularly

alternating. Testes, subsperid, in 2 rows that sometimes overlap in the anterior four fifths of mature proglottids; never seen to overreach lateral osmoregulatory canals. Testes 37–51 ( $44.4 \pm 7.2$ , 8) in number, 45–70 ( $61 \pm 12.4$ , 8) long by 15–41 ( $23 \pm 8.5$ , 8) wide. Cirrus unarmed; cirrus sac round, located in posterior third of mature and gravid proglottids, 93–134 ( $109.8 \pm 35.4$ , 5) long by 70–180 ( $110.8 \pm 43.9$ , 5) wide. External seminal vesicle present. Internal seminal vesicle absent. Vagina muscular, enters genital atrium ventral to cirrus sac moving posteriorly to eventually form a large sac-like seminal receptacle at ovarian isthmus. Ovary short, H shaped in dorsal–ventral view, each lobe measuring 100–248 ( $151.7 \pm 52.6$ , 8) long by 65–140 ( $96 \pm 29.6$ , 8) wide in gravid proglottids.

Uterus medial, reaching anterior margin of proglottid, tubular in mature proglottids, saccate with diverticula within gravid segments. Vitellaria circumcortical.

### Taxonomic summary

*Type host:* Haller's round ray, *Urobatis halleri* (Cooper, 1863).

*Type locality:* Puerto Peñasco, Sonora, Mexico (31°18'27"N; 113°32'52"W).

*Infection site:* Spiral intestine, chambers 1–12.

*Prevalence, mean intensity, abundance, and range of infection:* 50%, 7.6, 7.9 ( $\pm 10.7$ ), and 1–36.

*Species deposited:* Holotype (USNPC 92215) and paratypes (USNPC 92216, 92217) deposited in the USNPC.

*Etymology:* The specific epithet, "cortezensis," refers to the Sea of Cortez from which the host of the holotype was collected.

### Remarks

Only 6 species of *Eutetrarhynchus* have been described with a scolex covered by microtriches: *Eutetrarhynchus spinifer* Dollfus, 1969, *Eutetrarhynchus ocallaghani* Beveridge, 1990, *Eutetrarhynchus michiae* (Southwell, 1929) Beveridge, 1990, *Eutetrarhynchus micracanthus* (Carvajal, Campbell and Cornford, 1976) Beveridge, 1990, *Eutetrarhynchus owensi* Beveridge, 1990, and *E. schmidtii*. Among these species, *E. cortezensis* is unique in possessing an external seminal vesicle. Microtrichia cover the entire pars bulbosa surface of the scolex in *E. cortezensis* but do not extend beyond the region of the bulbs of the scolex in *E. owensi*. The basal armature of *E. ocallaghani* is distinguished by an area of increased hook numbers, whereas hook number in *E. cortezensis* remains consistently 10 throughout the basal armature. These taxa are also distinguished by hook shape: falciform in *E. cortezensis* but deltoid in *E. ocallaghani*. Similarly, *E. cortezensis* lacks the enlarged basal hooks of *E. michiae*, *E. spinifer*, and *E. schmidtii*. *Eutetrarhynchus cortezensis* is further distinguished from *E. schmidtii* by testes number (37–51 vs. 56–70, respectively).

