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SPECIES OF *GORGODERINA* (DIGENEA: GORGODERIDAE) IN *RANA VAILLANTI* AND *RANA* CF. *FORRERI* (ANURA: RANIDAE) FROM GUANACASTE, COSTA RICA, INCLUDING A DESCRIPTION OF A NEW SPECIES

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ABSTRACT: *Gorgoderina parvicava*, *G. diaster*, and *G. megacetabularis* n. sp. are reported inhabiting the urinary bladders of *Rana vaillanti* and *R.* cf. *forreri* from northwestern Costa Rica. *Gorgoderina megacetabularis* n. sp. differs from all other species of the genus by the combination of the following characters: small body size (2.78–3.17, mean 2.92 mm), sucker ratio (1:3.1–3.7), and by the presence of 2 compact, oval, unlobed vitelline masses. Redescription of *G. diaster* including previously undescribed details on the reproductive apparatus and morphometric data is provided. This is the first record of the 3 species of *Gorgoderina* in Costa Rica and is the first record of *G. diaster* in *R. vaillanti* and *R.* cf. *forreri*.

The digenean *Gorgoderina* comprises 51 described species, all of which are parasites in the urinary bladder of anurans and caudates (Amphibia) throughout the world. Approximately half of them are distributed in North and South America. As part of an inventory of eukaryotic parasites of vertebrates in the Área de Conservación de Guanacaste (ACG) in Costa Rica, specimens of 3 species of *Gorgoderina* were collected including an undescribed species, inhabiting *Rana vaillanti* or *R.* cf. *forreri* (or both).

Rana vaillanti Brocchi, 1877 is distributed in low and moderate elevations from southern México (Veracruz, Oaxaca, and Chiapas states) (Meyer and Wilson, 1971) through the Pacific slope down to Colombia and Ecuador (Hillis and de Sá, 1988). Few helminthological studies of this amphibian species have been conducted, most of them in México (Razo-Mendivil et al., 1999; Guillén-Hernández et al., 2000; Pérez-Ponce de León et al., 2000; Goldberg et al., 2002; Paredes-Calderón et al., 2004) and 2 records in Costa Rica (Zelmer and Brooks, 2000; León-Règagnon et al., 2001; Rodríguez-Ortíz et al., 2003). These studies have reported 25 helminth species parasitizing *R. vaillanti*.

Rana forreri Boulenger, 1883 was previously considered to occur along the Pacific coastal plain and adjacent lowlands of México and Central America (Flores-Villela et al., 1995), although molecular evidence indicates (Hillis et al., 1983; Zaldivar-Riverón et al., 2004) it is a composite taxon. Specimens in Costa Rica previously considered to be *R. forreri* presumably constitute an undescribed species of this group of frogs. Only 4 parasitological studies of this amphibian species complex have been conducted; 3 in México (Pérez-Ponce de León et al., 2000; Goldberg and Bursey, 2002; Cabrera-Guzmán et al., 2004) and 1 in Costa Rica (Desser, 2001; Rodríguez-Ortíz et al., 2003). These studies have reported 23 parasite taxa. Most of them dealt with nematodes having direct life cycles that reflect the more terrestrial character of this amphibian species complex().

MATERIALS AND METHODS

Between 1998 and 1999, specimens of *R. vaillanti* and *R.* cf. *forreri* were collected in various parts of the ACG, Costa Rica. Hosts were examined for helminth parasites. Specimens of *Gorgoderina* spp. were removed from the urinary bladder and placed in saline solution (0.6%), fixed in hot 4% formaldehyde, and preserved in 70% ethanol. Some specimens were stained in Mayer's paracarmine or Gomori's trichrome, dehydrated, cleared in methyl salicylate, and whole mounted in Canada balsam. Figures were drawn with the aid of a drawing tube. Measurements are presented as range with mean in parentheses and expressed in micrometers (μm). Specimens for scanning electron microscopy were dehydrated with a graded series of ethanol and critical-point dried with CO_2, then covered with gold–palladium mixture. They were examined using a Hitachi S2460N electron microscope. The following abbreviations are used: CHCR, Colección Helmintológica de Costa Rica; CNHE, Colección Nacional de Helmintos, Instituto de Biología, Universidad Nacional Autónoma de México; CHIOC, Coleção Helmintológica do Instituto Oswaldo Cruz Fundação Instituto Oswaldo Cruz, Río de Janeiro, Brazil; HWML, Harold W. Manter Laboratory of Parasitology, Lincoln, Nebraska; NHM, Natural History Museum, London, U.K.; NBM, New Brunswick Museum, New Brunswick, Canada; USNPC, United States National Parasite Collection, Beltsville, Maryland(). The following specimens were examined for comparison: *G. alobata* NHM, 1965.6.25. 1–2; *G. attenuata* CNHE, 1178–1180, 1182, 1446, 1544–1548, 2416, 3401–3405, 3412, 3413, 3793; HWML, 740, 17079, 20121–20126, 20888, 20955, 21344, 21949, 24898, 31259, 33206; USNPC, 051644.00, 075452.00, 081464.00; NBM, 3542 and 10 not cataloged slides; *G. diaster* CHIOC, 17426, 25255, 25256; HWML, 20250; NHM, 1980.11.12.7–8 and 1 slide from the reference collection of D. R. Brooks; *G. intermedia* USNPC, 007996.00; *G. parvicava* CNHE, 1177, 2415; CHIOC, 19076, 21076, 21509–21511, 21871–21877, 25261, 25262, 25264, 25269, 25271–25279, 25284, 25288, 25290, 29043, 34171; NHM, 1988.9.15.9; *G. tenua* USNPC, 008976.00; *G. vitelliloba* NHM, 1933.7.19.22, 1937.6.8.151, 1946.5.8.182, 1975. 8.16.113–114, 1976.4.9.18–22, 1983.6.9.3, 1984.10.9.16; HWML, 34301. Prevalence and intensity are used following Margolis et al. (1982).

