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A digenean parasite in a mudskipper: *Opegaster ouemoensis* sp. n. (Digenea: Opecoelidae) in *Periophthalmus argentilineatus* Valenciennes (Perciformes: Gobiidae) in the mangroves of New Caledonia

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Abstract: *Opegaster ouemoensis* sp. n. is described from *Periophthalmus argentilineatus* Valenciennes (Gobiidae). Distinctive features included the weak or undetectable papillae of the ventral sucker and the small, but distinct cirrus-sac. The new species is compared with 25 marine species of *Opegaster* for which a table of measurements and ratios is presented. The new combination *Opegaster queenslandicus* (Aken'Ova, 2007) (originally in *Opecoelus*) is formed. Fifteen mudskippers were intensively examined for parasites; larval anisakid nematodes and acanthocephalans were found, but no monogeneans, cestodes, copepods, isopods, hirudineans or adult nematodes. A brief summary of the helminth parasites of mudskippers is included.

Keywords: *Opegaster* review, helminths, Nematoda, Acanthocephala

Mudskippers are members of the subfamily Oxudercinae (tribe Periophthalmini), within the family Gobiidae (gobies) (Murdy 1989). Depending on the authority, there are some nine or ten genera, the commonest and best known of which is *Periophthalmus* Bloch et Schneider. As far as we are aware, this is the only genus from which an adult digenean has been reported, i.e. the lecithasterid *Lecithaster ghanensis* Fischthal et Thomas, 1971 described by Fischthal and Thomas (1971) from *Periophthalmus koelreuteri* (Pallas) [now considered *P. barbarus* (Linnaeus)] from the Kakum River estuary, Ghana.

We found a digenean in a high proportion of specimens of the barred mudskipper *Periophthalmus argentilineatus* Valenciennes amongst the mangroves in Nouméa, New Caledonia. This fish species is widespread in mangrove ecosystems and mudflats of the Indo-Pacific Region (Murdy 1989). It is a carnivorous opportunist feeder consuming small prey such as small crabs and other arthropods. Despite the widespread and common occurrence of the species, we can detect no records of digeneans from it.

MATERIALS AND METHODS

Fifteen fish caught on 16 February 2011 were examined, all from Ouémo. The fish varied between 90–113 mm (mean 98 mm) in length, and 7.2–11.8 g (mean 9.4 g) in weight. Gills were examined. The ovary, fins and body surface of five fish were also examined. Digeneans were collected live, immediately fixed in nearly boiling saline and then transferred to 80% ethanol (Cribb and Bray 2010). Wholemounts were stained with Mayer's paracarmine, cleared in beechwood creosote and mounted in Canada balsam. Measurements were made through a drawing tube on an Olympus BH-2 microscope, using a Digicad Plus digitising tablet and Carl Zeiss KS100 software adapted by Imaging Associates, and are quoted in micrometres. The following abbreviations are used: BMNH, British Museum (Natural History) Collection at the Natural History Museum, London, UK; MNHN JNC, Muséum National d'Histoire Naturelle, Paris, France.

We have devised a tabular key to the marine species of the genus *Opegaster*, using 16 metrical and ratio characters plotted into an Excel spreadsheet similar to that used in Bray and Palm (2009) and Bray and Justine (2010). This key is summarised in Table 2. The parameter 'seminal vesicle reach' is the distance from the anterior extremity of the body to the posterior most extent of the external seminal vesicle as a percentage of body-length.

RESULTS

Family Opecoelidae Ozaki, 1925
Subfamily Opecoelinae Ozaki, 1925
Genus *Opegaster* Ozaki, 1928

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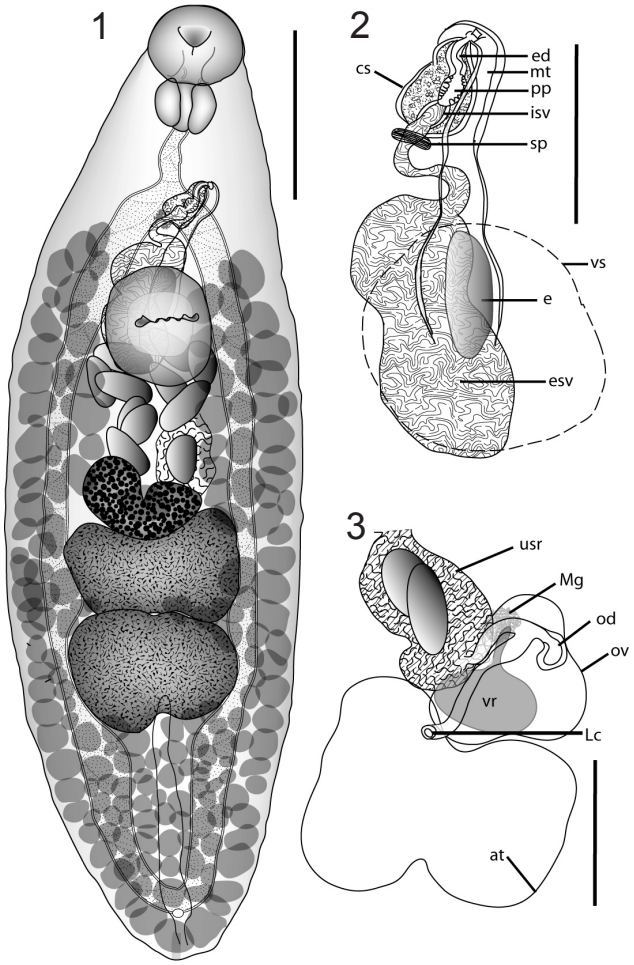

