Serendip deborahae n. gen. and n. sp. (Eucestoda: Tetraphyllidea: Serendipidae n. fam.) in Rhinoptera steindachneri Evermann and Jenkins, 1891 (Chondrichthyes: Myliobatiformes: Myliobatidae) from Southeastern Ecuador

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Nothing is known about the parasite fauna of elasmobranchs inhabiting the coast of Ecuador. During the initial stages of an inventory of the parasite biodiversity of Ecuadorean elasmobranchs, stingrays were collected from Puerto Bolivar, Puerto Jeli, and Puerto Hualtaco, Provincia de el Oro. Among the parasites collected were specimens of an undescribed and unusual tetrathyridine eucestode, which we describe and discuss herein.

**MATERIALS AND METHODS**

Stingrays were collected by professional fishermen in bottom trawls using bag seines. Cestodes were relaxed in sea water, killed in a relaxed condition with hot water, fixed immediately with AFA, and stored in 70% ethanol. Whole mounts were stained with Mayer’s hematoxylin. Serial cross sections of proglottids were cut 7 μm thick, stained with 70% ethanol. Whole mounts and cross sections were stained with Mayer’s hematoxylin, and counterstained with eosin. Whole mounts and cross sections were mounted in Canada balsam. All measurements are in μm unless otherwise noted; n = number of specimens examined or measured; MEPN refers to Museo de la Escuela Politecnica Nacional, Quito, Ecuador; MNHG refers to Museum of Natural History, Geneva, Switzerland.

**Serendipidiae n. fam.**

Diagnosis: Eucestoda; Tetrathyrididea. Scolex comprising 4 rounded or triangular bothridia, each subdivided by septa in various patterns; distinct loculi present or lacking. Bothridia exhibiting some degree of fusion to each other, to scolex, or both. Bothridial apical suckers lacking. Pedicels present or absent. Vestigial apical sucker embedded in tissues of scolex apex or apical pit may be present. Proglottids apolytic or anapolytic; markedly protandric. Testes in 2 or more layers in each proglottis. Postovarian testes present. Cirrus sac spherical to subspherical; cervix armed. Genital pore preequatorial. Vagina passing anteriorly to cirrus sac. Ovary X-shaped in cross section, lobes digitiform. Vitellaria follicular, medullary, in 2 lateral fields extending length of proglottis ventrally; vitelline fields converging dorsally in each proglottis, except for ovarian and terminal genitalia areas.

**Serendip deborahae n. sp.**

(Figs. 1–11)

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**ABSTRACT:** Cestodes collected in spiral valves of Rhinoptera steindachneri from the southern coast of Ecuador represent an undescribed species of Tetrathyrididea. The new species has bothridia possessing septa but lacking apical suckers. It is diagnosably distinct from all other tetrathyridine genera by possessing a scolex comprising 4 triangular bothridia that are fused together forming a platelike structure, each of which is subdivided by 2 simple and 1 bifurcating septa radiating from its base and ringed by marginal loculi; therefore, a new genus is proposed for it. By exhibiting some degree of bothridial fusion, testes arranged in 2 layers in the proglottis and postovarian tests, in each new species appears to be a member of a clade containing Dioscoetaenia, Duplicibothrium, and Glyphobothrium. The new species possesses vitelline fields that converge dorsally in each proglottis, except for the ovarian and terminal genitalia areas, a feature that has been reported previously only in Duplicibothrium and Glyphobothrium. Furthermore, Duplicibothrium and Glyphobothrium, like the new species, are markedly protandric. Therefore, we propose that Duplicibothrium, Glyphobothrium, and the new species comprise the sister group of the Dioscoetaeniidae, and propose a new family name for the clade. Tritaphros is rejected as a possible sister group for the clade; suggested alternatives include some species of Caulobothrium, Rhodobothrium, or some members of the Phyllobothrium centurum group.

**Type genus:** Serendip n. gen.


**Serendip n. gen.**

Diagnosis: Eucestoda; Tetrathyrididea. Scolex comprising 4 triangular bothridia, each subdivided by septa extending radially from base dividing bothridial face but not into distinct loculi, ringed with marginal loculi with thin velum. Bothridial apical suckers lacking. Bothridia fused to form a single platelike structure giving bothridial faces a dorsal rather than lateral aspect; pedicels lacking. Vestigial apical sucker embedded in tissues of scolex apex. Proglottids apolytic, protandric. Testes in 2 layers in each of 2 fields in each proglottid. Some testes postovarian in maturing proglottides, disappearing as ovary develops. Cirrus sac spherical; cirrus armed. Genital pore pre-equatorial. Vagina passing anteriorly to cirrus sac. Ovary X-shaped in cross section, lobes digitiform. Vitellaria follicular, medullary, in 2 lateral fields extending length of proglottis ventrally; vitelline fields converging dorsally in each proglottis, except for ovarian and terminal genitalia areas.

