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NEW INTESTINAL TREMATODES FROM SIGANID FISHES OFF THE SAUDI COAST OF THE RED SEA

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In small samples of the siganid fishes *Siganus rivulatus* Forsskål et Niebuhr and *S. luridus* Rüppel (Teleostei) from off the Saudi coast of the Red Sea, some individuals of each fish were found infected with a new intestinal trematode. Those of *S. rivulatus* were infected with *Hexangium saudii* sp. n. (Trematoda: Microscaphidiidae), whereas those of *S. luridus* with *Progyliauchen magnacetabulum* sp. n. (Trematoda: Gyliauchenidae). *Hexangium saudii* sp. n. differs clearly from the two valid species of the genus, *H. sigani* Goto et Ozaki, 1929 (type-species) and *H. brayi* Hassanine et Gibson, 2005 in many specific characters and is unique in having vitelline follicles arranged in rosette-like groups and short intestinal caeca distant from the testes. *Progyliauchen magnacetabulum* sp. n. differs clearly from *P. sigani* Shalaby et Hassanine, 1997, the type and the only species of the genus in many specific characters and is unique in having a much larger ventral sucker, a very long oesophagus (longer than the total body length), a much larger oesophageal bulb and a tubular seminal vesicle.

Key words: Trematoda, Microscaphidiidae, *Hexangium saudii* sp. n., Gyliauchenidae, *Progyliauchen magnacetabulum* sp. n., Red Sea.

INTRODUCTION

Siganid fishes are common in the Red Sea. To date, eight intestinal helminths have been described as new taxa from these fishes. This number includes four trematodes (*Hexangium sigani* Goto et Ozaki, 1929, *H. brayi* Hassanine et Gibson, 2005, *Gyliauchen volubilis* Nagaty, 1956 and *Progyliauchen sigani* Shalaby et Hassanine, 1997), two nematodes (*Procamallanus elatensis* Fusco et Overstreet, 1979 and *Cucullanus gardneri* Heckmann, Abdou et Gardner, 2009), and two acanthocephalans (*Sclerocollum rubrimaris* Schmidt et Paperna, 1978 and *S. saudii* Al-Jahdali, 2010).

Recently, the infrapopulations of *S. saudii* (Al-Jahdali & Hassanine 2012*a*), *P. elatensis* (Al-Jahdali 2012*a*) and *G. volubilis* (Al-Jahdali 2012*b*) in single species infections have been described and analysed, as has the life cycle of *G. volubilis* (Al-Jahdali & Hassanine 2012*b*).

In the present study, two new species of intestinal trematodes belonging to two different families are described from siganid fishes in the Red Sea, and their genera are briefly reviewed.

MATERIAL AND METHODS

Small samples including 40 and 50 specimens of the siganid fishes *Siganus rivulatus* Forsskål et Niebuhr and *S. luridus* Rüppel (Teleostei), respectively, were examined during April 2011 for infections by intestinal helminths. These fishes were caught using hand-nets (by scuba-diving) in the Red Sea off the coast of Rabigh (between 22°49'N and 22°54'N), Saudi Arabia, and identified according to Randall (1983) and Froese and Pauly (2011). Fish were killed using an overdose of benzocaine anaesthetic, pithing through the brain, or by a blow to the head prior to dissection. The entire alimentary canal of each fish was immediately removed. Trematodes were observed alive and carefully teased from the gut of each fish under a stereomicroscope; the opened gut was then shaken vigorously in a jar of saline to dislodge further worms and to remove mucus. Some worms were placed in whirling warm water before fixation in hot alcohol-formalin-acetic acid (AFA) under a very slight coverslip pressure and preserved in 75% ethyl alcohol; this procedure gives specimens a uniform size and shape. Whole-mounts were stained in alum carmine, cleared in terpineol and mounted in Canada balsam. Drawings were prepared with the aid of a drawing tube. Measurements are quoted as the range, with the mean in parentheses, and are given in micrometres. The specimens are deposited in the Natural History Museum, London.