Figs. 1–3. *Opegaster ouemoensis* sp. n. **1.** Ventral view of holotype. **2.** Terminal genitalia. **3.** Dorsal view of proximal female system. *Abbreviations*: at – outline of anterior testis; cs – cirrus-sac; e – egg; ed – ejaculatory duct; esv – external seminal vesicle; isv – internal seminal vesicle; Lc – opening of Laurer's canal; Mg – Mehlis' gland; mt – metraterm; od – oviduct; ov – outline of ovary; pp – pars prostatica; sp – sphincter; usr – uterine seminal receptacle; vr – vitelline reservoir; vs – outline of ventral sucker. Scale-bars: 1 = 200 μm; 2, 3 = 100 μm.

***Opegaster ouemoensis* sp. n.** Figs. 1–3

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Description (based on 26 worms; measurements in Table 1). Body oval, widest in mid-body (Fig. 1). Tegument unarmed. Preoral lobe absent. Oral sucker oval, subterminal. Ventral sucker rounded, pre-equatorial, usually bigger than oral sucker. Papillae weakly developed, sometimes seen on one or both lips of ventral sucker. Prepharynx short, entirely dorsal to oral sucker. Pharynx oval. Oesophagus distinct. Intestinal bifurcation in mid-forebody. Caeca unite close to posterior extremity and open through single ventral anus.

Testes two, oval or irregularly oval, longer axis transverse, tandem, contiguous, in mid-hindbody. Cirrus-sac small, short claviform, containing short ejaculatory duct, small vesicular pars prostatica and small subglobular portion of seminal vesicle. External seminal vesicle wide, elongate, coiled reaching dorsally to ventral sucker, with sphincter around distal extremity. Genital atrium small. Genital pore sinistral, mid-way between median line and body margin at level of intestinal bifurcation.

Ovary reniform, pretesticular, contiguous with anterior testis. Uterine seminal receptacle distinct. Mehlis' gland dorsal to ovary. Laurer's canal opens dorsally to posterior part of ovary or anterior part of anterior testis. Vitellarium

Table 1. Measurements and ratios of *Opegaster ouemoensis* sp. n.

	min.	max.	mean
Length	719	1 270	1 017
Width	206	357	294
Forebody length	227	377	315
Oral sucker length	68	104	88
Oral sucker width	68	106	89
Prepharynx length	0	18	4
Pharynx length	39	71	57
Pharynx width	46	87	65
Oesophagus length	48	115	81
Intestinal bifurcation to ventral sucker	55	142	100
Ventral sucker to anterior vitelline extent	53	177	126
Ventral sucker length	62	148	111
Ventral sucker width	66	154	111
Seminal vesicle length	47	200	86
Seminal vesicle width	24	53	37
Ventral sucker to ovary	43	139	92
Ovary length	50	97	72
Ovary width	71	143	101
Ovary to anterior testis	0	0	0
Anterior testis length	68	176	127
Anterior testis width	113	240	181
Distance between testes	0	0	0
Posterior testis length	100	196	141
Posterior testis width	117	231	177
Post-testicular distance	94	293	202
Egg length	60	78	70
Egg width	25	43	32
Width %*	25	35	29
Forebody %*	27	35	31
Sucker length ratio %*	85	165	127
Sucker width ratio %*	97	168	124
Pharynx: oral sucker width ratio %*	122	160	138
Ventral sucker to ovary %*	5	13	9
Post-testicular distance %*	10	25	20
Prepharyngeal distance	74	102	87
Prebifurcal distance	175	283	225
Pre-genital pore distance	150	250	199
Previtelline distance	128	248	190
Seminal vesicle reach	327	546	444
Preovarian distance	357	643	519
Post-uterine distance	339	598	474
Prepharynx distance%*	7	11	9
Prebifurcation distance %*	18	26	22
Pre-genital pore distance %*	16	22	20
Previtelline distance %*	14	23	19
Seminal vesicle reach %*	39	49	44
Preovarian distance %*	46	55	51
Post-uterine distance %*	41	50	46

n = 26; * % of body-length

follicular, fields reach from close to posterior extremity to level of intestinal bifurcation or just anterior or posterior, lateral to caeca and encroaching slightly over dorsal and ventral surface of caeca, confluent or not in forebody and dorsal to ventral sucker and confluent in post-testicular region. Uterus pretesticular, intercaecal. Metraterm of similar length as cirrus-sac. Eggs relatively few, tanned, operculate.

Excretory pore terminal. Vesicle I-shaped, reaches to posterior testis.

Type host: *Periophthalmus argentilineatus* Valenciennes (Perciformes: Gobiidae), barred mudskipper.

Type locality: Mangrove of Ouémo, Nouméa (22°16'38"S, 166°28'16"E; 16 February 2011).

Other collection date: 27 February 2010.

Site: Digestive tract.

Prevalence: 14/15; intensity: 1–17.

Type specimens: Holotype MNHN JNC3328-1, paratypes MNHN JNC3174, JNC3318, JNC3319, JNC3322, JNC3323, JNC3324, JNC3325, JNC3326, JNC3327, BMNH 2012.10.12.1-4.