### *Prochristianella multidum n. sp.* (Figs. 21–32)

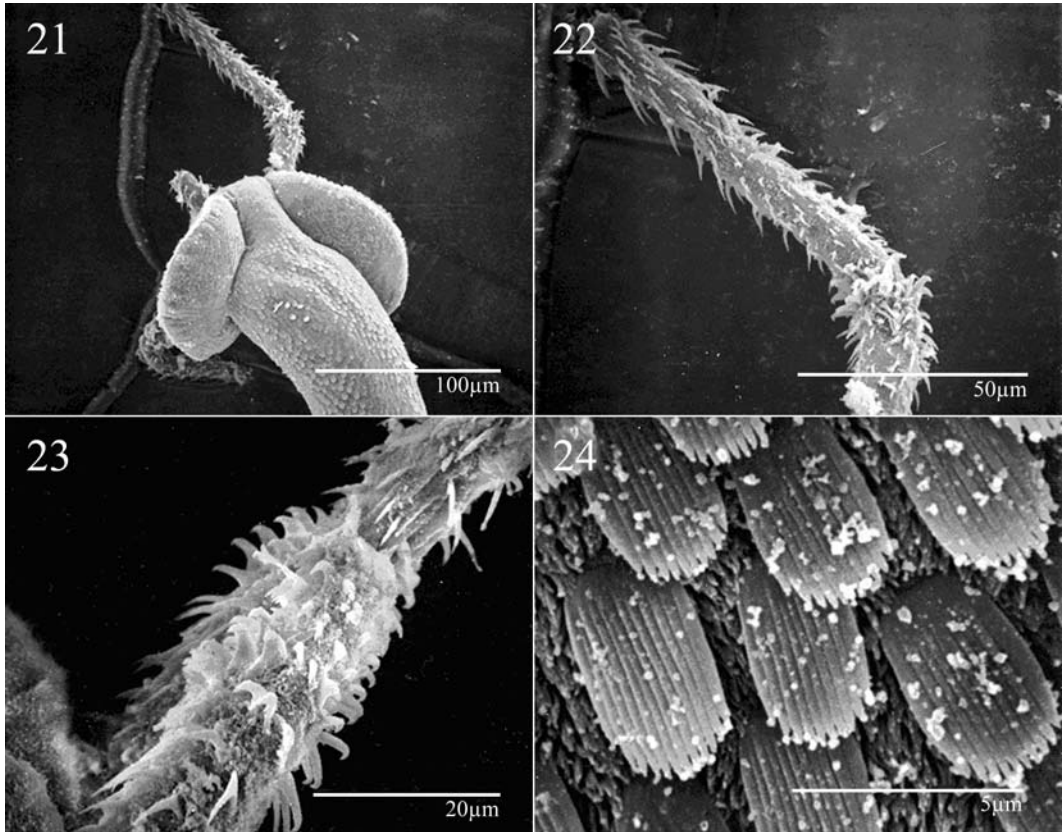
#### Description

With the characteristics of the genus. Based on 12 whole mounted specimens and 2 specimens examined

by SEM. Worms small, measuring 1.2–2.2 mm ( $1.9 \pm 307.5$  mm, 14), acraspidote, apolytic, consisting of 3–7 ( $4.5 \pm 1.2$ , 14) proglottids. Scolex acraspidote with 2 patelliform bothridia; pars vaginalis, pars bulbosa, and distal surfaces of bothria covered in pectinate microtriches. Proximate surface of bothria irregularly covered in filiform microtriches. Bothrial margins free, often with notably thickened rims. Pars bothridialis 85–139 ( $114.6 \pm 15.2$ , 14) long, pars bulbosa 164–263 ( $231.9 \pm 33.8$ , 14) long, bulb width 35–55 ( $45.2 \pm 7.9$ ; 11), pars vaginalis 272.8–367 ( $333.9 \pm 29.4$ , 14) long. Ratio pars bothridialis:pars bulbosa:pars vaginalis, 1.0:2.9:2.0. Tentacle sheaths sinuous. Retractor muscles originate at base of bulbs; prebulbar organs absent.

Hooks hollow, heteromorphous, heteroacanthous typical. Distinctive basal armature characterized by 5 rows of 9 hooks (3 bent-tipped falciform, 3 hastate, and 3 falciform) rising from antiothrial surface of tentacle; sixth row with 1 bent-tipped falciform hook 4.5 long, followed by 3 uncinat hooks 3.8 long, and 3 rosethorn hooks measuring 4.5 long and 4.5 width at base. Seventh row with 8 uncinat hooks of slightly varying morphology and size (3.8–4.0 long) and 1 rosethorn hook 4.5 long on the bothrial face of the tentacle. Eighth and final row slightly offset of previous row; basal armature consists of 8 uncinat hooks of slightly different morphology followed by 1 falciform hook 4.0 long. Hooks becoming less dense distally; metabasal and distal armature characterized by obliquely rising half rows of 8 falciform hooks. Longest hooks (4.5 long) on bothrial face (8 [8']). Hooks 1 (1') 3.8 long, decreasing in size from antiothrial face to external side of tentacle (hooks 2 [2'] are 3.5, hooks 3 [3'] and 4 [4'] are 3.2, and hooks 5 [5'] are 3 long), then increasing again toward bothrial face (hooks 6 [6'] 3.4 long).