SYSTEMATICS

Family: Microscaphidiidae Looss, 1900 (syn: Angiodictyidae Looss, 1902)
Genus: *Hexangium* Goto et Ozaki, 1929 (syn: *ArthurLoossia* Nagaty, 1954)

Hexangium was erected by Goto and Ozaki (1929) as a new genus within the trematode family Angiodictyidae Looss, 1902 to include *H. sigani* Goto et Ozaki, 1929, collected by them from the intestine of the siganid fish *Siganus fuscescens* off Misaki and Takamatsu, Japan. In *H. sigani*, the body is elongate, the oral sucker is absent (the structure surrounding the mouth has long been accepted as a pharynx rather than an oral sucker (Blair 2005)), the ventral sucker is absent, the oesophagus is long and ends in an oesophageal bulb, the intestinal caeca extend posteriorly close to the testes which are situated diagonally in the posterior region of body, the genital pore is situated midway between the pharynx and the intestinal bifurcation, the ovary is round and immediately post-testicular, the vitelline follicles are arranged singly in rows extending lateral and medial to the caeca for almost their entire length, and each of the two arms of the excretory vesicle divides into three long collecting ducts.

Subsequently, two new species of *Hexangium* have been described from siganid fishes off the Philippines, *H. affinum* Tubangui et Masilungan, 1944 from the intestine of *Amphacanthus javus* by Tubangui and Masilungan (1944) and *H. secundum* Annereaux, 1947 from the intestine of *Teuthis concatenata* by Annereaux (1947). However, Yamaguti (1958) placed *Hexangium* in the He-

xangiinae Yamaguti, 1958, a new subfamily within the family Angiodictyidae, and, based on the striking similarity, he considered *Arthur loossia* Nagaty, 1954 a synonym of *Hexangium*, transferring the type and the only species of the former, *A. loossi* Nagaty, 1954, to *Hexangium* as a new combination. This species was collected from the intestine of the labrid fish *Pseudoscarus harid* and the siganid fish *Teuthis oramen* in the Red Sea off Egypt. *Hexangium affinum*, *H. secundum* and *H. loossi* are very similar to each other and to the type-species, *H. sigani*, and only differ from it in having symmetrically rather than diagonally arranged testes. Therefore, Razarihelisoa (1959) and Velasquez (1961) expressed doubt about the validity of these species, suggesting that they might be conspecific and synonyms of *H. sigani*.

H. elongatum Manter, 1963 was described from the intestine of an acanthurid fish, *Naso* sp., off Fiji. He distinguished this species from *H. sigani* by the absence of an oesophageal bulb, the long intestinal caeca which extend to near the posterior end of body, the tandemly arranged testes and by the excretory collecting ducts which are three in number.

During the years 1964–2004, several authors (e.g. Fischthal & Kuntz 1964 1965, Al-Yamani & Nahhas 1981, Geets & Ollevier 1996, Sey *et al*. 2003, Dzikowski *et al*. 2003) agreed with Razarihelisoa (1959) and Velasquez (1961) and continued to consider *H. affinum*, *H. secundum* and *H. loossi* as synonyms of *H. sigani*.

H. leptosomum Machida et Uchida, 1990 was described from the intestine of the acanthurid fish *Naso vlamingii*, off Japan. They distinguished this species from the two valid species of *Hexangium*, *H. sigani* and *H. elongatum*, by the combination of many characters including the absence of an oesophageal bulb, the long intestinal caeca which extend to the posterior end of body, the tandemly arranged testes and by the genital pore which is located posterior to the intestinal bifurcation. However, they observed that in *H. elongatum*, the anterior region of the ventral surface is concave and acts as an accessory attachment organ.

H. brayi Hassanine et Gibson, 2005 was described from the intestine of the siganid fish *Siganus luridus* in the Red Sea off Sharm El-Sheikh, Egypt. They distinguished this species from *H. sigani* and *H. elongatum* by body shape, which is distinctly pyriform, the terminations of the intestinal caeca which are distinctly saccular, the vitelline follicles which are confined to the intercaecal field and by the arms of the excretory vesicle which divide into two long collecting ducts. They also agreed with previous authors in considering *H. affinum*, *H. secundum* and *H. loossi* as synonyms of *H. sigani*.

In a comprehensive revision of the Microscaphidiidae Looss, 1900, Blair (2005) considered the Angiodictyidae as its synonym, and because the relationships among many of the microscaphidiid genera are unclear, he did not

accept and did not recognise the subfamilies within this family. Accordingly, *Hexangium* was transferred to the Microscaphidiidae. He also transferred *H. elongatum* to a new genus, named *Parawardula* Jones et Blair, 2005, within the family Mesometridae Poche, 1926, since in this species the anterior region of the ventral surface is concave and acts as an accessory attachment organ (Machida & Uchida 1990), the oesophageal bulb is absent, the intestinal caeca almost reach the posterior end of the body and the testes are tandemly arranged. All of these characters, especially the first, are essential in distinguishing the Mesometridae from Microscaphidiidae. However, he erected *Pseudohexangium* Blair, 2005 as a new microscaphidiid genus for *H. leptosomum*, in which the oesophageal bulb is absent, the intestinal caeca almost reach the posterior end of the body, the testes are tandemly arranged and the genital pore is situated posterior to the intestinal bifurcation.