Remarks. The papillae on the ventral sucker are never very distinct, and sometimes not detectable. Of the specimens measured, 21 were oriented such that the ventral sucker lips could be clearly seen. In six cases clear evidence of three papillae on each lip were seen and in four there were no signs of papillae. Three worms had distinct papillae on the anterior lip and a wavy margin of the posterior lip, two had a wavy margin on the anterior lip and three papillae on the posterior lip, and two had a wavy margin on the anterior lip and no indication of papillae on the posterior lip. Unique combinations were: wavy margins on both lips, three papillae on anterior lip and none on posterior lip, three papillae on anterior lip and four on posterior lip and no papillae on anterior lip and a wavy margin on the posterior lip.

DISCUSSION

We reckon that there are 27 marine species satisfying the criteria used by Cribb (2005) to define the genus, including one of the *Opecoelus* species described by Aken'Ova (2007). They are listed below (see also Table 2), and the features distinguishing them from *Opegaster ouemoensis* sp. n. are discussed. In general the comparisons are made from the original description, with observations on subsequent records.

Opegaster pentedactyla Manter, 1940 has its vitellarium extending from posterior edge of acetabulum to posterior end' and is not treated here (Manter, 1940). *Opegaster alykhani* Bilqees, Hadi, Khatoon, Muti-ur-Rehman, Perveen et Haseeb, 2009 appears to have a large, muscular cirrus-sac reaching to the posterior margin of the ventral sucker (Bilqees et al. 2009) and is not here considered a member of *Opegaster*.

The discussion below presents the features distinguishing *Opegaster ouemoensis* sp. n. from other *Opegaster* species, in order of their similarity to the new species. For data see Table 2.

Opegaster iniistii Yamaguti, 1970. This species is very similar to *O. ouemoensis*. Only two features do not overlap the variation, i.e. the body width and the length of the post-testicular region. The ovary is said to be rounded, triangular (Yamaguti 1970). The cirrus-sac appears to be very weakly developed and is not as prominent as in *O. ouemoensis*. This species, known only from three specimens, has "five papillae on anterior and posterior margins respectively (three median papillae conical, but two laterals much smaller and rounder)" (Yamaguti 1970).

Opegaster pritchardae Overstreet, 1969. This Atlantic species, based on 12 specimens, does not overlap *O. ouemoensis* in prepharyngeal, preovarian and post-uterine distances, seminal vesicle reach and distance between the ventral sucker and ovary (Overstreet 1969). These are minor distinctions, but the ventral sucker bears no papillae, the ovary is 'slightly irregular' and the range of egg sizes, although overlapping, includes much shorter eggs. In the illustration the caecal confluence is almost immediately post-testicular. The host is a gobiid, but the wide geographical separation precludes any likelihood of conspecificity.

Opegaster dermatogenyos Yamaguti, 1970. This Indo-Pacific species, based on eight specimens, does not overlap *O. ouemoensis* in body and forebody length, sucker-width ratio, prepharyngeal, prebifurcal, pregenital pore and ventral sucker to ovary distances. The ventral sucker is said to have three or more simple papillae on each lip (Yamaguti 1970). The testes are close together, but not contiguous in the illustration and are irregularly lobed. The excretory vesicle reaches to the ovary. The genital pore appears to be slightly more anterior.

Opegaster plotosi Yamaguti, 1940. Our comparison is based on the original description based on two specimens (Yamaguti 1940), where there is no overlap of data for body-length, seminal vesicle reach and post-uterine and post-testicular distances. The seminal vesicle reach is likely to be most significant, as it is only just overlapping the anterior edge of the ventral sucker. The ventral sucker bears three papilliform protuberances on each lip. The excretory vesicle reaches to the ovary. The description of this species by Yamaguti (1942) indicates a much greater sucker ratio than the original description (sucker width ratio 206–256% vs 159–167%).

Opegaster synodi Manter, 1947. According to the original description (Manter 1947), based on two specimens, including one immature, the eggs size is 50–54 × 30–32 µm, distinctly smaller than those of *O. ouemoensis*, but the dimensions given by Chinchilla and Mago (2002) overlap those of *O. ouemoensis* at 55–65 × 25–30 µm.

Table 2. Tabular key to marine *Opegaster* spp.