DESCRIPTION

Gorgoderina megacetabularis n. sp.
(Figs. 1–4)

Description (based on 46 specimens): Measurements based on 13 mature specimens. Body spindle shaped, blunt anterior end, pointed posterior end; body length (BL) 2,780–3,170 (2,920) (n = 7). Forebody 340–680 (520) long (12.2–21.4% [17.8%] of BL) (n = 7), 160–220 (190) (n = 7) wide at level of cecal bifurcation. Hindbody 1,110–1,770 (1,580) long (39.9–55.8% [51.1%] of BL) (n = 7), 240–290 (270) (n = 7) wide at level of anterior testis (Fig. 1). Tegumental surface aspinose, with numerous regular ridges surrounding body, covered with knoblike protuberances. Numerous large papillae present on tegument, concentrating on oral sucker and on the region between both suckers (Figs. 2, 3A, B).

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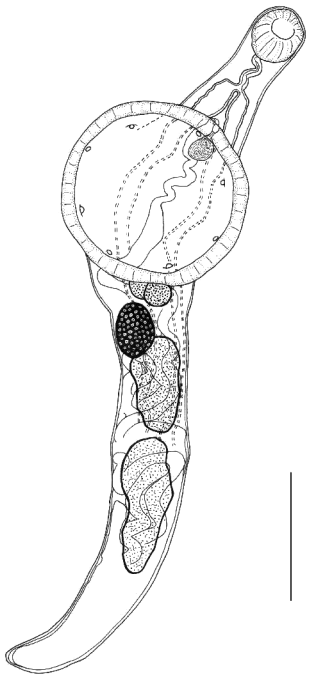

FIGURE 1. *Gorgoderina megacetabularis* n. sp. ventral view. Bar = 50 μm.

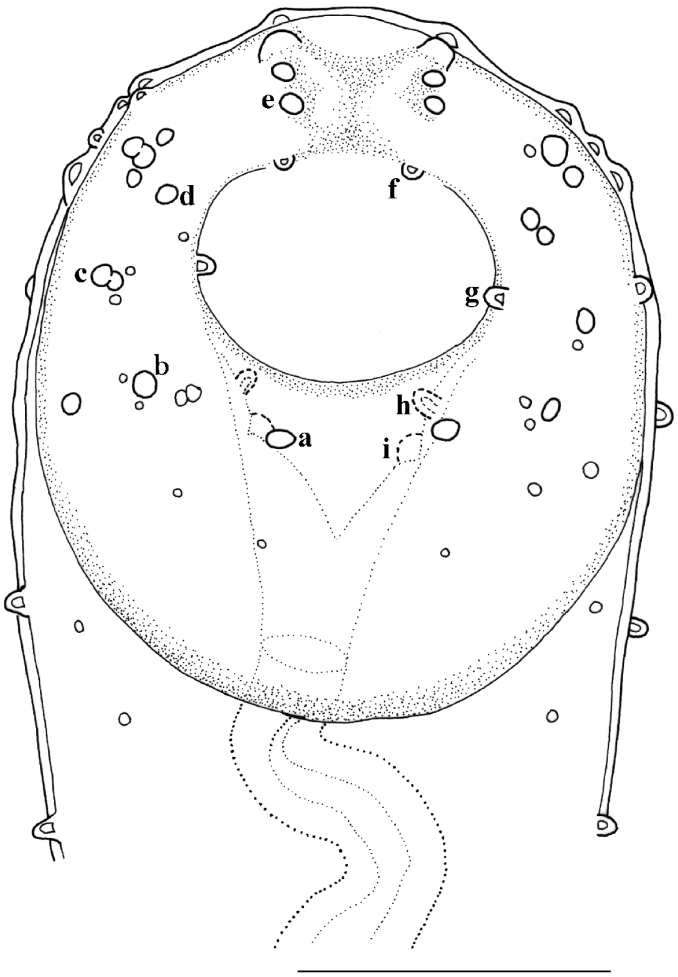

FIGURE 2. *Gorgoderina megacetabularis* n. sp. Oral sucker. (**a**–**e**) 5 pairs of papillae surrounding oral opening; (**f**–**i**) 4 pairs of papillae in the oral opening. Bar = 20 μm.

Oral sucker subterminal, spherical (Fig. 2), 180–250 (210) long, 170–220 (200) wide (n = 9); 5 pairs of papillae surrounding oral opening (Fig. 2a–e). Four additional pairs of papillae flanking the stylet pit on apical region of body (Fig. 3C); 1 pair of papillae on dorsal border of oral opening (Figs. 2f; 3A), and 1 pair on lateral borders of oral aperture (Fig. 2g); 2 extra pairs are located on the oral cavity (Fig. 2h, i). Small papillae on the oral sucker surface, arrangement varying among examined specimens (Fig. 3A). Pharynx absent. Esophagus curved, thick walled, 140–230 (190) long (5–7.25% [6.5%] of BL) (n = 10). Intestinal bifurcation 250–360 (330) (8.99–11.35% [11.3%] of BL) (n = 10) from anterior end of body. Ceca simple, initial portion wider and lobed; ceca ending at 170–400 (260) (6.1–12.6% [8.9%] of BL) (n = 8) from posterior extremity (Fig. 1).

Ventral sucker in anterior third of body; 380–740 (560) long, 510–730 (600) wide (n = 6). Eight papillae on internal surface of acetabulum (Fig. 1); 2 pairs lateral to longitudinal axis, covered with flattened scales (Fig. 3D); 1 pair of simple papillae located on middle line of longitudinal axis of sucker and 1 additional pair on transversal axis (Fig. 3E). Sucker ratio 1:3.1–3.7 (3.43).