Accordingly, two species of *Hexangium* are currently recognized, i.e. *H. sigani* Goto et Ozaki, 1929 (type species) and *H. brayi* Hassanine et Gibson 2005.

Hexangium saudii sp. n.
(Fig. 1)

Type-host: *Siganus rivulatus* Forsskål et Niebuhr (Teleostei, Siganidae).
Site: Middle intestine.
Type-locality: Red Sea off the coast of Rabigh (between 22°49'N and 22°54'N), Saudi Arabia.
Prevalence: 8/40 fishes examined; 20%.

Type-material: Holotype and paratypes are deposited in the Natural History Museum, London, Reg. nos. 2011.8.2.1 and 2011.8.2.2–8.

Description (Based on 10 fully gravid specimens): Body lanceolate or elongate-pyriform, stout, somewhat dorso-ventrally flattened, 2,261–3,551 (2,906) in length, 648–1,019 (834) in maximum width in its posterior third. Tegument armed with fine sharp spines dorsally and ventrally (often lost during fixation). Suckers absent. Pharynx sub-terminal, globular, well developed, directly surrounds oral opening, 152–238 × 143–225 (195 × 184). Oesophagus long, 529–831 (680), provided with round oesophageal bulb at its posterior end; bulb small, 74–118 (96) in diameter. Intestinal bifurcation at about junction of first and second thirds of body; caeca distinctly short, wide, extend into middle third of body. Testes 2, usually oval, sometimes round, situated obliquely in posterior region of body, subequal, 260–408 × 232–366 (334 × 299). Cirrus sac absent. Seminal vesicle elongate, slender, extends anteriorly from short distance posterior to intestinal bifurcation to near the genital pore, 350–568 × 42–62 (429 × 52); distal end of vesicle joins that of the uterus to form relatively short hermaphroditic duct. Genital pore situated mid-way between pharynx and intestinal bifurcation. Ovary round, median, immediately post-testicular, near to posterior extremity, 119–183 (151) in diameter. Seminal receptacle and Laurer's canal absent; uterine seminal receptacle present. Uterus relatively long, coiled in testicular region and between testes and intestinal caeca, then passes directly between caeca to genital pore. Eggs oval, yellowish, thick-shelled, moderately large, 56–66 × 38–46 (61 × 42). Vitelline follicles moderately large,

arranged in 5–7 rosette-like groups on each side, extending lateral to caeca for almost their entire length. Excretory vesicle V-shaped; excretory arms divide near posterior end of each caecum, giving rise to 3 long collecting ducts extending anteriorly to near level of genital pore. Excretory pore dorso-subterminal.

Comment – *Hexangium* Goto et Ozaki, 1929 currently includes two valid species, *H. sigani* Goto et Ozaki, 1929 and *H. brayi* Hassanine et Gibson, 2005. The first is the best known, since it has been recorded in numerous siganid species (Velasquez 1961, Fischthal & Kuntz 1964, 1965, Al-Yamani & Nahhas 1981, Geets & Ollevier 1996, Kardousha 2003, Sey *et al*. 2003, Dzikowski *et al*. 2003, El-Labadi *et al*. 2006), whereas the second is known only from its original description.

The above description of *H. saudii* sp. n. agrees with the concept of *Hexangium* Goto et Ozaki, 1929. However, it clearly differs from the two known species of the genus, being unique in having the following two characters:

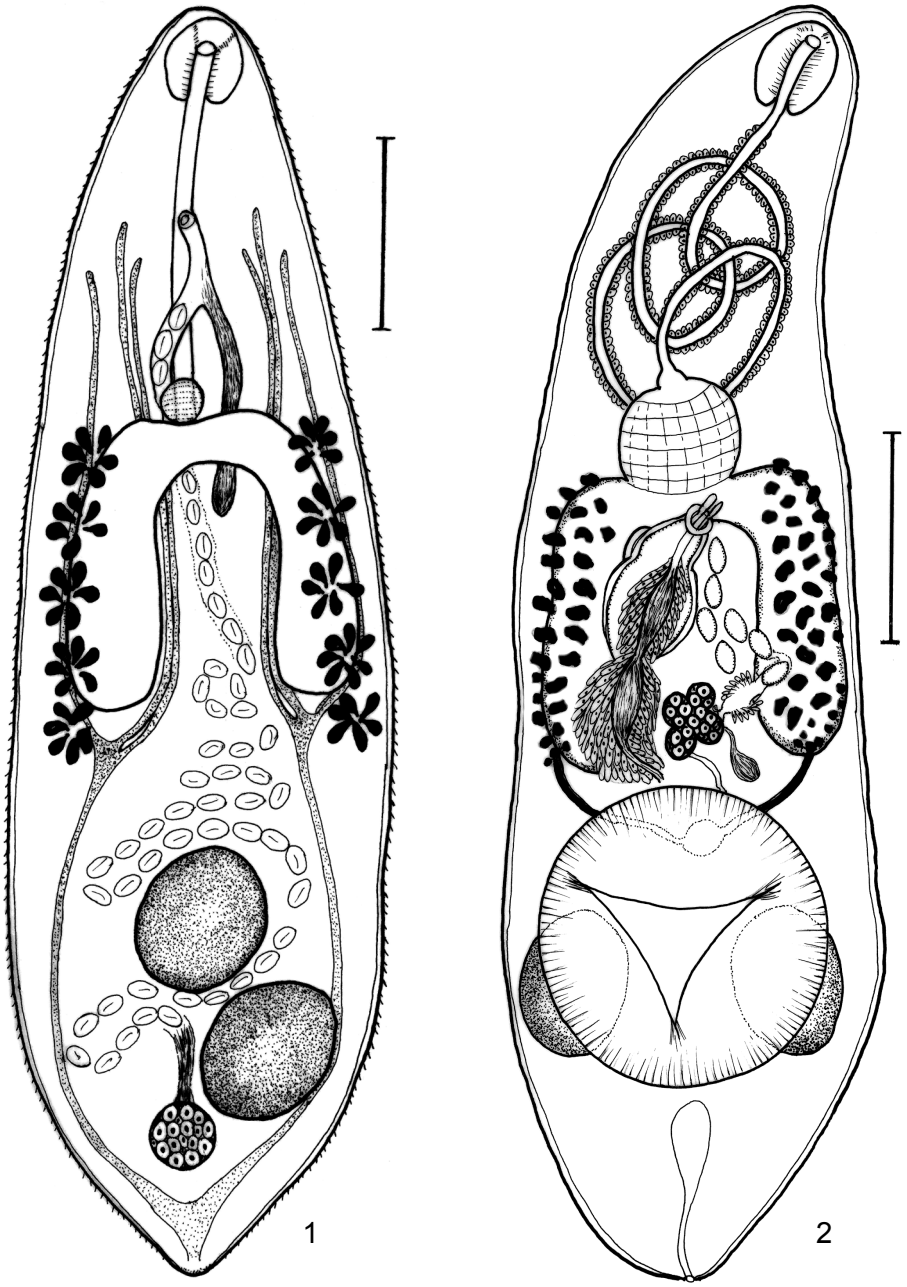
- The intestinal caeca are distinctly short, extending only to the middle third of the body and are more distant from the testes (versus long and extending to close to the testes).
- The vitelline follicles are arranged in rosette-like groups (versus arranged singly without a characteristic appearance).

However, the new species differs from each of the other two species of the genus in several other specific characteristics: from *H. sigani* in having vitelline follicles only distributed lateral to the caeca (versus distributed lateral and medial to the caeca) and in having smaller eggs (56–66 × 38–46 μm) (versus 77–85 × 50–56 μm); and from *H. brayi* in having a distinctly smaller oesophageal bulb, obliquely arranged testes (versus symmetrically arranged), vitelline follicles distributed lateral to the caeca (versus confined to the intercaecal field) and smaller eggs (56–66 × 38–46 μm) (versus 70–85 × 55–60 μm). In view of these specific differences, the present species is considered to be new to science.

Etymology: The specific name *"saudii"* of the new species refers to the locality off the coast of Saudi Arabia.

