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Trematodes of Red Sea fishes: *Hexangium brayi* n. sp. (Angiodictyidae Looss, 1902) and *Siphodera aegyptensis* n. sp. (Cryptogonimidae Ward, 1917), with a review of their genera

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Abstract

Specimens of the marine fishes *Siganus luridus* (Siganidae) and *Caesio suevica* (Lutjanidae) were caught in the Red Sea off the coast of Sharm El-Sheikh, South Sinai, Egypt. Twelve (30%) and eight (17%) fish, respectively, were found to harbour intestinal trematodes. *S. luridus* was parasitised by *Hexangium brayi* n. sp. (Angiodictyidae) and *C. suevica* by *Siphodera aegyptensis* n. sp. (Cryptogonimidae). *H. brayi* n. sp. is differentiated from the other two species of the genus by the vitelline follicles which are confined to the inter-caecal field, its body shape which is distinctly pyriform, the terminations of the intestinal caeca which are distinctly saccular, the eggs which are few in number, and by the excretory vesicle which gives off a lateral arm on each side that divides into two long collecting ducts. *S. aegyptensis* n. sp. is most similar to *S. cirrhiti* Yamaguti, 1970, but differs in having a definite number of testes (nine), seven arranged in a ring and the other two situated symmetrically or diagonally within this ring, and vitelline follicles extending posteriorly to the level of the anterior lobes of the ovary. Both genera *Hexangium* Goto & Ozaki, 1929 and *Siphodera* Linton, 1910 are reviewed in detail and redefined.

Introduction

Studies on the helminth parasites of Red Sea fishes tend to be limited to short papers describing new taxa or longer works where the Red Sea is dealt with in larger studies on the Indian Ocean. Consequently, parasitic helminths are one of the least known parts of the Red Sea fauna. Previous studies on trematodes of the subclass Digenea in the region include those by H.F. Nagaty between the 1930s and 1970s, A.M. Parukhin and T.M. Abdel-Aal in the 1970s, M.F. Saoud and M.M. Ramadan in the 1970s and 1980s, R.M. Overstreet in the 1980s, and I.M. Shalaby and R.M. Hassanine since the 1990s. The present report deals with two new digenean species from the Red Sea fishes. These worms were collected by the first author off the coast of the Red Sea at Sharm El-Sheikh, South Sinai, Egypt, and their study was completed at the Natural History Museum, London.

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Materials and methods

During May of 2003, 40 and 45 individuals of the fishes *Siganus luridus* (Siganidae) and *Caesio suevicus* (Lutjanidae), respectively, were caught in the Red Sea off the coast of Sharm El-Sheikh, South Sinai, Egypt, and kept alive in aquaria. Fish identifications were based on Randall (1983) and modern names follow Froese & Pauly (2004). Standard parasitological techniques were used to examine the alimentary canal of the fish. The trematodes were removed from their host fishes under a dissecting microscope and observed live under a compound microscope. Other worms were fixed in alcohol-formalin-acetic acid (AFA) under a slight coverslip pressure and preserved in 75%

ethyl alcohol. Whole-mounts were stained in alum carmine, cleared in terpineol and mounted in Canada balsam. Measurements are quoted as the range, with the mean in parentheses, and are given in micrometres, except where indicated. The specimens are deposited in the Natural History Museum, London, and in the Helminthological Collection of the Red Sea Fishes, Marine Science Department, Faculty of Science, Suez Canal University, Ismailia, Egypt.

Family Angiodictyidae Looss, 1902
Subfamily Hexangiinae Yamaguti, 1958

Genus *Hexangium* Goto & Ozaki, 1929

Goto & Ozaki (1929) erected *Hexangium* for *H. sigani* Goto & Ozaki, 1929 collected from the intestine of *Siganus fuscescens*, off Misaki and Takamatsu, Japan. It was partly redescribed by Yamaguti (1934) from the same host in the Inland Sea of Japan. Yamaguti later (1953) recorded *H. sigani* from the intestine of a *Siganus* sp. off the Celebes.

Tubangui & Masilungan (1944) described *H. affinum* as a new species from the intestine of *Amphacanthus* [now *Siganus*] *javus* off Manila, the Philippines. This species is very similar to the type-species, but differs in having a smaller body size and symmetrical testes.