Testes 2, elongate, borders irregular, sometimes bilobed, in tandem, intercecal, postequatorial, at 84–570 (215) (3–18% [7.36%] of BL) (n = 10) from posterior margin of ventral sucker. Anterior testis smaller than posterior testis, sometimes partially overlapping one another. Anterior end of anterior testis overlapping posterior end of ovary; 200–430 (340) long, 90–250 (170) wide, 150–220 (180) deep (n = 12). Posterior testis 330–730 (530) long, 140–270 (180) wide, 130–220 (170) deep (n = 11). Vas deferens runs anteriorly. Seminal vesicle oval or spherical, dorsal to the anterior edge of acetabulum; 57–210 (130) long, 70–140 (110) wide, 90–210 (140) deep (n = 10). Distal end of seminal vesicle surrounded by prostatic cells; opening into genital atrium. Genital pore anterior to ventral sucker, medially, at 400–520 (570) (14.4–16.4% [19.5%] of BL) (n = 5) from anterior extremity of body (Fig. 1). Ovary oval, dextral (in 39 of the 46 specimens), posterior to vitellaria, at 50–160 (100) (1.8–5.0% [3.42%] of BL) (n = 3) from posterior end of acetabulum, 180–250 (220) long, 130–170 (140) wide, 130–160 (140) deep (n = 11). Vitellaria 2, compact oval masses, immediately posterior to acetabulum on middle line of body (Fig. 4A). Dextral vitelline gland 81–130 (110) long, 79–120 (90) wide, 80–130 (110) deep (n = 12); left vitelline gland 80–140 (110) long, 70–130 (100) wide, 60–120 (90) deep (n = 12). Mehlis' gland and Laurer's canal not observed. Uterine loops filling postacetabular region and overlapping dorsally and ventrally with testes, partially overlapping ovary and vitelline glands, opening to genital atrium (Fig. 4B). Eggs thin shelled, embryonated, 25–32 (28) long, 15–20 (17) wide. Excretory vesicle could not be observed. Excretory pore terminal (Fig. 3F).

Taxonomic summary

Type host: Rana vaillanti Brocchi, 1877 (Anura: Ranidae).
Site of infection: Urinary bladder.
Prevalence, intensity: See Table II.

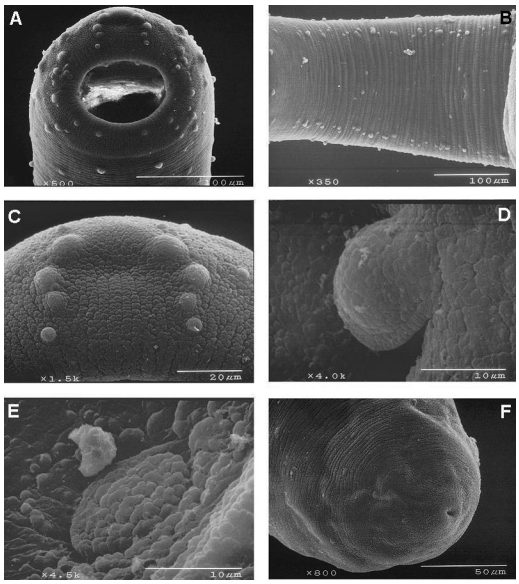

FIGURE 3. SEM photomicrographs of *Gorgoderina megacetabularis* n. sp. **A.** Oral sucker. **B.** Preacetabular region. **C.** Stylet pit. **D.** Acetabular papilla covered with flattened scales. **E.** Acetabular simple papilla. **F.** Body posterior extremity.

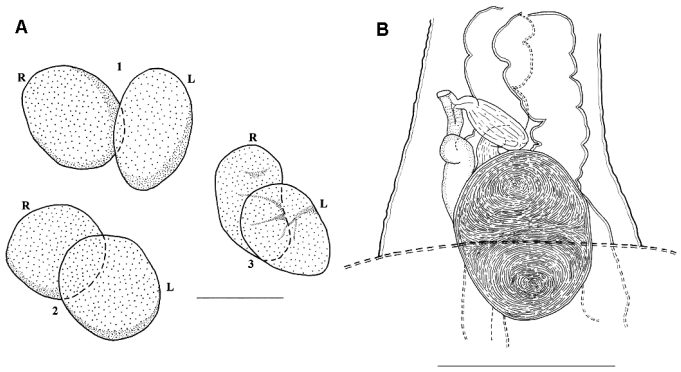

FIGURE 4. *Gorgoderina megacetabularis* n. sp. **A.** Vitellaria from 3 specimens; 1 and 2 ventral view, 3 lateral view (L left vitellaria, R right vitellaria). **B.** Ventral view of seminal vesicle and genital atrium. Bar = 100 μm.

Co-occurrence: Gorgoderina megacetabularis n. sp. co-occurred with *G. parvicava* in 2 hosts and with *G. diaster* in 2 hosts.

Type locality: Río Pizote between Brasilia and Dos Ríos, sector San Gerardo (San Cristóbal), ACG, Costa Rica.

Other localities: Río Pizote, sector Santa Rosa and Sector Caribe, ACG, Costa Rica.

Type specimens: Holotype, CNHE 5000; paratypes, CNHE 5001, USNPC 94751, 94752, CHCR 115; vouchers, CNHE 5002, USNPC 94793, 94754.

Etymology: The specific epithet refers to the size of the ventral sucker, which is relatively much larger than that for any other known species in the genus.

Remarks

The new species differs from all the described species of *Gorgoderina* in having a sucker ratio of 1:3.1–3.7; *G. insularis* Richard, Chabaud and Brygoo, 1968, which occurs in *Ptychadena mascareniensis* in Madagascar has a sucker ratio averaging 1:2.4 and is most similar in this regard (Table I).