Terminal gravid proglottid 635–1,280 ( $1,102.3 \pm 236.1$ , 11) long by 149–327 ( $222.1 \pm 70.7$ , 11) wide. Genital pore postequatorial and alternating. Testes elliptical or subspherical, in 2 rows that sometimes overlap in the anterior four fifths of mature proglottids. Each proglottid containing 30–37 ( $33.5 \pm 1.7$ , 11) testes, 26–60 ( $43.8 \pm 12.1$ , 9) long by 6–20 ( $12.8 \pm 4.7$ , 9) wide. Cirrus armed; cirrus sac round, located in posterior third of mature proglottids, 70–149 ( $98.6 \pm 35$ , 5) long by 50–59.5 ( $60.4 \pm 11$ , 5) wide. External and internal seminal vesicles absent. Vagina muscular, entering genital atrium posterior to cirrus sac and continuing posteriorly, eventually forming a large sac-like seminal receptacle at the isthmus of the ovary. Ovary H shaped in dorsoventral view, each lobe measuring 130–471 ( $306.3 \pm 177.9$ ,



**Figures 21–24.** Scanning electron micrographs of *Prochristianella multidum* n. sp. **21.** Scolex. **22.** Tentacle showing basal and metabasal armature. **23.** Basal portion of tentacle. **24.** Pectinate microtriches from the proximal bothrial and pars bothridialis surface of the scolex.

5) long by 90–198 ( $131.9 \pm 49, 5$ ) wide in gravid proglottids. Uterus is median, tubular in mature proglottids, saccate with diverticula in gravid proglottids. Vitellaria circumcortical.

#### Taxonomic summary

*Type host:* Haller's round ray, *Urobatis halleri* (Cooper, 1863).

*Type locality:* Puerto Peñasco, Sonora, Mexico ( $31^{\circ}18'27''\text{N}$ ;  $113^{\circ}32'52''\text{W}$ ).

*Infection site:* Spiral intestine, chambers 1–11.

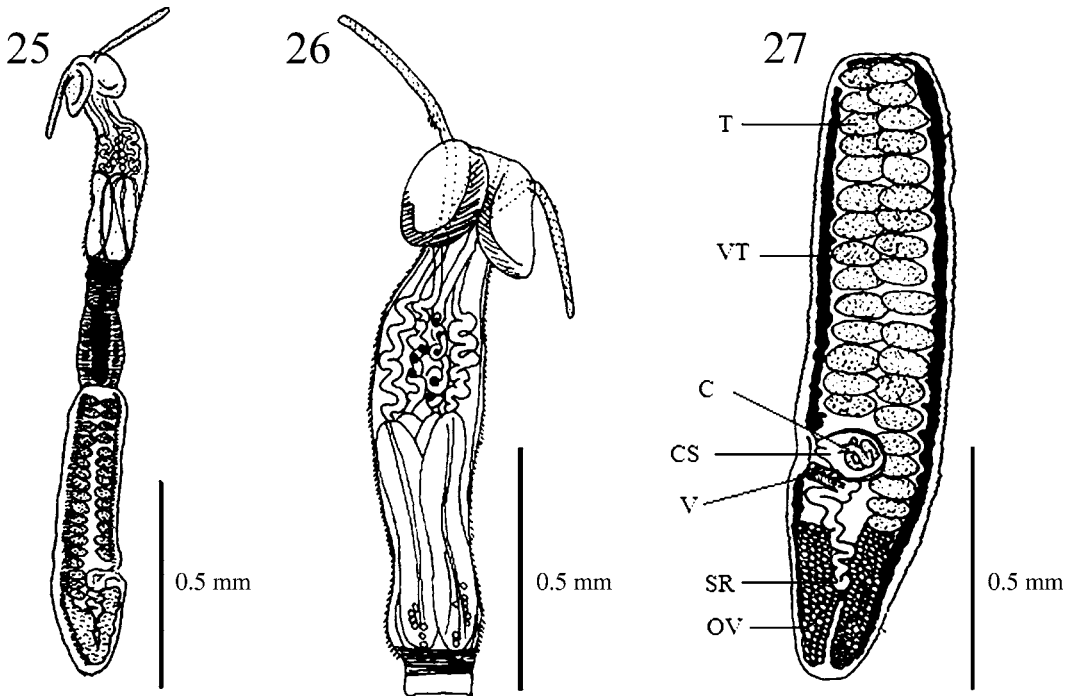
*Prevalence, mean intensity, abundance, and range of infection:* 71%, 39.7, 53.8 ( $\pm 70.7$ ), and 1–289.

*Species deposited:* Holotype (USNPC 92218) and paratype (USNPC 92219) deposited in the USNPC.

*Etymology:* The specific epithet, *multidum*, refers to the high intensity of infection within each host individual.