	Length	Width %*	Forebody %*	Sucker ratio %*	Prepharyngeal distance %*	Prebifurcal distance %*	Pre-genital pore distance %*	Seminal vesicle reach %*	Previtelline distance %*
***O. ouemoensis* n. sp.**	**719–1 270**	**25–35**	**27–35**	**97–168**	**7–11**	**18–26**	**16–22**	**39–49**	**14–23**
O. acuta	950–1 633	27–32	20–23	155–175	9	17	9	33	22
O. apogonichthydis	3 300	30	21	156	7	14	13	33	11
O. bothi	1 800–4 200	14–25	19	195–256	6	13	9	34	8
O. brevifistula	1 900–2 900	34–37	26	139–143	9	16	16	37	14
O. brevifistula	1 200–3 750	23–33	-**	159–235	-	-	-	-	-
O. brevifistula	2 560–2 880	23–28	18	183	6	13	11	31	13
O. cryptocentri	1600	35	39	160	13	26	20	38	25
O. dactylopteri	1 200–2 200	21–23	19	144–179	6	13	9	32	16
O. dendrochiri	1 400–3 600	19–24	9	154–175	6	14	10	35	8
O. dermatogenyos	1 780–2 750	19–30	24	180–210	6	17	10	41	14
O. ditrematis	1 550	35	24	208	8	16	14	29	10
O. ditrematis	-	-	-	130–194	-	-	-	-	-
O. ditrematis	1 216–1 741	21–24	20–27	154–177	9	22	20	40	17
O. ditrematis	1 500–1 587	34–35	23	157–166	10	18	14	24	12
O. gobii	800–2 100	36–38	29	150–170	7	19	18	32	19
O. hawaiiensis	770–2 400	21–26	14	186	6	12	7	32	12
O. hawaiiensis	1 150	21	-	184	-	-	-	-	-
O. hippocampi	867–1 598	36–49	22	127–185	10	14	13	34	16
O. iniistii	1 180–1 650	23	33	118–200	11	22	18	48	22
O. lobulus	2 720	32	21	160	6	14	13	24	14
O. longivesicula	1 300	34	30	138	9	20	19	56	22
O. lutiani	1 060–1 440	28–30	19–21	150–190	7	16	11	33	15
O. macrorchis	2 300–2 900	27–29	23	165–179	6	15	12	35	14
O. macrorchis	1 900–2 100	30	-	173–175	-	-	-	-	-
O. macrorchis	1 920–2 460	25–26	20	167	8	17	13	34	13
O. ovatus	1 800–2 000	36–38	28	131–143	8	19	16	26	20
O. ovatus	1 600–1 800	-	-	-	-	-	-	-	-
O. paramacrorchis	2 628–3 270	32–34	18–20	160–180	6	12	10	37	11
O. parapristipomatis	2 500–2 800	24	23	164	5	15	15	23	12
O. parapristipomatis	1 200–1 790	22	25	186	7	17	16	28	14
O. parapristipomatis	3 360–3 420	17–19	26	200	6	14	13	36	17
O. plotosi	1 420–1 450	26	30	159–167	8	19	16	32	18
O. plotosi	1 060–2 580	25–26	-	206–256	-	-	-	-	-
O. pritchardae	1 000–1 400	32–34	30–38	160–200	13	24	20	35	17
O. queenslandicus	950–1 950	22–26	19–26	160–230	7	18	10–17	29	14–23
O. rectus	2 150–2 400	30	25	153	8	20	15	31	15
O. syngnathi	1 310–1 470	19	25	155–162	10	21	22	35	24
O. syngnathi	1 300–1 580	20–24	-	153–157	-	-	-	-	-
O. syngnathi	3 680–3 820	14–17	15	130	6	11	10	26	23
O. synodi	1 051	29	26	220	10	21	18	44	20
O. synodi	1 155–1 715	31–39	-	159–164	-	-	-	-	-
O. tamori	3 000–3 300	16–24	23	200	5	15	14	39	23
O. tamori	1 980	25	-	158	-	-	-	-	-

(continued)

The original specimen appears to be in poor condition as the ovary and Mehlis' gland could not be distinguished. The cirrus-sac is apparently narrow, but was not described by Manter (1947). The ventral sucker bears three papillae on each lip. Shen (1990) reported *O. synodi* from the gold-lined seabream *Rhabdosargus sarba* (Forsskål) (Sparidae) off Hainan Island China. The illustration shows the vitellarium restricted to the hindbody. We reckon that this is probably an *Opecoelus* and will not discuss this record further. Szidat (1965) reported *O. synodi* from the yellow-belly rockcod *Notothenia neglecta* Nybelin (Nototheniidae) from the South Orkney Islands. This record is now considered to refer to *Neolebouria antarctica* (Szidat et Graefe, 1967) (see Zdzitowiecki 1997).

Opegaster longivesicula Yamaguti, 1952. This species is based on a single specimen amongst specimens of *O. gobii*. It does not overlap *O. ouemoensis* in length, seminal vesicle reach and preovarian, ventral sucker to ovary and post-uterine distances. The seminal vesicle reaches virtually to the ovary. The ventral sucker bears three strongly flattened papillae on each lip (Yamaguti 1952). The excretory vesicle apparently reaches to the ovary.

Opegaster syngnathi Yamaguti, 1934. In the original description, based on three specimens, the vitellarium is

Table 2. Continued.