Fully ovigerous specimens of *G. megacetabularis* n. sp. are small, thus resembling *G. alobata* Lees and Mitchell, 1966, *G. attenuata* (Stafford, 1902) Stafford, 1905, *G. carli* Baer, 1930, *G. chilensis* Dioni, 1947, *G. darwini* Mañé-Garzón and González, 1978, *G. intermedia* Holl, 1928, *G. insularis*, *G. gracilis* Wongsawad et al., 1999, *G. tenua* Rankin, 1937, *G. symmetriorchis* Dwivedi, 1968, and *G. vitelliloba* Olsson, 1876. In addition to the sucker ratio, the new species differs from *G. attenuata*, *G. chilensis*, *G. darwini*, *G. intermedia*, *G. insularis*, *G. tenua*, and *G. vitelliloba* by having vitelline glands arranged in 2 compact, unlobed oval masses, whereas the vitellaria are lobed in all other small species of *Gorgoderina*.

The new species most closely resembles *G. alobata*, which occurs in *Bombina variegata* in Europe, by having small body size and unlobed vitellaria. However, *G. alobata* has a sucker ratio of 1:1 and intestinal ceca extending only to the level of the posterior end of the posterior testis, whereas in the new species they reach two thirds the way between the posterior testis and the posterior end of the body.

REDESCRIPTION

Gorgoderina diaster Lutz, 1926

(Fig. 5)

Six specimens were collected in 2 hosts. Measurements are based on 3 mature specimens. Body length 7,820–7,910 (7,860), maximum wide at level of posterior testis 930 (11.8% of BL). Forebody 810–1,020 (915) long (10.35–12.89% [11.64%] of BL), 750 wide at level of cecal bifurcation; hindbody 6,311 long (80.3% of BL), 930 maximum wide. Oral sucker subterminal, spherical, 480 in diameter. Pharynx absent. Esophagus long and curved. Intestinal bifurcation 740 (9.35–9.5% of BL) from anterior end of body. Ceca simple and lobed; right cecum ending at 350–850 (620) (4.5–10.7% [7.9%] of BL) from posterior extremity; left cecum at 350–550 (460) (4.5–6.95% [5.85%] of BL) (Fig. 5A). Four penetration glands on each side of the oral sucker, opening dorsally, anterior to this structure. Ventral sucker at 3,200 (41% of BL) from anterior end, 700–780 (730) long, 740–750 wide. Sucker ratio 1: 1.25–1.59 (1.49). Testes 2, oval, in tandem. Anterior testis at 800 (10.2% of BL) to posterior margin of ventral sucker, 640–730 long, 450–570 wide; posterior testis 710–750 long, 410–500 wide. Seminal vesicle bipartite, anterior to acetabulum; proximal portion 130–250 long, 150–160 wide, distal portion 170 long, 190 wide. Genital pore at 890 (11.32% of BL) from anterior end of body. Ovary pretesticular, sinistral, at 450 (5.72% of BL) to posterior margin of ventral sucker, 450–520 (470) long, 300–390 (350) wide. Vitellaria 2 clusters of preovarian follicles, at 100–370 (1.3–4.7% of BL) to posterior margin of ventral sucker, right vitellarium with 12 follicles, left vitellarium with 7–8 follicles (Fig. 5B). Mehlis' gland dorsal at junction of vitelline duct. Laurer's canal opening dorsally between vitellarium, ovary, and anterior testis (Fig. 5C). Uterine loops filling postacetabular region. Eggs 27–32 (29) long, 17 wide. Excretory vesicle Y-shaped, bifurcation at level of vitellaria. Excretory pore terminal.

TABLE I. Species of *Gorgoderina* Looss, 1902. BL = body length (mm); OS = oral sucker; Ac = acetabulum.

Species	Distribution	Host	Vitelline glands	BL	OS/Ac
G. africana Meskal, 1970	Africa	*Rana angolensis*	Unlobed	4.02–5.85	1:1.59–2
G. alobata Lees & Mitchell, 1966	Austria; Yugoslavia; Czech Republic; Greece; Poland	*Bombina variegata*	Unlobed	2.24–3.2	1:1
G. attenuata (Stafford, 1902) Stafford, 1905	Canada; United States; México; Guatemala	*R. catesbeiana* *R. virescens* *Bufo* sp. *Triturus viridescens* *Ambystoma lermaensis* *A. dumerilii* *R. dunni* *R. montezumae* *R. megapoda* *R. vaillanti* *R. pipiens* *R. blairi* *Leptodactylus melanonotus*	Lobed	3.3–7.2	1:2.1
G. aurora Ingles, 1936	United States	*R. aurora* *B. boreas*	Lobed	5–8	1:2–2.4
G. beninensis Bourgat, Dossou & Gasc, 1976	Africa	*Dicroglossus occipitalis*	Unlobed	7.5	1:1.76
G. bilobata Rankin, 1937	United States	*A. opacum* *Desmognathus fuscus* *Pseudotriton montanus* *P. ruber* *T. viridescens*	Lobed	3.49–8.16	1:1.26
G. bombinae Yu & Lee, 1983	Korea	*Bombina orientalis*	Unlobed	1.79–4.84	1:1.2–1.5
G. bufonis (Frandsen, 1957) Yamaguti, 1971	United States	*B. boreas*	Lobed	7.5–9	1:1.2
G. capsensis Joyeux & Baer, 1934	Tunisia	*R. esculenta ridibunda*	Lobed	6.0	1:2
G. carangis (MacCallum, 1913) Yamaguti, 1971	United States	*Caranx crysos*	Unlobed	13	1:0.6
G. carioca Fernandes, 1958	Brazil	*L. ocellatus*	Clusters of follicles	6–11.95	1:1.5
G. carli Baer, 1930	India	*Uraeotyplus oxyurus* *Ichthyophis orthoplicatus*	Unlobed	3	1:0.65–1.66
G. cedroi Travassos, 1924	Brazil	*Elosia nasus*	Unlobed	4.3–6	1:1.6
G. chauhani Prasad & Prasad, 1990*					
G. chilensis Dioni, 1947	Uruguay; Chile.	*Rhinoderma darwini*	Lobed	2.76–3.63	1:2.1
G. cryptorchis Travassos, 1924	Ecuador; Brazil; Paraguay	*B. crucifer* *L. ocellatus* *B. d'orbignyi*	Lobed	4–4.7	1:1.35
G. darwini Mañe-Garzón & González, 1978	Chile	*Melanophyniscus stelzneri*	Lobed	2.85–3.99	1:0.73
G. diaster Lutz, 1926	Venezuela; Colombia; Costa Rica	*Pseudis paradoxus* *R. palmipes* *Hyla goughi* *Rana* sp. *B. marinus* *R.* cf. *forreri* *R. vaillanti*	Clusters of follicles	5.39	1:1.3
G. ellipticum Dwivedi, 1968	India	*R. cyanophlyctis* *Haplobatrachus tigerinus* *Euphlyctis cyanophlyctis*	Unlobed	4.69–5.72	1:1.5
G. gracilis Wongsawad et al., 1999	Thailand	*Ichthyophis supachaii*	Unlobed	2.25–2.4	1:0.75–1
G. guptai Jahan, 1973	India	*Bufo* sp.	Lobed	3.58	1:0.7
G. indica Gupta & Jehan, 1971	India	*Bufo* sp.	Lobed	3.58	1:0.7
G. infundibulata Dwivedi, 1968	India	*B. melanostictus*	Unlobed	5.58–6.01	1:1.6–1.8
G. insularis Richard, Chabaud & Brygoo, 1968	Madagascar	*Ptychadaena mascareniensis*	Lobed	1.99–2.2	1:2.3—2.4