Annereaux (1947) seemed unaware of the work of Tubangui & Masilungan (1944) when he described *H. secundum* as the second species of the genus from a single specimen obtained from the intestine of *Teuthis concatenata* [now *Siganus guttatus*] off Mercedes, Samar, the Philippines. This species is very similar to the type-species, but was said to differ in having a smaller body size, symmetrically arranged testes and a larger ovary.

Yamaguti (1958) created the Hexangiinae in the family Angiodictyidae Looss, 1902 for *Hexangium*. However, he considered *Arthurloossia* Nagaty, 1954 a synonym of *Hexangium*. Accordingly, the type and the only species of the former genus, *A. loossi* Nagaty, 1954, was transferred as *H. loossi* (Nagaty, 1954) Yamaguti, 1958. This species was originally (Nagaty, 1954) collected from the intestine of two fish species, *Pseudoscarus* [now *Hipposcarus*] *harid* (Labridae) and *Teuthis oramen* [now *Siganus canaliculatus*] (Siganidae) in the Red Sea off Hurgada, Egypt.

In 1959, Razarihelisoa recorded *H. sigani* Goto & Ozaki, 1929 from the intestine of *Holocentrus* [now *Neoniphon*] *sammara* (Holocentridae) off Madagascar. In doing so, she expressed doubt about the validity of *H. affinum*, *H. secundum* and *H. loossi*, and suggested that they might be conspecific. Velasquez (1961) also recorded *H. sigani* from the intestine of *Teuthis rostrata* [now *Siganus argenteus*] off the Philippines, and she too observed the close similarity between *H. affinum* and *H. secundum* and both her specimens and Yamaguti's (1953) description of *H. sigani*. Accordingly, she also considered *H. affinum* and *H. secundum* as synonyms of *H. sigani*.

Manter (1963) described *H. elongatum* Manter, 1963 from the intestine of *Naso* sp., an acanthurid, off Fiji. He only compared his species with *H. sigani*, since he concurred with the synonymies suggested by Razarihelisoa (1959) and Velasquez (1961). *H. elongatum* was differentiated from *H. sigani* by the testes which are always tandem, the longer caeca which extend posteriorly to the testes, the excretory vessels which are three in number, body shape which is much more elongate with the greatest width near the posterior end, the absence of an oesophageal bulb, and by the distribution of the vitelline follicles which are confluent medially anterior to the testes.

Fischthal & Kuntz (1964) recorded *H. sigani* from the intestine of *Siganus striolatus* [now *spinus*] and *S. oramin* [now *canaliculatus*] and an engraulid (*Stolephorus commersonii*) off Palawan Island, the Philippines. They also agreed with previous authors in considering *H. affinum*, *H. secundum* and *H. loossi* as synonyms of *H. sigani*. This same species was redescribed by Gupta & Miglani (1976) from the intestine of an unnamed acanthurid off the Andaman and Nicobar Islands and by Gupta & Tandon (1985) from the intestine of *Sciaena volgeri* [now *Johnius borneensis*] in the Bay of Bengal. However, from off the Andaman and Nicobar Islands, Gupta & Miglani also redescribed *H. loossi* from the intestine of *Siganus vermiculatus*, thus appearing to disagree with the views of previous authors. Nevertheless, subsequent reports of *H. sigani* by workers, such as Al-Yamani & Nahhas (1981), Geets & Ollevier (1996) and Sey et al. (2003), from numerous siganid species in the NW Indian Ocean region and the Arabian Gulf, have continued to accept these synonymies.

Accordingly, two species are now generally accepted as valid, i.e. *H. sigani* Goto & Ozaki,1929 (type-species) and *H. elongatum* Manter, 1963.

Hexangium brayi n. sp

Type-host: Siganus luridus (Rüppell) (Siganidae).
Site: Intestine.
Type-locality: Red Sea off Sharm El-Sheikh, South Sinai, Egypt.
Prevalence: 12/40 fishes examined; 30%.
Type-material: Holotype and paratypes in the Natural History Museum, London, 2004.11.30.1 and 2004.11.30.2-3; other paratypes in the Helminthological Collection of the Red Sea Fishes, Marine Science Department, Faculty of Science, Suez Canal University, Ismailia, Egypt.
Etymology: The new species is named for Dr R.A. Bray, Department of Zoology, the Natural History Museum, London, in recognition of his great contributions to marine helminthology.