	Preovarian distance %*	Ventral sucker to ovary distance %*	Ovary to anterior testis distance %*	Distance between testes %*	Post-uterine distance %*	Post-testicular distance %*	Egg-size	References
O. ouemoensis n. sp.	**46–55**	**5–13**	**0**	**0**	**41–50**	**10–25**	**60–78 × 25–43**	**new data**
O. acuta	48	8	1	1	52	29	44–47 × 24–27	Manter (1940)
O. apogonichthydis	42	10	0	1	57	38	69–72 × 36–42	Yamaguti (1938)
O. bothi	44	14	0	2	56	30	60–67 × 37–44	Yamaguti (1970)
O. brevifistula	47	10	0	0	48	33	54–61 × 33–37	Ozaki (1928)
O. brevifistula	-	-	-	-	-	-	57–66 × 30–38	Yamaguti (1940)
O. brevifistula	40	12	0	0	62	31	64–68 × 34–36	Wang et al. (1992)
O. cryptocentri	63	12	0	0	35	18	63–73 × 34–39	Yamaguti (1958)
O. dactylopteri	43	14	0	2	59	26	55–65 × 37–43	Yamaguti (1970)
O. dendrochiri	43	20	0	0	63	30	51–65 × 35–46	Yamaguti (1970)
O. dermatogenyos	53	14	0	2	45	23	60–70 × 30–35	Yamaguti (1970)
O. ditrematis	46	7	0	0	49	21	54–57 × 33–36	Yamaguti (1942)
O. ditrematis	-	-	-	-	-	-	50–64 × 26–45	Manter and Pritchard (1960)
O. ditrematis	58	14	0	1	47	28	56–64 × 26–32	Bray and Cribb (1989)
O. ditrematis	48	10	1	0	51	20	54–58 × 33–36	Shen and Qiu (1995)
O. gobii	54	13	0	0	47	23	63–76 × 45–51	Yamaguti (1952)
O. hawaiiensis	45	17	0	2	55	27	53–65 × 37–42	Yamaguti (1970)
O. hawaiiensis	-	-	-	-	-	-	53–61 × 28–32	Reimer (1987)
O. hippocampi	43	9	0	1	56	36	48–57 × 27–33	Shen (1982)
O. iniistii	55	6	0	0	45	27	55–65 × 37–40	Yamaguti (1970)
O. lobulus	42	11	3	5	61	31	66–70 × 42–46	Wang (1977)
O. longivesicula	58	14	0	0	37	20	66–75 × 48–50	Yamaguti (1952)
O. lutiani	43	11	0	0	57	28	47–56 × 34–39	Bravo-Hollis and Manter (1957)
O. macrorchis	43	11	0	0	55	24	57–72 × 22–42	Yamaguti (1938)
O. macrorchis	-	-	-	-	-	-	56–66 × 39–42	Yamaguti (1959)
O. macrorchis	46	18	1	2	57	26	60–66 × 32–38	Wang et al. (1992)
O. ovatus	60	22	0	0	41	21	45–52 × 30–36	Ozaki (1928)
O. ovatus	-	-	-	-	-	-	-	Yamaguti (1934)
O. paramacrorchis	45	13	1	2	54	26	50–59 × 26–41	Hafeezullah (1971)
O. parapristipomatis	42	12	0	0	59	37	58–71 × 31–42	Yamaguti (1934)
O. parapristipomatis	51	10	0	0	48	27	48–54 × 26–30	Manter (1940)
O. parapristipomatis	46	11	1	0	55	28	58–66 × 30–38	Wang et al. (1992)
O. plotosi	48	5	2	2	52	26	51–63 × 32–35	Yamaguti (1940)
O. plotosi	-	-	-	-	-	-	57–63 × 31–39	Yamaguti (1942)
O. pritchardae	56	4	0	0	39	9–14	54–64 × 31–39	Overstreet (1969)
O. queenslandicus	46	12	0	0	54	24–34	45–63 × 27–45	Aken'Ova (2007)
O. rectus	56	22	0	0	47	20	45–50 × 30–35	Ozaki (1928)
O. syngnathi	52	17	0	0	48	27	68–76 × 42	Yamaguti (1934)
O. syngnathi	-	-	-	-	-	-	57–63 × 31–34	Yamaguti (1951)
O. syngnathi	41	22	3	6	64	31	54–68 × 35–38	Wang et al. (1992)
O. synodi	53	11	0	0	43	23	50–54 × 30–32	Manter (1947)
O. synodi	-	-	-	-	-	-	55–65 × 25–30	Chinchilla and Mago (2002)
O. tamori	45	14	0	0	56	29	62–72 × ?	Yamaguti (1938)
O. tamori	-	-	-	-	-	-	60–66 × 28–35	Reimer (1987)

* % of body-length; ** no data available

described as reaching near the level of the intestinal bifurcation, where they are greatly reduced in size and number (Yamaguti 1934). It goes on to say "The rudimentary condition of the anteriormost follicles is more pronounced in a paratype". In the Yamaguti (1951) description, based on two specimens from the type-host and locality, the vitellarium is described as reaching between the acetabulum and posterior extremity. Wang et al. (1992) illustrated no vitelline follicles in the forebody. In addition, the original specimens do not overlap *O. ouemoensis* in length, width, forebody, seminal vesicle reach and ventral sucker to ovary and post-testicular distances. The Japanese specimens are described as having three inconspicuous papillae on each lip of the ventral sucker. None are illustrated for the Chinese specimens.

Opegaster gobii Yamaguti, 1952. The original description, based on numerous specimens, indicates that this species is very similar to, but differs from, *O. ouemoensis* in the seminal vesicle reach and cirrus-sac shape. The seminal vesicle is small, just overlapping the ventral sucker and the cirrus-sac relatively long and narrow. Six papillae (three on each lip) are described by Yamaguti (1952) and Manter (1954), the latter saying that they are very small, sometimes not observable. The illustration of

O. gobii by Wang et al. (1992) shows no papillae, and the cirrus-sac appears large, enclosing the seminal vesicle, suggesting that this form may have been placed in the wrong subfamily.

Opegaster brevifistula Ozaki, 1928. This is a bigger worm reaching to 2.9 mm (Ozaki 1928), 3.75 mm (Yamaguti 1940) or 2.88 mm (Wang et al. 1992). The post-testicular region is distinctly greater than in *O. ouemoensis* and the cirrus-sac is narrow. The species is described as having six finger-like conspicuous marginal papillae on the ventral sucker (Ozaki 1928). Yamaguti (1940) described them as tentacular appendages. None were shown on the illustration of the Chinese material (Wang et al. 1992).