#### Remarks

There are 11 valid species of *Prochristianella*: *Prochristianella mooreae* Beveridge, 1990, *Prochristianella clarkeae* Beveridge, 1990, *Prochristianella butlerae* Beveridge, 1990, *Prochristianella papillifer* (Polyarkoff, 1909) Dollfus, 1957 (= *Prochristianella trygonicola* Dollfus, 1946), *P. minima*, *P. fragilis*, *Prochristianella hispida* (Linton 1890) Campbell and Carvajal, 1975, *Prochristianella tenuispinis* Linton, 1890, *Prochristianella thalassia* (Kovacs and Schmidt, 1980) Beveridge, 1990, *Prochristianella tumidula* (Linton, 1890) Campbell and Carvajal, 1975, and *Prochristianella spinulifera* Beveridge and Jones, 2000. *Prochristianella multidum* is



Figures 25–27. *Prochristianella multum* n. sp. 25. Entire worm. 26. Scolex. 27. Mature proglottid. (C, cirrus; CS, cirrus sac; OV, ovary; SR, seminal receptacle; V, vagina; VT, vitellaria; T, testes.)

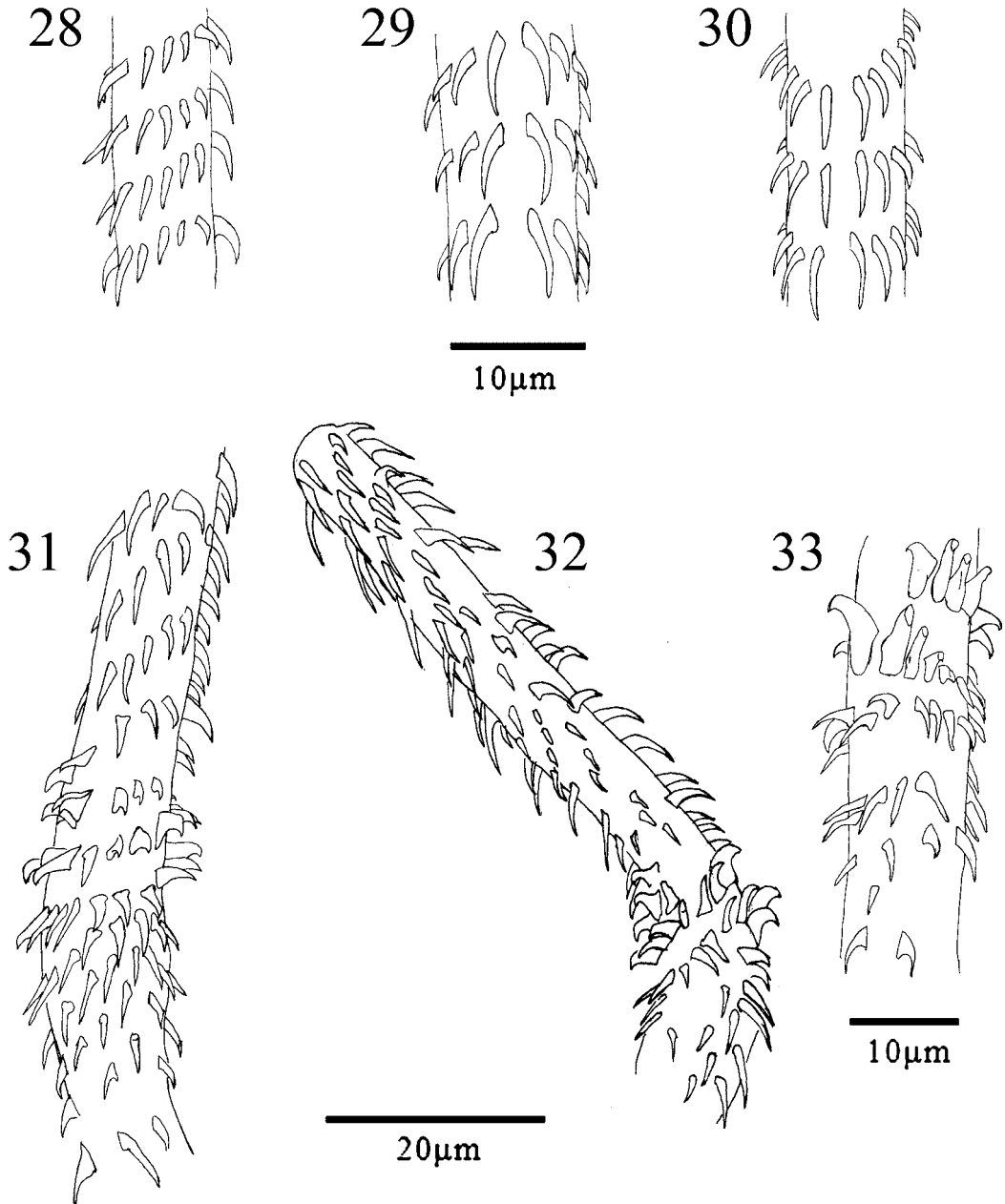
distinguished from *P. minima*, the only other species of this genus described from a urolophid host, by number of testes (30–37 vs. 18–25, respectively) and tentacle armature (*P. multum* possesses enlarged rosethorn hooks in sixth and seventh rows whereas *P. minima* does not). *Prochristianella multum* has 8 rows of hooks on its basal swelling, whereas *P. minima* possesses at least 20 and *P. butlerae*, *P. clarkeae*, *P. thalassia*, *P. papillifer*, *P. hispida*, and *P. mooreae* all have 11–12 rows of hooks. Basal hook row number and hook count are similar in *P. multum* and *P. tumidula*, but these taxa differ in both testes number (26–60 vs. 50–60, respectively) and the insertion of their metabasal hook rows (antibothrial vs. internal surface of the tentacle, respectively). The microtrichia-covered scolex of *P. multum* further distinguishes this species from *P. mooreae*, *P. papillifer*, *P. tumidula*, *P. fragilis*, and *P. hispida*.