TABLE I. Continued.

Species	Distribution	Host	Vitelline glands	BL	OS/Ac
G. intermedia Holl, 1928	United States	*T. viridescens*	Lobed	1.44–2.76	1:1.56 1:1.87
G. kajika (Ozaki, 1926) Ozaki, 1935	Japan	*Polypedates buergeri*	Unlobed	4.55	1:1.42
G. malaysiensis Fichtal & Kuntz, 1965	Borneo	*R. kuhli*	Lobed	3.574	1:1.02–1.14
G. megacysta Mañé-Garzón & González, 1978	Uruguay	*L. ocellatus*	Unlobed	3.97–4.84	1:0.6
G. megalorchis Bravo, 1949	México; Costa Rica	*B. marinus*	Lobed	6.33–8.88	1:1.6
G. multilobata Ingles & Langston, 1933	United States	*R. boylii* *R. pretiosa* *R. aurora*	Clusters of follicles	7.1–11.7	1:1.69
G. opaca (Stafford, 1902) Stafford, 1905	Canada	*B. lentiginosus*	Lobed	6.58–7.59	1:1.5
G. orientalis Strom, 1940	Kirghizia	*R. esculenta*	Lobed	5.54–8.0	1:1.92
G. parvicava Travassos, 1922	México; Guatemala; Brazil; Uruguay; Costa Rica	*L. ocellatus* *L. pentadactyllus* *R vaillanti* *Pseudis* sp. *Rana* sp.	Unlobed	11–14	1:0.9
G. permagna Lutz, 1926	Venezuela	*L. pentadactylus*	Lobed	8.4–21.1	1:0.82–1.42
G. pigulevskyi Fernandes, 1958	Brazil	*L. ocellatus*	Clusters of follicles	10.5–14.7	1:1.2
G. rhyacosiredonis (Bravo, 1943)	México	*Rhyacosiredon altamirani*	Lobed	3.22–3.94	1:2.1
G. rochalimai Pereira & Cuocolo, 1940	Brazil	*B. paracnemys*	Clusters of follicles	10.3–16.6	1:1.6
G. schistorchis Steelman, 1938	United States	*Necturus maculosus*	Lobed	1.58–3.28	1:1.27
G. simplex Looss, 1902	Canada; United States	*R. catesbeiana* *R. clamitans* *R. pipiens* *B. americanus*	Lobed	7–12	1:1.3 1:1.5
G. skarvilovitschi Pigulevsky, 1953	México	*R. montezumae*	Lobed	3–10	1:2–2.3
G. sphincterostoma Fischthal, 1977	Africa	*Phrynobatrachus* sp.	Unlobed	2.96–3.02	1:1.46–2.13
G. skrjabini Pigulevsky, 1953	Russia	*R. temporaria*	Clusters of follicles	9–10	1:1.5–2.3
G. stricta (Oshmarin, 1965) Yamaguti, 1975*	Russia	*Formio niger*		2.8–5.35	
G. symmetriorchis Dwivedi, 1968	India	*R. limnocharis*	Unlobed	2.81–3.39	1:1.6
G. tanagawaensis Uchida & Itagaki, 1974	Japan	*B. japonicus*	Lobed	6.5–8.5	1:1.28–1.33
G. tanneri Olsen, 1937	United States	*R. pretiosa*	Lobed	2.07–7.67	1:2.25
G. tenua Rankin, 1937	United States	*Eurycea guttolineata*	Lobed	3.06–3.32	1:1.3
G. translucida (Stafford, 1902) Stafford, 1905	Canada; United States	*T. americanus* *Rana* *Bufo*	Lobed	8.06–9.45	1:1.5
G. valdiviensis Puga, 1979	Chile	*Caudiverbera caudiverbera*	Unlobed	4.63–9.86	1:1.6
G. vitelliloba (Olsson, 1876) Ssinizin, 1905	Spain; Turkey; Russia	*R. temporaria* *R. ridibunda* *R. arvalis* *R. macronecmis* *B. vulgaris* *B. bufo* *Bombinatus igneus*	Lobed	3–3.45	1:1.09
G. zigzagorchis Chin, 1963	China	*R. boulengeri* *R. adenopleura*	Lobed	5.6–6.2	1:1.45
G. megacetabularis n. sp.	Costa Rica	*R. vaillanti*	Unlobed	2.78–3.17	1:3.1–3.7

* Cited in reviewed literature; original descriptions were unavailable.