Opegaster dactylopteri Yamaguti, 1970. This species, based on 22 specimens, apparently grows much larger than *O. ouemoensis*, the seminal vesicle reaches various distances into the hindbody, but because of the short forebody, has a shorter percentage reach than *O. ouemoensis*. The genital pore and intestinal bifurcation are situated more anteriorly in this shorter forebody. The oral sucker bears 3–5 conical papillae on anterior and posterior margins (Yamaguti 1970).

Opegaster ditrematis Yamaguti, 1942. Basing the discussion on the original description of a single worm, it appears that the forebody and seminal vesicle reach are shorter than in *O. ouemoensis* (Yamaguti 1942). The sucker ratio is greater (208%) and the vitelline follicles reach anteriorly beyond the genital pore as far as the pharynx. The eggs are mostly smaller. In specimens from Hawaii, Manter and Pritchard (1960) gave the sucker ratio as 130–194% and the vitellarium does not reach anteriorly beyond the genital pore. Great Barrier Reef specimens (Bray and Cribb 1989) have a sucker ratio of 154–177%, and a vitellarium reaching asymmetrically no further anteriorly than the mid-oesophagus. Chinese specimens (Shen and Qiu 1995) have a sucker ratio of about 157–166% and a vitellarium reaching to the pharynx, with the genital pore also at the level of the pharynx.

The original description stated that there was a row of several papilliform protuberances on anterior and posterior lips of the ventral sucker. Manter and Pritchard (1960) considered that there were ten acetabular papillae, five on each margin of the ventral sucker, which are inconspicuous and invisible if the lips are pressed together. Bray and Cribb (1989) said that both anterior and posterior ventral sucker lips bear five short dome-shaped papillae, usually clearly seen and counted. The illustration in Shen and Qiu (1995) shows about five papillae on each ventral sucker lip. It is difficult to be certain of the true characteristics of this species, but it can be said that our specimens differ distinctly from the type-specimen. The status of other forms under this name awaits further study. Bray and Cribb (1989) stated "It seems likely that this species is not a robust concept, but may form part of a species complex, the constituent species of which may be indistinguishable, or at least difficult to distinguish, morphologically, but which may eventually be recognized by life-cycle, host-specificity and biochemical characteristics".

Opegaster lutiani Bravo-Hollis et Manter, 1957. The published information on the morphology of this species is based on four specimens (Bravo-Hollis and Manter 1957). The cirrus-sac is said to be lacking. The post-uterine distance is greater and the forebody and seminal vesicle reach are shorter than in *O. ouemoensis*. The genital pore is lateral to the pharynx. The egg-length, preovarian and post-testicular distances do not overlap. There are five small papillae on each ventral sucker lip.

Opegaster bothi Yamaguti, 1970. This species, based on 18 specimens, differs from *O. ouemoensis* in the shorter forebody, pre-genital pore distance, prebifurcal and previtelline lengths, and the greater body-length, sucker width ratio and post-uterine and post-testicular distances. There are four or five more or less conical papillae on each ventral sucker lip, and the median papillae are most prominent (Yamaguti 1970).

Opegaster queenslandicus (Aken'Ova, 2007) n. comb. (Syn. *Opecoelus queenslandicus* Aken'Ova, 2007). This species, based on six specimens, differs from *O. ouemoensis* in the shorter forebody and seminal vesicle reach and the longer post-uterine distance. There are five distinct papillae on each ventral sucker lip (Aken'Ova 2007). Having decided to recognise the genus *Opegaster*, we feel that it is necessary to form this new combination in the discussion of this species, which clearly fits into the concept of *Opegaster* accepted here.

Opegaster rectus Ozaki, 1928. This species differs from *O. ouemoensis* in the greater size, ventral sucker to ovary distance, smaller eggs, shorter seminal vesicle reach and deeply lobed testes. No papillae are described or illustrated on the ventral sucker lips (Ozaki 1928). The cirrus-sac appears to be narrow.

Opegaster cryptocentri Yamaguti, 1958. This species, based on a single specimen, differs from *O. ouemoensis* in its long forebody, body-length, prepharyngal, prebifurcal, previtelline, preovarian and post-uterine distances. The ventral sucker bears seven papillae on each lip (Yamaguti 1958).

Opegaster ovatus Ozaki, 1928. The seminal vesicle reach of this species is distinctly smaller than that of *O. ouemoensis* as it only just overlaps the ventral sucker. The worm is larger than *O. ouemoensis,* with a much longer uterus with many eggs, and therefore there is a distinctly longer ventral sucker to ovary distance and preovarian distance. The eggs are distinctly smaller (45–52 µm long). The cirrus-sac is narrow and the ventral sucker papillae rudimentary (Ozaki 1928).

Opegaster hawaiiensis Yamaguti, 1970. The forebody of this species, which was originally based on six specimens, is much shorter than that found in *O. oue-*

moensis and the genital pore much more anterior, being at the level of the pharynx. Other distinct differences include the seminal vesicle reaching into the hindbody and shorter prebifurcal and longer post-uterine and ventral sucker to ovary distances. The ventral sucker papillae are described as 3–7 on the anterior lip and 3–6 on the posterior, and illustrated as distinctly digitiform (Yamaguti 1970), or seven (presumably on each lip) (Reimer 1987). The cirrus-sac is small and narrow.