Description (Figure 1)

[Based on 8 mature specimens.] Body pyriform or elongate-pyriform, stout, 1,860-2,960 × 574-850 (2,410 × 712), widest in its posterior region. Tegument covered with minute sharp spines (often lost during fixation). Oral sucker ventro-terminal, round, 180-221 × 220-235 (200 × 228). Ventral sucker absent.

Pharynx absent. Oesophagus long, 331-400 (366), provided with oblong oesophageal bulb at its posterior end; bulb 135-200 × 93-145 (159 × 119). Intestinal bifurcation at about junction of first and second thirds of body; caeca blind, wide with distinct saccular posterior extremities, reaching posteriorly to near anterior borders of testes.

Testes 2, usually oval, sometimes round, symmetrically situated in posterior region of body, subequal, 230–417 × 220–280 (324 × 250). Cirrus-sac weakly developed, but large, elongate-claviform, extending anteriorly from near middle of body to genital pore, 600–800 × 83–110 (700 × 92), contains elongate, saccular seminal vesicle and inconspicuous prostatic complex. Genital pore situated mid-way between oral sucker and intestinal bifurcation.

Ovary spherical, median, immediately post-testicular, or overlapping posterior borders of both testes, close to posterior extremity of worm, 90–119 (105) in diameter. Seminal receptacle and Laurer's canal absent; uterine seminal receptacle present. Uterus inter-caecal, relatively long, slightly coiled between level just anterior to testes and intestinal bifurcation, then passes anteriorly directly to genital pore. Eggs few in number, oval, thick-shelled, moderately large, 70–85 × 55–60

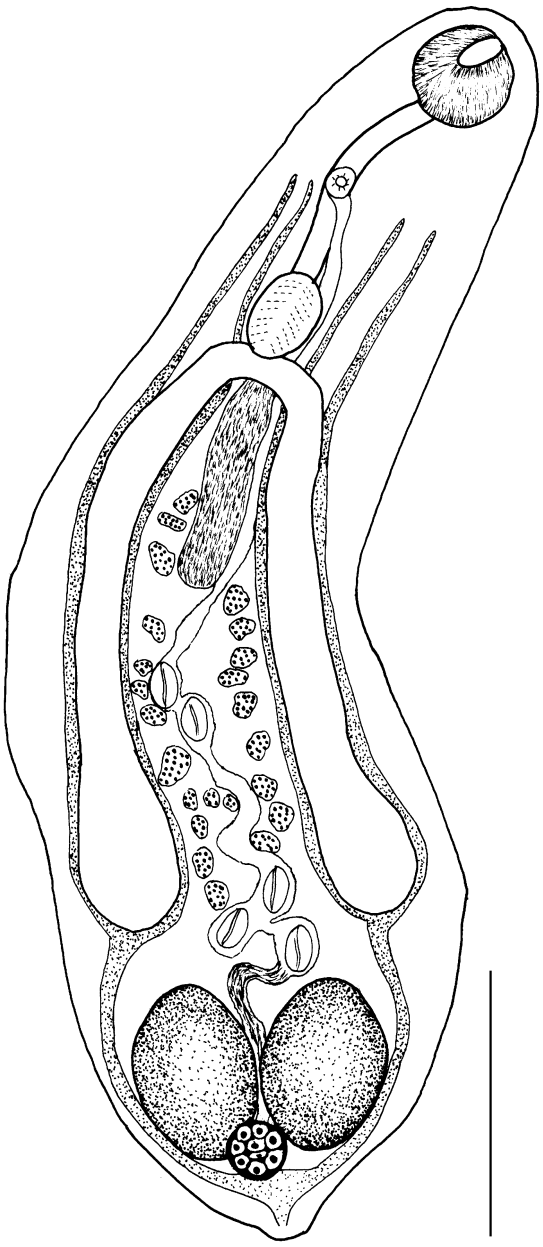

Figure 1. Hexangium brayi n. sp. from *Siganus luridus*, Red Sea. Note that small tegumental spines are present on live specimens. *Scale-bar:* 500 μm.