Only 1 other species, *P. minima*, has been reported to have hooks arising from the antibothrial tentacular surface. Beveridge and Jones (2000) noted inconsistencies in armature descriptions of species in this genus, which likely arise from the difficulty in determining the tentacle orientation in such small

worms and concluded that members of *Prochristianella* are characterized by hook rows that originate on the bothrial surface. This description of *P. multum* reports an arrangement that is the mirror opposite of that suggested by Beveridge and Jones (2000). Given the lack of consistency among other descriptions of *Prochristianella* armature, it is difficult to assess implications of this observation with regard to generic classification. More interesting is the metabasal armature of *P. multum*, which departs from that of most other *Prochristianella* species by having large 1('1) hooks followed by hooks of decreasing and then increasing size. This arrangement contrasts the typical metabasal armature, where 1('1) hooks are smallest, followed by hooks of increasing length as they reach the opposite side of the tentacle.

## DISCUSSION

Currently, 6 species of *Rhinebothrium*, *R. urobati-dium*, *Rhinebothrium bilobatum* (Young, 1955) Appy and Dailey, 1977, *R. biorchidum*, *Rhinebothrium ditesticulum* Appy and Dailey, 1977, *Rhinebothrium magniphallum* Brooks, 1977 (Brooks and Mayes, 1980), and *R. flexile* (Young, 1954); 4 species of



**Figures 28–33.** Tentacle armature of *Prochristianella multidum* n. sp. 28. Distal external armature. 29. Distal bothrial armature. 30. Distal antibothrial armature. 31. Basal and metabasal external armature. 32. Basal and metabasal bothrial armature, oblique view. 33. Basal antibothrial armature.

*Eutetrarhynchus*, *E. thalassius*, *Eutetrarhynchus caribbensis* Kovacs and Schmidt, 1980, *E. schmidti*, *E. geraschmidti*; and *P. minima* have been reported from urolophid hosts. In addition, several species of *Acanthobothrium* (Goshroy and Caira, 2001), as well

as *Pararhinebothroides hobergi* Zamparo, Brooks, and Barriga, 1999, *Phyllobothrium hallericola* Church and Schmidt, 1990, *Anthocephalum duszynskii* Ruhnke, 1994, *Grillotia trigonisbucconis* (Wagener, 1854) Young, 1954, *M. myliobati*, *O. paulinae*, and

*Parachristianella trigonis* (Dollfus, 1946) Young, 1954, have been described or reported from urolophid hosts.

In this article, we add 1 *Prochristianella* and 2 *Rhinebothrium* species to the known cestode fauna of *U. halleri*, bringing the total number of *Prochristianella* and *Rhinebothrium* species described from *U. halleri* to 2 and 8, respectively. This is the first report of these genera from elasmobranchs inhabiting the Gulf of California. We also present the first description of a *Eutetrarhynchus* species infecting *U. halleri* and the first report of a eutetrarhynch from the Gulf of California. The descriptions presented in this study lack some specific details because the specimens were stored in formalin for 4 yr and their condition precluded histology and examination of cross-sectional detail. Nonetheless, these descriptions are useful and we hope that other workers will supplement these descriptions with data from other specimens.

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