Opegaster hippocampi Shen, 1982. This species, based on eight specimens, has a much longer post-testicular region than *O. ouemoensis* (Shen 1982). Other features that appear distinct are the longer post-uterine region, the shorter seminal vesicle reach, the genital pore at the level of the pharynx, the more anterior extent of the vitellarium and the egg length (48–57 μm), which does not overlap that of *O. ouemoensis*. There are four papillae on each ventral sucker lip. The cirrus-sac is narrow.

Opegaster macrorchis Yamaguti, 1938. Members of this species are larger than *O. ouemoensis*. The uterus is larger and with many eggs; minor differences may also be found in post-uterine distance, forebody length, pre-genital pore distance and seminal vesicle reach (Yamaguti 1938, 1959). The testes appear to be more lobed and the cirrus-sac somewhat narrower. The ventral sucker bears three papillae on each lip (not illustrated by Wang et al. 1992).

Opegaster paramacrorchis Hafeezullah, 1971. Madhavi (1975) considered this species synonymous with *O. ditrematis*. While not rejecting this synonymy, we are treating the form described by Hafeezullah (1971) separately. This is a much larger species than *O. ouemoensis*, with a shorter forebody and prebifurcal and pre-genital pore distances. It has many more eggs in the uterus. The ventral sucker bears five papillae on one lip (usually the anterior lip).

Opegaster tamori Yamaguti, 1938. This is a large worm (3.0–3.3 mm long – Yamaguti 1938; 1.93 mm long – Reimer 1987). This species differs from *O. ouemoensis* in the sucker ratio (according to the original description), the forebody is shorter, the post-uterine and post-testicular distances are longer and the genital pore is relatively more anterior. The ventral sucker lacks papillae and the excretory vesicle reaches to the ovary. Reimer (1987) corrected his 1984 attribution of *O. gonorhynchi* to *O. tamori*.

Opegaster apogonichthydis Yamaguti, 1938. This species, based on a single specimen, is larger than *O. ouemoensis* (3.3 mm long) and has a much greater post-testicular region. Other differences include the longer post-uterine distance, shorter forebody, prebifurcal distance, preovarian distance and seminal vesicle reach. The cirrus-sac is small, the excretory vesicle reaches to the ovary and the ventral sucker bears three papillae on each lip (Yamaguti 1938).

Opegaster acuta Manter, 1940. This species, based on 12 specimens, differs in a distinctly more anterior genital pore and smaller eggs. In addition the forebody length, prebifurcal distance, seminal vesicle reach and post-uterine and post-testicular distances do not overlap the variation shown in *O. ouemoensis*. The vitellarium is described as "extending anterior to acetabulum almost to intestinal bifurcation on one or both sides. In one specimen … only rudimentary follicles could be seen anterior to acetabulum". Unfortunately, this latter specimen is the only one illustrated (Manter 1940). The ventral sucker bears five pairs of small, interlocking papillae.

Opegaster dendrochiri Yamaguti, 1970. This species, based on seven specimens, is relatively elongate with a very short forebody, and a long post-uterine distance. Other differentiating features are the long ventral sucker to ovary and post-testicular distances, the short pre-genital pore distance, previtelline and prebifurcal distances. The ventral sucker is said to be pedunculate, and bears four papillae on each lip. The cirrus-sac is rudimentary and the excretory vesicle reaches to the ovary (Yamaguti 1970).

Opecoelus lobulus Wang, 1977. This large worm (2.72 mm long) is reported in a catadromous eel. It has a short seminal vesicle reach, just overlapping the ventral sucker. The post-uterine and post-testicular distances are long and the forebody, prebifurcal, preovarian and pre-genital pore distances are short. The cirrus-sac is not illustrated and no papillae are illustrated on the ventral sucker. The excretory pore reaches to the ovary (Wang 1977).

Opegaster parapristipomatis Yamaguti, 1934. This species was originally based on several specimens, but it is not clear whether more than one was measured. It differs from *O. ouemoensis* in its size: it grows to 2.8 mm according to the original description. The seminal vesicle reach is smaller and the post-testicular region is greater. Also there appear to be distinctions in the post-uterine region (greater), the preovarian region (greater) and forebody (smaller). Later descriptions cast some doubt on these distinctions, but it is not at all clear that all are correct identifications. Wang et al. (1992) illustrated a relatively long seminal vesicle, which appears to be surrounded by a thick (? muscular) wall. They also show no papillae on the ventral sucker. According to Yamaguti (1934) the ventral sucker bears inconspicuous papillae and Manter (1940) stated that while "most specimens showed 3 large and 2 small lateral papillae on each lip of the acetabulum, a few showed these structure inconspicuously". The cirrus-sac was not described by Yamaguti (1934) and, if present, must be very small.

Opegaster Ozaki, 1928 or *Opecoelus* Ozaki, 1925?

Ozaki (1928), in the paper in which he erected the genus *Opegaster*, produced a key to the members of his

concept of the Opecoelidae. The new genus was differentiated in the key by body ovate and vitellaria extending into the neck, as opposed to body elongate and vitellaria entirely post-acetabular for *Opecoelus*. Subsequent workers have mostly continued to recognize these genera as distinct, based mainly on the vitelline distribution (Manter 1940, 1954, Yamaguti 1953, Banerjee 1965), but also on the ventral sucker being pedunculate or not (Skryabin and Petrov 1958, Mehra 1966) or the presence or absence of papillae on the ventral sucker (Yamaguti 1971).