(79 × 58). Vitelline follicles moderately large, relatively few in number, confined to inter-caecal field, where follicles are arranged in 2 irregular longitudinal rows, along inner border of each caecum.

Excretory vesicle V-shaped; arms bifurcate at level of posterior end of each caecum, giving rise to 2 long collecting ducts, which extend anteriorly to near level of genital pore; excretory pore dorso-subterminal.

Discussion

As indicated above, there are currently two valid species of *Hexangium*. *H. sigani* is a well-known and widely distributed species, which has been recorded by several authors in many siganid species from different localities. In contrast, *H. elongatum* is still known only from its original description.

The new species differs significantly from these species and is unique in having the following characters:

- The vitelline follicles are confined to the inter-caecal field (versus mainly lateral to the caeca in the other species).
- The body shape is distinctly pyriform (versus elongate).
- The terminations of the intestinal caeca are distinctly dilate and saccular (versus undifferentiated).
- The eggs are few in number (versus numerous).
- The arms of the excretory vesicle bifurcate, each giving rise to two long collecting ducts (in *H. sigani*, each arm apparently divides into three collecting ducts; in *H. elongatum*, the vesicle is said to have three arms, two lateral and one median).

As the most recent generic diagnosis of *Hexangium* is that of Yamaguti (1971), the diagnosis is amended as follows to include *H. brayi* n. sp.

***Hexangium* Goto & Ozaki, 1929**

Body elongate or pyriform, spinose. Oral sucker subterminal, sometimes ventro-terminal. Ventral sucker absent. Pharynx absent. Oesophagus moderately long, with or without posterior bulb; caeca blind, wide, sometimes with saccular terminations, usually terminating short distance anterior to testes, occasionally reaching to posterior extremity. Testes symmetrical, diagonal or tandem, usually post-caecal, occasionally inter-caecal. Cirrus-sac weakly developed, globular or claviform; seminal vesicle internal, elongate-saccular or tubular. Genital pore halfway between oral sucker and intestinal bifurcation. Ovary round, comparatively small, immediately post-testicular, close to posterior extremity. Seminal receptacle absent; uterine seminal receptacle present. Uterus winding forward with its main bulk confined to inter-caecal field. Eggs few or numerous, moderately large. Vitellarium follicular, mainly extra-caecal to entirely inter-caecal, in middle region of body. Excretory vesicle V-shaped, with its antero-lateral extremities produced forward and divided each into two or three long collecting ducts; sometimes vesicle has three long arms, two lateral and one median. Excretory pore dorso-subterminal. Intestinal parasites of marine (especially siganid) teleosts; warmer parts of Indo-West Pacific region. Type-species *H. sigani* Goto & Ozaki, 1929.

Family Cryptogonomidae Ward, 1917
Subfamily Siphoderinae Linton, 1910

Genus *Siphodera* Linton, 1910

Linton (1901) described *Monostomum vinaledwardsii* Linton, 1901 from the intestine of the toadfish *Opsanus tau* off Woods Hole, New England. This trematode was subsequently reported in several papers by Linton from other hosts, such as *Orthopristis chrysoptera* off Beaufort, North Carolina (1905), *Neomaenis* [now *Lutjanus synagris*] and *Ocyurus chrysurus* off Bermuda (1907) and *O. chrysopterus* at Dry Tortugas, Florida (1910). In the latter paper, Linton amended the description of *M. vinaledwardsii* and erected a new genus, *Siphodera*, for it. No generic diagnosis was given at that time. He (1910) also created the Siphoderidae for *Siphodera* and four other newly erected genera (*Genolopa*, *Prodistomum*, *Stegopa* and *Metadena*). Manter (1926) redescribed *S. vinaledwardsii* from preserved material collected from the intestine of the toadfish off Woods Hole, but later (1934) did not accept the Siphoderidae Linton, 1910 as a valid family but did recognise it at

subfamily level, within the family Heterophyidae Odhner, 1914, to include two genera, i.e. *Siphodera* and a new genus, *Siphoderina*. In a revision on the superfamily Opisthorchioidea, Price (1940) transferred the subfamily Siphoderinae to the family Cryptogonimidae Ward, 1917, and Yamaguti (1958, 1971) considered *Siphodera* as the sole genus in the subfamily.