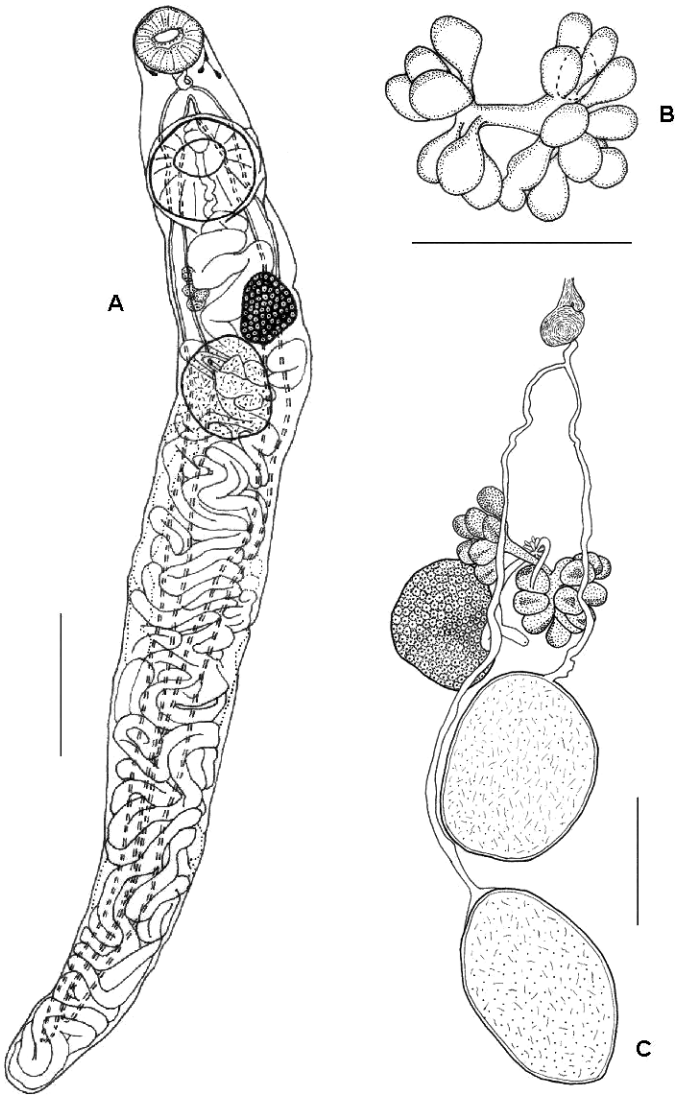

FIGURE 5. *Gorgoderina diaster*. **A.** Ventral view. Bar = 1,000 μm. **B.** Vitelline glands. Bar = 300 μm. **C.** Mehlis' gland, Laurer's canal, ovary, and testes. Bar = 500 μm.

Taxonomic summary

Host: Rana vaillanti Brocchi, 1877; *R.* cf. *forreri* Boulenger, 1883 (Anura: Ranidae), new host, new record.

Site of infection: Urinary bladder.

Prevalence, intensity: See Table II.

Co-occurrence: With *G. megacetabularis* n. sp. in 2 specimens of *R. vaillanti*.

Locality: Río Pizote between Brasilia and Dos Ríos, sector San Gerardo, ACG, Costa Rica (*R. vaillanti*).

Other localities: Laguna Los Jicaros, sector Santa Elena; Camino a Playa Naranjo, sector Santa Rosa, ACG, Costa Rica (*R.* cf. *forreri*).

Vouchers: CNHE 4984

Previous records: Rana palmipes and *Pseudis paradoxa* from Maracay, Venezuela (Lutz, 1928; Fernandes, 1958); *Bufo marinus* from 15 km west of Neiva, Huila, Colombia (Brooks, 1976), and from King Rhom, Jamaica (voucher NHM-1980.11.12.7–8); new record.

Remarks

The original description of *G. diaster* (Lutz, 1926) is inadequate. Fernandes (1958) redescribed this species adding some morphometric information, but he based his observations on 1 single specimen. In this study, previously undescribed details about the male and female reproductive apparatus, penetration glands, and additional morphometric data are provided, based on the study of the material collected by Lutz—CHIOC17426, 25255, 25256—and on the material collected in Guanacaste.

ADDITIONAL OBSERVATIONS

Gorgoderina parvicava Travassos, 1922

Taxonomic summary

Host: Rana vaillanti Brocchi, 1877 (Anura: Ranidae).

Site of infection: Urinary bladder.

Prevalence, intensity: See Table II.

Co-occurrence: With *G. megacetabularis* n. sp. in 2 specimens of *R. vaillanti*.

Locality: Río Pizote between Dos Ríos and Brasilia, sector San Cristobal, ACG, Costa Rica, new locality.

Vouchers: CNHE 4985, 4986.

Previous records: Leptodactyllus ocellatus from Provincia do Manguinhos, Angra dos Reis, São Paulo, Brazil (Travassos, 1922), Recife (Chacon, Cordeiro, Engenho do Meio, Tejipió,

TABLE II. Prevalence (P) and intensity (I) of *Gorgoderina diaster, G. parvicava,* and *G. megacetabularis* n. sp. in *Rana vaillanti* (Rv) and *R.* cf. *forreri* (Rf) of Guanacaste, Costa Rica.