**Type and only species:** Serendip deborahae.

**Taxonomic summary**

*Type host:* Rhinoptera steindachneri Evermann and Jenkins, 1891 (Chondrichthyes: Myliobatiformes: Myliobatidae).

*Type locality:* vic. Puerto Bolivar, Provincia de el Oro, Ecuador.

*Site of infection:* Middle 1/3 of spiral valve.


etymology: Schmidt (1974) noted that when he found Dioecotaenia in Rhinoptera bonasus and realized it belonged in its own family, he was tempted to name it Serendip, type genus of the family Serendipidae (serendipity) because he was looking for something else at the time he discovered Dioecotaenia. We discovered this cestode species living in a species of Rhinoptera while looking for something else, so we have named it Serendip to honor the memory of Gerald D. Schmidt. The species is named for Deborah A. McLennan.

Remarks

The Tetraphyllidea lack much rigorous phylogenetic examination. Traditional classifications, e.g., Wardle and McLeod (1952), Euzet (1959), and Yamaguti (1959), divided the order into 2 families, the Phyllobothriidae and the Onchobothriidae, diagnosed on the basis of the presence (Onchobothriidae) or absence (Phyllobothriidae) of hooks associated with the bothridia. Regardless of its convenience, this scheme is weak because the absence of hooks is plesiomorphic (Brooks et al., 1991; Brooks and McLennan, 1993; Berman and Brooks, 1994) and thus not an appropriate character on which to base taxonomic groupings (Wiley et al., 1991). This may have led Schmidt (1986) to recognize the Dioecotaeniidae, comprising 1 genus with 2 species (which Schmidt placed in its own order) and the Triloculariidae, comprising 4 genera with 5 species (Berman and Brooks, 1994).

The “Phyllobothriidae” can be divided into cestodes that have bothridial apical suckers, but lack bothridial septa dividing the bothridial face into distinct loculi (e.g., Anthobothrium van Beneden, 1850; Calectobothrium Monticelli, 1893; Clistobothrium Dailey and Vogelbein, 1990; Clydonobothrium Euzet, 1956; Crossobothrium Linton, 1889; Echeneobothrium van Beneden, 1805; Monorygma Diesing, 1863; Orsygnobothrium Diesing, 1863; Rhodobothrium Linton, 1889; and the Phyllobothrium lacteum species group) and species that have bothridial septa dividing the bothridial face into distinct loculi but lack bothridial apical suckers (e.g., Caulobothrium Baer, 1948; Duplicibothrium Williams and Campbell, 1978; Glyphobothrium Williams and Campbell, 1977; Rhadiobothrium Euzet, 1953; Rhinebotherium Linton, 1889;
Rhinebothriodes Mayes, Brooks, and Thorson, 1981; Triatophros Lönberg, 1889; and the Phyllobothrium centrum group species group. Notably, the Triloculariidae comprises species having bothridial septa and loculi, some possessing bothridial apical suckers (Trilocularia Olsson, 1867 and Escherbothrium Berman and Brooks, 1994) and some lacking them (Zyxibothrium Hayden and Campbell, 1981 and Pentaloculum Alexander, 1953), and the members of the Dioecotaeniidae have bothridial loculi but lack apical suckers.

The absence of bothridial septa by the first group of phyllobothriids is a plesiomorphic trait that renders the taxa a paraphyletic collection of undetermined phylogenetic relationships. Because it contains the paraphyletic Phyllobothrium, this group retains the appellation Phyllobothriidae pending a full phylogenetic analysis of the assemblage. The second group, including the Triloculariidae and Dioecotaeniidae, comprises those taxa that have bothridial septa and loculi. If the septa and loculi in all these taxa are homologous, and are nonhomologous with the bothridial loculi in many onchothriids, the group would form a clade. The form and structure of the bothridia and the septa and loculi in each of the 3 groups are, however, diverse. Bothridia of the Triloculariidae are round to elongate with 3–5 loculi arranged in nonlinear patterns. In the Dioecotaeniidae, the bothridia are rounded with close-packed hexagonal loculi arranged as a central row of loculi surrounded by large marginal loculi. Glyphobothrium is similar to Dioecotaenia, but the loculi are round to squared rather than hexagonal. Duplicibothrium exhibits bothridia with transverse septa anteriorly and a cup-shaped posterior end with indistinct radially arranged septa. Finally, members that we will refer to as the "Rhinebothrium group" (e.g., Caulobothrium, Rhabdotobothrium, Rhinebothrium, Triatophros, Rhodobothrium, Zyxibothrium, and the Phyllobothrium centrum group), have elongate bothridia with linearly arranged loculi. Members of the Dioecotaeniidae, Duplicibothrium, Glypobothrium, and the Rhinebothrium group share another apparently derived trait, the absence of bothridial apical suckers. This may indicate that these taxa are more closely related to each other than either is to the Triloculariidae; however, 2 members of the Triloculariidae, Zyxibothrium and Pentaloculum, also lack bothridial apical suckers. The presence or absence of bothridial apical suckers, by itself, may not be a strong indicator of phylogenetic relationship, or the Triloculariidae may be paraphyletic.