Cable & Hunninen (1942) described the life-history of *S. vinaledwardsii*. They recovered the larval stages from the small marine snail *Bittium alternatum*. Subsequently, *S. vinaledwardsii* has been reported from many fish species: *Pomolobus* [now *Alosa*] *pseudoharengus* off Woods Hole, Massachusetts (Linton, 1940); *Ocyurus chrysurus* off Tortugas, Florida (Manter, 1947); *Seriola dumerili* and lutianids off Bermuda (Hanson, 1950); *Opsanus beta* in Boba Ciega Bay, Florida (Sogandares-Bernal & Hutton, 1959); *Lutianus synagris* and *L. analis* off Porto Rico (Siddiqi & Cable, 1960); *L analis, L. aya* [? *Bodianus aya*], *L. buccanella*, *L. synagris* and *Ocyurus chrysurus* off Curaçcao or Jamaica (Nahhas & Cable, 1964); *L. mahogoni*, *L. synagris* and *Opsanus beta* off Biscayne Bay, Florida (Overstreet, 1969); *L. analis*, *L. synagris* and *Ocyurus chrysurus* from the Barrier Reef and Reef Lagoon of Belize (Fischthal, 1977); *L. synagris* off the British Virgin Islands (Dyer, 1983); and *L. synagri*, *L. purpureus* and *L. griseus* from the Caribbean Sea (Velez, 1987).

In 1968, Fischthal & Thomas described *S. ghanensis* as a new species from the intestine of the catfish *Chrysichthys nigrodigitatus*, an estuarine fish from Ghana. They differentiated it from the type-species by its ventral sucker, which is larger than the oral sucker, the unlobed or tri-lobed ovary and the greater extent of the vitellarium. They also stated that this species differs further in lacking both uterine coils anterior to the testes and a pit-like cavity in which the ventral sucker lies. However, they also examined the original specimens of *S. vinaledwardsii* and declared that it has a circular post-oral muscular ring and a circular muscle band around the anterior part of the pharynx which is mostly obscured by extensive flattening of the body. Later, Obiekezie et al. (1988) recorded the presence of *S. ghanensis* in the catfish *C. nigrodigitatus* from the Cross River estuary, Nigeria.

Yamaguti (1970) described *S. cirrhiti* Yamaguti, 1970 from the intestine of *Cirrhitus alternatus* [now *pinnulatus*] (Cirrhitidae) off Hawaii. He differentiated this species from *S. vinaledwardsii* by the vitelline follicles which extend between the level of the pharynx and the uterine field, without overlapping the latter, and by the number of testes (3–5 on the left side and 1–5 on the right side).

In 1986, Machida described *S. gurukum* Machida, 1986 from the intestine of two lutjanid fishes (*Caesio xanthonota* and *C.* [now *Pterocaesio*] *diagramma*) off the Ryukyu Islands to the south of Japan. He differentiated this species from the others of the genus by the testes, which are arranged in a compact cluster between the caeca, and the seminal receptacle, which never extends anterior to ovarian level. He also amended the generic diagnosis of *Siphodera* to include his species.

Accordingly, four species of *Siphodera* have been recognised, i.e. *S. vinaledwardsii* (type-species), *S. ghanensis*, *S. cirrhiti* and *S. gurukum*.

***Siphodera aegyptensis* n. sp.**

Type-host: Caesio suevica Klunzinger (Lutjanidae).
Type-locality: Red Sea, off Sharm El-Sheikh, South Sinai, Egypt.
Prevalence: 8/45 fish examined; 17.77%.
Site: Pyloric caeca and intestine.
Type-material: Holotype and paratypes in the Natural History Museum, London, 2004.11. 30.4 and 2004.11.30.5-10; other paratypes are in the Helminthological Collection of the Red Sea Fishes, Marine Science Department, Faculty of Science, Suez Canal University, Ismailia, Egypt.