		1998		1999	
		Rv	Rf	Rv	Rf
Number of Examined specimens		44	26	13	13
Gorgoderina diaster	P	1/44 (2.3%)	0	0	1/13 (7.69%)
	I	2/1	0	0	4/1
Gorgoderina parvicava	P	0	0	3/13 (23.1%)	0
	I	0	0	16/3	0
Gorgoderina megacetabularis n. sp.	P	23/44 (52.3%)	0	3/13 (23.1%)	0
	I	163/23	0	19/3	0

Tórre) and Cavaleiro (Municipio de Jaboatão), Estado de Pernambuco, Brazil (Dobbin, 1957); Volta Redonda, Río de Janeiro, Brazil (Vicente and dos Santos, 1976; Faria, 1978) and Lake Diario, Maldonado, Uruguay (Mañe-Garzón and González, 1978); *L. pentadactyllus labyrinthicus* from Recife (Chacon, Cordeiro, Engenho do Meio, Tejipió, Tórre) and Cavaleiro (Municipio de Jaboatão), Estado de Pernambuco, Brazil (Dobbin, 1957), Belo Horizonte, and Minas Gerais, Brazil (Fernandes, 1958); *Rana* sp. from La Guardianía de Macá, Municipio de Santa Bárbara, Suchitepéquez, Guatemala (Caballero, 1946); *R. vaillanti* from Los Tuxtlas, Veracruz, México (Guillén-Hernández et al., 2000; Paredes-Calderón et al., 2004).

DISCUSSION

Pereira and Cuocolo (1940), Pigulevsky (1953), and Fernandes (1958) separately proposed subgeneric divisions within *Gorgoderina*, mainly based on the structure and position of vitelline glands. However, the characters they used are variable among the genera in the Gorgoderidae. Therefore, we do not consider any subgeneric divisions in this study.

This is the second report of *Gorgoderina* in Costa Rica. Caballero et al. (1957) reported *G. megalorchis* Bravo-Hollis, 1948 in *Rana* sp. from Piedades de Santa Ana, Provincia de San José (Rodríguez-Ortíz et al., 2003). This study expands our knowledge of the distribution of some trematodes of *Rana* hosts through new parts of its range. These new records of *Gorgoderina* spp. in Costa Rica suggest historical affinities with the host groups.

Gorgoderina diaster has been reported previously in Venezuela in *R. palmipes*, *Pseudis paradoxus*, and *Hyla goughi* and in Colombia in *B. marinus*. In a phylogenetic study of the *R. palmipes* complex based on morphological and molecular characters, Hillis and de Sá (1988) suggest that *R. vaillanti* and *R. palmipes* are sister species. According to their proposal, the Andes of South America are the primary geographical barrier between these 2 species. *Rana vaillanti* is distributed in the lowland tropical forests west of the Andes and north into Central America, whereas *R. palmipes* is restricted to the lowland tropical forests east of the Andes. The presence of this digenean species in both host species may suggest an ancestral association between the parasite and the ancestor of *R. vaillanti* and *R. palmipes*. It also suggests that both host species share similar environmental conditions and feeding habits.

Gorgoderina parvicava occurs in México in *R. vaillanti*, in Guatemala in *Rana* sp., and in Brazil in *Leptodactylus* spp. and *Bufo* spp. These records indicate an extensive neotropical distribution, probably reflecting the distribution of their preferred hosts.

Whether *G. megacetabularis* n. sp. originated with the speciation of *R. vaillanti* or as a host-switching event from other amphibians in the region can only be tested with a phylogenetic hypothesis for species of *Gorgoderina*. *Rana vaillanti* has also been recorded as host of *G. attenuata* and *G. parvicava* in Los Tuxtlas, Veracruz, México, with a total of 4 species of *Gorgoderina* recorded in this host species. *Rana vaillanti* has predominantly aquatic habits that favor the completion of the life cycle of *Gorgoderina* and many other digeneans. This characteristic, together with its wide geographic range probably also favors speciation events by host switching of parasites that typically infect other amphibians. A similar case occurs with *G. attenuata*, known in green frogs (*R. clamitans*), bull frogs (*R. catesbeiana*), and leopard frogs (of wich *R. forreri* is a member) in North America.

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LITERATURE CITED

BROOKS, D. R. 1976. Five species of platyhelminths from *Bufo marinus* L. (Anura: Bufonidae) in Colombia with descriptions of *Cretotrema lynchi* sp. n. (Digenea: Allocreadiidae) and *Glypthelmins robustus* sp. n. (Digenea: Macroderoididae). Journal of Parasitology **62:** 429–433.

CABALLERO, C. E. 1946. Estudios helmintológicos de la región Oncocercosa de México y de la República de Guatemala. Trematoda. II. Presencia de *Paragonimus* en reservorios naturales y descripción de un nuevo género. Anales del Instituto de Biología, Universidad Nacional Autónoma de México **17:** 137–165.

———, R. R. BRENES, AND O. JIMÉNEZ-QUIRÓS. 1957. Helmintos de la República de Costa Rica. Algunos tremátodos de animales domésticos y silvestres. Revista de Biología Tropical **5:** 135–155.

CABRERA-GUZMÁN, E., V. LEÓN-RÈGAGNON, AND L. GARCÍA-PRIETO. 2005. Helminth infracommunities of leopard frog *Rana forreri* (Amphibia: Ranidae) in Acapulco municipality in Guerrero, Mexico. Comparative Parasitology. [In press.]

DESSER, S. S. 2001. The blood parasites of anurans from Costa Rica with reflections on the taxonomy of their trypanosomes. Journal of Parasitology **87:** 152–160.

DOBBIN, J. E. 1957. Fauna Helmintológica de batráquios de Pernambuco, Brasil. I. Trematoda. Separata dos Anais da Sociedade de Biologia de Pernambuco **15:** 29–61.

FARIA, M. J. DE. 1978. Prevaléncia de trematódeos parasites de anfibios anuros, n. estado do Rio de Janeiro. Atas da Sociedade de Biología do Rio de Janeiro **19:** 55–57.