Family: Gyliauchenidae Fukui, 1929
Subfamily: Gyliaucheninae Fukui, 1929
Genus: *Progyliauchen* Shalaby et Hassanine, 1997

Shalaby and Hassanine (1997) erected *Progyliauchen* as a new gyliauchenid genus for *P. sigani* Shalaby et Hassanine, 1997 from the intestine of the siganid fish *Siganus rivulatus* in the Red Sea off Sharm El-Sheikh, Egypt. They



Figs 1–2. Holotypes (whole-mount, ventral view): 1 = *Hexangium saudii* sp. n. from *Siganus rivulatus*, Red Sea. 2 = *Progyliauchen magnacetabulum* sp. n. from *Siganus luridus*, Red Sea. Scale bar= 500 μm.

referred the genus to the family Gyliauchenidae Fukui, 1929 and subfamily Gyliaucheninae Fukui, 1929, and differentiated it from all genera known at that time in this subfamily by its tetra-lobed ovary, the ventral sucker which is well separated from the posterior end of the body, and by the absence of a postero-terminal protuberant papilla (excretory papilla). Based on these differences, Hall and Cribb (2005) in their comprehensive revision of the Gyliaucheninae accepted *Progyliauchen* as valid gyliauchenid genus. To date, *Progyliauchen* is known only from its type-species.

Progyliauchen magnacetabulum sp. n.
(Fig. 2)

Type-host: *S. luridus* Rüppel (Teleostei, Siganidae).
Site: Lower intestine.
Type-locality: Red Sea off the coast of Rabigh (between 22°49′N and 22°54′N), Saudi Arabia.
Prevalence: 12/50 fishes examined; 24%.

Type-material: Holotype and paratypes are deposited in the Natural History Museum, London, Reg. nos. 2011.8.2.1 and 2011.8.2.2–10.

Description (Based on 14 fully gravid specimens): Body fleshy, robust, tapered anteriorly, elongate to pyriform, 1,980–3,200 (2,590) in length, 610–950 (780) in maximum width at its middle. Excretory papilla absent. Tegument unspined. Oral sucker absent. Ventral sucker large, spherical, 495–753 (624) in diameter, in middle of posterior half of body, well separated from posterior extremity. Pharynx elongate, 161–255 × 121–191 (208 × 156). Oesophagus very long, relatively narrow, highly coiled, with 2–3 loops, longer than body length, surrounded by glandular cells along most of its length. Oesophageal bulb round, large, 198–295 × 229–323 (246 × 276). Intestinal bifurcation at beginning of middle third of body; caeca simple, wide, extend into middle third of body. Testes 2, oval, symmetrical, dorsal to ventral sucker, sub-equal, 241–383 × 177–281 (312 × 229). Cirrus sac short, claviform, mainly intercaecal, 251–383 (317) in length, 148–230 (189) wide at its base, contains tubular seminal vesicle (partly external to cirrus sac), well-developed prostatic complex and relatively short ejaculatory duct; prostatic cells extend outside the cirrus sac to cover external part of seminal vesicle. Genital pore median, directly posterior to intestinal bifurcation. Ovary tetra-lobed, median, anterior to ventral sucker or between caecal extremities. Seminal receptacle oval, submedian, between ventral sucker and left caecum. Mehlis' gland well developed. Insemination chamber located between ovary and oötype. Laurer's canal opens on dorsal surface at level of ventral sucker. Uterus short, winding between ovary, cirrus sac and left caeum. Eggs thin-shelled, yellowish, 68–80 × 42–54 (74 × 48). Vitelline follicles relatively small, irregular, numerous, extend along caeca for almost their entire length. Transverse vitelline collecting ducts coming from vitelline follicles of each side open into small spherical vitelline reservoir dorsal to anterior border of ventral sucker. Excretory vesicle claviform, extends anteriorly to near ventral sucker; excretory pore postero-terminal.

Comment – Morphologically, the above description of *P. magnacetabulum* sp. n. agrees well with the concept of *Progyliauchen* Shalaby et Hassanine 1997, which is to date still endemic to the *Siganus* spp. in the Red Sea. Although, *P. magnacetabulum* sp. n. and *P. sigani* (previously, the only species of the genus) are from closely related, sympatric hosts of a similar size, the new species clearly differs in some specific features:

- The ventral sucker is spherical, large and stout (495–753 μm in diameter), but in *P. sigani* this sucker is transversely elongate and much smaller (188–293 × 245–372 μm).
- The oesophagus is very long, highly coiled (with 2–3 loops) and longer than the total body length if straightened, but in *P. sigani* the oesophagus slightly convoluted into lateral folds and much shorter (about 55% of the total body length).
- The oesophageal bulb is large (198–295 × 229–323 μm), but in *P. sigani*, the bulb is much smaller (130–172 μm in diameter).
- The seminal vesicle is tubular, but in *P. sigani* it is constricted into three parts.

In view of these differences, the present species is considered to be new to science.

Etymology: The specific name "*magnacetabulum*" of the new species refers to the large ventral sucker of the new species.

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