Description (Figure 2)

[Based on 10 fully-gravid specimens.] Body elongate-oval, somewhat dorso-ventrally flattened, 960-1,450 × 341-462 (1,205 × 401). Forebody 352–521 (436) in length, representing ≤36% of total body length. Tegument spinose throughout. Numerous gland-cells scattered in parenchyma of forebody. Oral sucker ventro-terminal, globular, relatively large, 110-149 (129) in diameter. Ventral sucker comparatively small, spherical, 58-70 (64) in diameter, situated at junction of second and third fifth of body, embedded in circular fold of body wall ('acetabulo-genital pouch'). Sucker-width ratio 1:0.47-0.53 (1:0.5).

Prepharynx short, 20-24 (22) in length. Pharynx well developed, globular, 51-81 × 76-110 (66 × 93). Oesophagus short, 45-65 (55) long. Intestinal

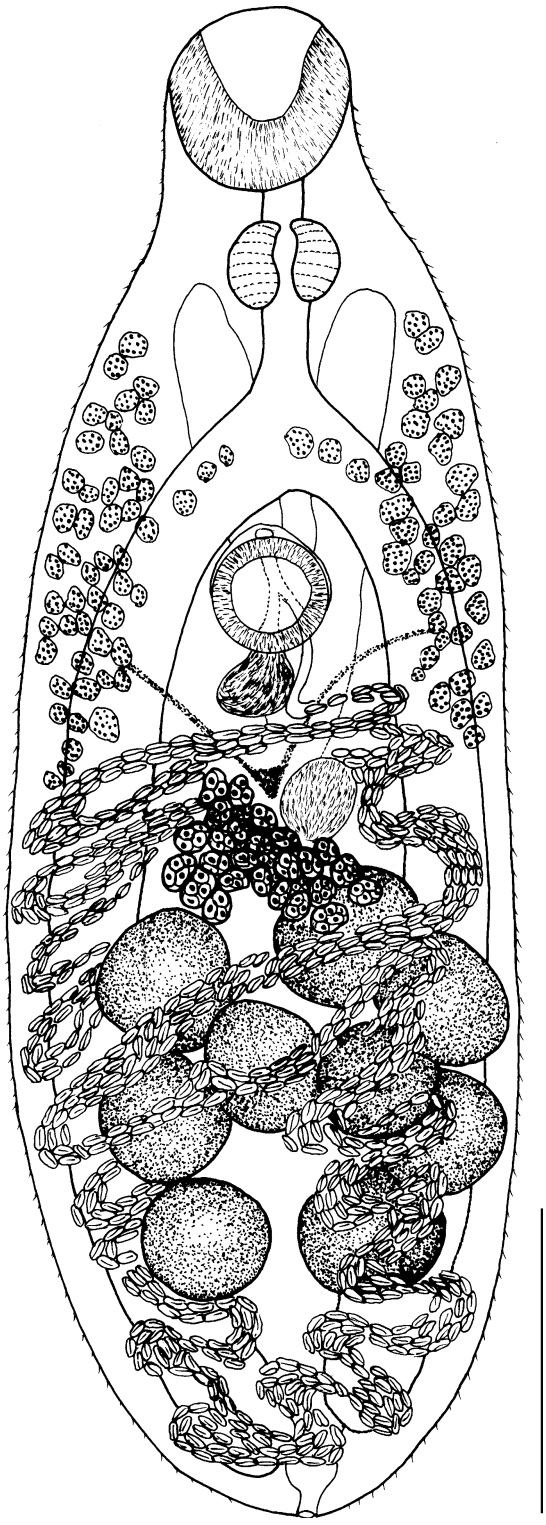

Figure 2. Siphodera aegyptensis n. sp. from *Caesio suevica*, Red Sea. *Scale-bar:* 250 μm.

bifurcation just anterior to ventral sucker. Caeca wide, terminate blindly near posterior extremity.