FERNANDES, J. C. 1958. Notas sobre algumas espécies do genero *Gorgoderina* Looss, 1902 (Trematoda: Gorgoderidae). Memorias do Instituto Oswaldo Cruz **56:** 1–15.

FLORES-VILLELA, O., F. MENDOZA-QUIJANO, G. P. GONZÁLEZ, AND E. PÉREZ-RAMOS. 1995. Recopilación de claves para la determinación de anfibios y reptiles de México. Publicaciones Especiales del Museo de Zoología de la Facultad de Ciencias, 10. Universidad Nacional Autónoma de México, México City, D.F., México, 285 p.

GOLDBERG, S. R., AND C. R. BURSEY. 2002. Helminth parasites of seven anuran species from Northwestern Mexico. Western North American Naturalist **62:** 160–169.

———, ——— G. SALGADO-MALDONADO, R. BÁEZ, AND C. CAÑEDA. 2002. Helminth parasites of six species of anurans from Los Tuxtlas and Catemaco Lake, Veracruz, México. Southwestern Naturalist **47:** 293–299.

GUILLÉN-HERNÁNDEZ, S., G. SALGADO-MALDONADO, AND R. LAMOTHE-ARGUMEDO. 2000. Digeneans (Platyhelminthes: Trematoda) of seven sympatric species of anurans from Los Tuxtlas, Veracruz, México. Studies of the Neotropical Fauna and Environment **35:** 10–13.

HILLIS, D., AND R. DE SÁ. 1988. Phylogeny and taxonomy of the *Rana palmipes* group (Salientia: Ranidae). Herpetological Monographs **2:** 1–26.

———, J. S. FROST, AND D. A. WRIGHT. 1983. Phylogeny and biogeography of the *Rana pipiens* complex: a biochemical evaluation. Systematic Zoology **32:** 132–143.

LEÓN-RÈGAGNON, V., D. R. BROOKS, AND D. A. ZELMER. 2001. Morphological and molecular description of *Haematoloechus meridionalis* n. sp. (Digenea: Plagiorchioidea: Haematoloechidae) from *Rana vaillanti* Brocchi of Guanacaste, Costa Rica. Journal of Parasitology **87:** 1423–1427.

LUTZ, A. 1928. Estudios sobre trematodes observados en Venezuela. *In* Estudios de zoología y parasitología Venezolanas (1st Ed.), p. 101–105.

MAÑE-GARZÓN, F., AND L. R. GONZÁLEZ. 1978. Dos especies del genera *Gorgoderina* (*Gorgorimma*) de la vejiga turinaria de *Leptodactylus ocellatus* (L.) del Uruguay. Revista de Biologa del Uruguay **6:** 45–50.

MARGOLIS, L., G. W. ESCH, J. C. HOLMES, A. M. KURIS, AND G. A. SCHAD. 1982. The use of ecological terms in parasitology (Report of an ad hoc committee of the American Society of Parasitologists). Journal of Parasitology **68:** 131–133.

MEYER, J. R., AND L. D. WILSON. 1971. A distributional checklist of the amphibians of Honduras. Contributions in Science of the Natural History Museum of Los Angeles County **218:** 1–47.

PAREDES-CALDERÓN, C. E. L., V. LEÓN-RÈGAGNON, AND L. GARCÍA-PRIETO. 2004. Helminth infracommunities of *Rana vaillanti* Brocchi (Anura: Ranidae) in Los Tuxtlas, Veracruz, México. Journal of Parasitology. **90:** 692–696.

PEREIRA, C., AND R. CUOCOLO. 1940. Trematoides vesicais de anfibios do nordeste brasileiro. Arquivos do Instituto de Biología **11:** 413–420.

PÉREZ-PONCE DE LEÓN, G., V. LEÓN-RÈGAGNON, L. GARCÍA-PRIETO, U. RAZO-MENDIVIL, AND A. SÁNCHEZ-ÁLVAREZ. 2000. Digenean fauna of amphibians from Central México: nearctic and neotropical influences. Comparative Parasitology **67:** 92–106.

PIGULEVSKY, S. W. 1953. Family Gorgoderidae Looss, 1901. *In* Trematodes of animals and man, vol. VIII, K. I. Skrjabin (ed.). Akademya Nauk, Moscow, Russia, p. 251–618.

RAZO-MENDIVIL, U., J. P. LACLETTE, AND G. PÉREZ-PONCE DE LEÓN. 1999. New host and locality records of three species of *Glypthelmins* (Digenea: Macrideroididae) in anurans of México. Journal of the Helminthological Society of Washington **66:** 197–201.

RODRÍGUEZ-ORTÍZ, B., L GARCÍA-PRIETO, AND G. PÉREZ-PONCE DE LEÓN. 2003. Checklist of the helminth parasites of vertebrates in Costa Rica. Revista de Biología Tropical **51:** 1–41.

TRAVASSOS, L. 1922. Contribuçoes para o conhecimento da fauna helmintologica brasileira. Especies brazileiras da Familia Gorgoderidae Looss, 1901. Brazil Médico **1:** 17–20.

VICENTE, J. J., AND E. DOS SANTOS. 1976. Fauna Helmintológica de *Leptodactylus ocellatus* (L., 1758) de Volta Redonda, Estado do Rio de Janeiro. Atas da Sociedade de Biologia de Rio de Janeiro **18:** 27–42.

ZALDIVAR-RIVERÓN, A., V. LEÓN-RÈGAGNON, AND A. NIETO-MONTES DE OCA. 2004. Phylogeny of the Mexican coastal leopard frogs of the *Rana berlandieri* group based on mitDNA sequences. Molecular Phylogenetics and Evolution **30:** 38–49.

ZELMER, D. A., AND D. R. BROOKS. 2000. *Halipegus eschi* n. sp. (Digenea: Hemiuridae) in *Rana vaillanti* fron Guanacaste, Costa Rica. Journal of Parasitology **86:** 1114–1117.