Manter (1954) stated "The genus *Opegaster* is so similar to *Opecoelus* that if retained it must be distinguished on some arbitrary basis", and invoked the vitelline distribution as a convenient basis. He pointed out that the variation found in *Opegaster minimus* (Tubangui, 1928) by Tubangui and Masiluñgan (1944) probably involved more than one species. Cribb (1985) described the Australian freshwater species *Opecoelus variabilis* Cribb, 1985 as having vitelline fields that extend laterally in continuous zone along caeca, dorsally and ventrally, from 169 (0–314) in front of the posterior margin of the ventral sucker and the illustrations show that the vitelline fields may extend slightly into the forebody. He redefined the genus *Opecoelus* with *Opegaster* as a synonym. Shimazu (1988) also produced a definition of *Opecoelus* to include *Opegaster* as a synonym.

On the other hand, Bray and Cribb (1989) retained the genera as separate awaiting a critical revision of the group. This appeared in the form of Cribb's (2005) chapter on the Opecoelidae in the Keys to the Trematoda, where he retained the genera as separate, but essentially on the basis of it being 'entrenched' in the literature. Most recently, Aken'Ova (2007) recognised the synonymy of the genera, making many new combinations.

In consideration of Aken'Ova's (2007) work, we contemplated using the term *Opegaster*-like members of *Opecoelus* in comparisons with our new species, but thought this confusing, so for the sake of clarity we are retaining the genus *Opegaster*, relying on the distinction of the vitelline field extent as a character that is satisfactory in almost all cases. No doubt we will be criticised for this 'non-scientific' action, but, as any worker who has struggled with opecoelid systematics will know, separation of taxa in this family is largely arbitrary and is a prime candidate for molecular solutions.

Helminth parasites of mud-skippers

As far as we are aware, the only report of an adult digenean from a mudskipper is that, mentioned earlier, of *Lecithaster ghanensis* in *Periophthalmus koelreuteri* (now considered *P. barbarus*) from the Kakum River estuary, Ghana (Fischthal and Thomas 1971). Similarly, we are aware of only one report of metacercariae from mudskippers. Metacercariae of the heterophyids *Heterophyopsis continua* (Onji et Nishio, 1916) and *Heterophyes nocens* Onji et Nishio, 1916 were found in the mudskippers *Boleophthalmus pectinirostris* (Linnaeus) and *Scartelaos* sp. and *Stictodora fuscata* Onji et Nishio, 1916 from *B. pectinirostris* off Jeollanam-do, Republic of Korea, by Sohn et al. (2005).

In view of the scarcity of parasitological information on mudskipper helminths, we add here further results of our observations, including negative reports, which are of value to parasitologists (Whittington 1998). Digeneans were found only in the intestine at a prevalence of 93% (14/15) and an intensity of 1–12. Acanthocephalan larvae were found in the abdominal cavity at a prevalence of 47% (7/15) and an intensity of 1–17, and anisakid nematodes were ensheathed on the surface of liver at a prevalence of 13% (2/15) and an intensity of 3–9. No cestodes, isopods, copepods, hirudineans or adult nematodes were recovered. Gills were examined from all 15 fish and no monogeneans were detected. Similarly, the ovary, fins and body surface of five fish were examined but no parasites were detected.

Acanthocephalans are the most frequently reported helminths in mudskippers. Golvan (1969) listed *Echinorhynchus* sp. larvae from *P. barbarus* (as *P. koelreutheri*) with no further data. Then, Troncy and Vassiliadès (1974) described *Acanthosentis papilio* Troncy et Vassiliadès, 1974 from *P. papilio* Schneider et Bloch (now also considered *P. barbarus*) from mangroves off Joal-Fadiouth, Senegal. The acanthor larva of *A. papilio* from the same host, but without locality data, was described by Marchand (1984). Wang (1980) described *Acanthosentis periophthalmi* Wang, 1980 from *Periophthalmus cantonensis* (Osbeck) (now considered *P. modestus* Cantor) and *Boleophthalmus chinensis* Valenciennes [now considered *Scartelaos histophorus* (Valenciennes)] from off Fujian, China. Both of these species are now considered to be in the subgenus *Acanthogyrus* (*Acanthosentis*) Verma et Datta, 1929 (Amin 1985, 2005). Mhaisen and Al-Maliki (1996) found *Neoechinorhynchus* sp. in the dark-blotched mudskipper *Periophthalmus waltoni* from Iraqi waters and we found acanthocephalan larvae in *P. argentilineatus*.

Other helminth groups have few or no reports. Baylis (1940) reported nematode larvae as *Porrocaecum* sp. from *Periophthalmus barbarus* (as *P. papilio*) from the Belgian Congo (now the Democratic Republic of Congo) and Mhaisen and Al-Maliki (1996) reported the monogenean *Diplozoon* sp. from *P. waltoni* from Iraqi waters. We are unable to find any records of cestodes from mudskippers.

Clearly, most mudskippers harbour few or no helminths. Even when reported they tend to be at a low prevalence. Mhaisen and Al-Maliki (1996) reported that the monogenean and acanthocephalan were each recovered from only one fish specimen of the 97 examined. Al-Behbehani and Ebrahim (2010) examined 50 mudskippers and found

the total absence of either external and/or internal parasites in the mudskipper tissues and organs. The finding of digeneans at a prevalence of over 90% percent is, therefore, highly unusual.

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