Serendip deborahae has bothridia possessing septa, but lacking apical suckers. This would seem to place it with the Dioecotaeniidae, Duplicibothrium, Glyphobothrium, and Rhinebothrium group. Dioecotaenia, Duplicibothrium, and Glyphobothrium exhibit several traits that appear to be apomorphic among the Tetraphyllidae, suggesting a relationship with Serendip. They exhibit some degree of fusion of the bothridia, either with each other (Dioecotaenia, Duplicibothrium, Serendip) or with the scolex (Glyphobothrium). They also possess testes arranged in 2 layers in the proglottis and some postovarian testes. We believe these 3 traits, that are present in Dioecotaenia, Duplicibothrium, Serendip, and Glyphobothrium form a clade. Serendip exhibits vitelline fields that converge dorsally in each proglottis, except for dorsal to the terminal genitalia, a feature that has been reported previously only in Duplicibothrium and Glyphobothrium (Williams and Campbell, 1977, 1978). Like Glyphobothrium, Serendip also lacks vitelline follicles dorsal to the ovary. The radial pattern and arrangement of the bothridial septa, lack of distinct loculi, triangular shape of the bothridia, and fusion of the bothridia to form a single plate-like structure with dorsal aspect in S. debobrahae, however, differ from previously known tetraphyllides. In this regard, S. debobrahae is distinct from Duplicibothrium and Glyphobothrium, supporting the designation of a new genus for it. Furthermore, Duplicibothrium and Glyphobothrium, like Serendip, are markedly protandric; Dioecotaenia exhibits separate male and female strobila. Of secondary significance is the observation that all members of these taxa inhabit only myliobatid stingrays. Therefore, we propose that Duplicibothrium, Glyphobothrium, and Serendip form a clade that is the sister group of Dioecotaenia. Because its sister group is recognized at the family level, we propose a new family name for the clade containing Duplicibothrium, Glyphobothrium, and Serendip.

**DISCUSSION**

Brooks (1982) suggested that if the scolex of Dioecotaenia evolved as a result of progressive addition of loculi, a species like Triatophros retzii, a member of the Rhinebothrium group having 3 bothridial loculi, would be its sister species. Given the bothridial morphology of the members of the Serendipidae + Dioecotaeniidae, this assumption is not warranted, and the search for the sister group of this clade begins anew. Below we list some possibilities.

Members of the Dioecotaeniidae + Serendipidae possess cirrus sacs in the anterior half, often in the anterior ¼, of the proglottis, a trait that is unusual among unarmed tetraphyllid cestodes with loculi and no bothridial apical suckers (although common among members of the basal "Phyllobothriidae"). Species of Caulobothrium, from the Rhinebothrium group, exhibit this trait. At least some species of Caulobothrium also have postovarian testes or testes extending posteriorly between the ovarian lobes (Brooks et al., 1981). These traits may indicate a phylogenetic relationship between Caulobothrium and the Dioecotaeniidae + Serendipidae, although preliminary phylogenetic analysis indicates that Caulobothrium is paraphyletic, comprising 2 clades within Rhinebothrium (Brooks, unpublished data). In addition, members of the Dioecotaeniidae + Serendipidae possess marginal bothridial loculi, as do members of the Phyllobothrium centrum group and Rhinebothriodes. Marginal loculi are lacking in all members of the Rhinebothrium group, including all species assigned to Caulobothrium. Finally, species of Rhodobothrium Linton, 1889 also inhabit myliobatid stingrays, are markedly protandric, have testes lying in 2 layers in each proglottis, and possess postovarian testes, suggesting a possible relationship with the Dioecotaeniidae + Serendipidae. Like S. deborahae, they possess vestigial suckers embedded in the scolex apex (the "apical pit" of Glyphobothrium may also be a vestigial apical sucker). Species of this group lack bothridial septa or marginal loculi, although the bothridial faces are covered with "numerous convolutions forming an irregular pattern" (Campbell and Carvajal, 1979; Mayes and Brooks, 1981). They lack the vitelline configuration diagnostic for the Serendipidae and show no sign of bothridial fusion. If Rhodobothrium is a member of the Dioecotaeniidae + Serendipidae clade, it would be the sister group of the other 2.

Phylogenetic systematic studies begin with Hennig's Auxiliary Principle (Hennig, 1966; Brooks and McLennan, 1991, 1993; Wiley et al., 1991) that similarity equals homology. Such initial assumptions are corroborated by congruence with other characters in a phylogenetic analysis and are falsified by incongruence. Testing and supporting the above hypotheses of homology and classification consistent with them will require a larger suite of characters than the few discussed above.

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LITERATURE CITED