Testes 9, round to oval, 81–135 (108) in diameter, situated in middle of hindbody, usually contiguous, usually 7 of 9 testes arranged in ring with other 2 situated symmetrically or diagonally inside this ring. Cirrus-sac absent. Seminal vesicle saccular, directly posterior to ventral sucker; prostatic complex inconspicuous; distal portion of ejaculatory duct unites with uterus dorsal to ventral sucker to form short hermaphroditic duct. Genital pore median, directly anterior to ventral sucker, inside 'acetabulo-genital pouch'.

Ovary multi-lobed, median, immediately pre-testicular or contiguous with anterior testes. Seminal receptacle round, sinistrally submedian immediately pre-ovarian. Laurer's, canal present. Uterus very long, coiled with wide loops, occupies most of available space between ventral sucker and posterior extremity. Eggs numerous, elongate oval, 18–24 × 8–10 (21 × 9). Vitelline follicles small, extending anteriorly in lateral fields from level of anterior lobes of ovary to level of oesophagus; diagonal vitelline collecting ducts arise from vitelline follicles on each side, just posterior to ventral sucker, open into small triangular vitelline reservoir situated directly anterior to ovary.

Excretory system Y-shaped with postero-terminal excretory pore; bifurcation at level of ovary; excretory arms wide, reaching to level of pharynx.

Discussion

As indicated above, four species of *Siphodera* have previously been recognised. *S. vinaledwardsii* can be readily differentiated from the new species, as five of its nine testes are arranged in a longitudinal row on one side of the body and the other four are arranged in a similar row on the other side, and the vitelline follicles are confined to the hindbody. *S. ghanensis* is unique in having a ventral sucker larger than the oral sucker, an unlobed or tri-lobed ovary and no 'acetabulo-genital pouch'. *S. gurukum*, which occurs in a closely related host, is unique in having its nine (occasionally four, five or eight) testes arranged in a compact cluster (irregular, paired or linear) between the caeca, vitelline fields extending between the ventral sucker and testicular level, and a post-ovarian seminal receptacle never extending anterior to ovarian level. *S. aegyptensis* n. sp. is

most similar to the Hawaiian species, *S. cirrhiti*, but differs in having the following characters:

– The testes are distinctly nine in number, with seven arranged in a ring and the other two situated symmetrically or diagonally inside this ring, whereas, in *S. cirrhiti*, the arrangement of testes varies, with three to five on the right side and one to five on the left side of the body.
– The vitelline follicles extend posteriorly as far as the level of the anterior lobes of the ovary, but, in *S. cirrhiti*, they reach only to mid-way between the ventral sucker and the ovary.

The most recent diagnosis of genus *Siphodera* was given by Machida (1986); this diagnosis is amended as follows to include the new species:

***Siphodera* Linton, 1910**

Body oval to elongate, armed with small spines. Numerous gland-cells scattered in parenchyma of forebody. Oral sucker terminal, occasionally subterminal. Ventral sucker smaller (usually) or larger than oral sucker, embedded or not in circular fold of body wall ('acetabulo-genital pouch') in anterior half of body. Prepharynx short. Pharynx well developed. Oesophagus short. Intestinal bifurcation in forebody. Caeca terminate blindly near posterior extremity. Testes usually nine (sometimes fewer), in posterior half of body, arranged in two lateral rows or clustered. Cirrus-sac absent. Seminal vesicle tubular or saccular, reaches posterior to ventral sucker; pars prostatica short; ejaculatory duct short, unites with distal end of uterus to form short hermaphroditic duct. Genital pore median, just anterior to ventral sucker, inside 'acetabulo-genital pouch' when present. Ovary median, posterior to seminal vesicle, usually multi-lobed, sometimes tri-lobed or un-lobed. Seminal receptacle pre-ovarian or post-ovarian. Uterus fills much of available space in hindbody, reaches to near posterior extremity; eggs small. Vitellarium follicular; follicles in pre-testicular extra-caecal field, usually confined to hindbody, sometimes extending more anteriorly to reach level of oesophagus. Excretory vesicle Y-shaped, with postero-terminal pore; excretory arms wide reaching to level of pharynx. Intestinal parasites of marine teleosts (especially lutjanids) in warmer waters of Indian, Pacific and Atlantic Oceans. Type-species: *S. vinaledwardsii* (Linton, 1901).

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