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VERSITA

Pseudopecoelus sosoae sp. nov. and *P. sewelli* (Digenea, Opecoelidae) from the deep-sea fish *Neoscombrops pacificus* (Perciformes, Acropomatidae) off New Caledonia

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Abstract

Pseudopecoelus sosoae sp. nov. and *P. sewelli* Bray, 1990 are described from the rare fish *Neoscombrops pacificus* from the deep-sea (about 200–400 m) off Nouméa, New Caledonia, the southernmost report of this fish species. A visual key based on 12 characters is presented, which shows that *P. sosoae* is distinguished from the most similar species (*P. vulgaris*, *P. elongatus*, *P. priacanthi*, *P. akamachi* and *P. sphyraenae*) by its very large eggs, elongate body and unlobed gonads. *P. sewelli* has a similar shape, but much smaller eggs and lobed gonads.

Résumé

Pseudopecoelus sosoae sp. nov. et *P. sewelli* Bray, 1990 sont décrits du poisson rare *Neoscombrops pacificus* pêché en mer profonde au large de Nouméa, Nouvelle-Calédonie, la mention la plus au Sud de cette espèce. Une clé visuelle basée sur 12 caractères est présentée, et montre que *P. sosoae* se distingue par ses œufs très grands, son corps allongé et ses gonades non lobées. *P. sewelli* a une forme similaire, mais des œufs plus petits et des gonades lobées.

Keywords

Digenea, Opecoelidae, *Pseudopecoelus sosoae* sp. nov., *P. sewelli*, deep-sea fish, *Neoscombrops pacificus*, New Caledonia

Introduction

The opecoelid genus *Pseudopecoelus* von Wicklen, 1946 contains, by our reckoning, 35 described species from a wide variety of marine fishes. Several are reported from deep-sea fishes (Klimpel *et al*. 2001, Bray 2004), and in some cases data on depth of capture are available, indicating that members of the genus occur in depths to nearly 700 m (Overstreet and Martin 1974). *Neolebouria blatta* Bray et Justine, 2009, is the only opecoelid described from deep-sea fishes off New Caledonia having been found in lutjanids at 150–250 m depth (Bray and Justine 2009a). Shallow water opecoelids of New Caledonia are reported in papers by Durio and Manter (1968) and Bray and Justine (2007, 2009b). In this paper we report two species of *Pseudopecoelus* from an individual of a deep-sea fish species reported, for the first time, from waters off mainland New Caledonia.

Materials and methods

On October 1st, 2008, an angler from Nouméa (New Caledonia, South Pacific) familiar with deep-sea fishes, caught an unusual specimen off Nouméa at about 200–400 m. He wisely photographed the fresh fish and immediately brought it to one of us (JLJ). The specimen, a mature female 320 mm in fork length and 642 g in weight, was examined for parasites and then prepared for deposition in a collection. It was later identified (from photographs) as *Neoscombrops pacificus* Mochizuki, 1979 by an ichthyologist and deposited in the collections of the Muséum National d'Histoire Naturelle, Paris, France (registration number JNC2653). Information and these photographs are available in FishBase; see: http://www.fishbase.org. *N. pacificus* is known from waters off Japan, Samoa, Fiji, and Tuvalu; in New Caledonian waters it has already been recorded from the Chesterfield Islands (Kulbicki *et al*. 1994),

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but never previously from off mainland New Caledonia. The present record is thus the southernmost for this species. Its living colour pattern has never been reported; the back is greenish with some blue tints, the flanks are silvery with four vertical brownish bands, and the belly is brownish. Rapidly after the catch, this pattern fades and the fish become blackish.

Digeneans were collected live, immediately fixed in nearly boiling saline and then transferred to 80% ethanol. Whole-mounts 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, with the range and the mean in parentheses. The following abbreviations are used: BMNH, the British Museum (Natural History) Collection at the Natural History Museum, London, UK; MNHN, Muséum National d'Histoire Naturelle, Paris.

To aid identification of the two *Pseudopecoelus* species recovered from *Neoscombrops pacificus* we have devised a visual key modelled on the keys to the bucephalid genera *Rhipidocotyle* Diesing, 1858 and *Prosorhynchus* Odhner, 1905 used by Bray and Palm (2009). These keys were developed as the genera had become large and difficult to produce keys for in the conventional fashion. As we are aware of 35 described species of *Pseudopecoelus* we have found it useful to produce a similar key using, in this case, twelve criteria:

1. Length in micrometres (Length).
2. Width as a % of body-length, an indication of shape (width%).
3. Ventral sucker width as % of oral sucker width (SW%).
4. The distance from the posterior extremity of the seminal vesicle to the anterior extremity as a % of body-length, or seminal vesicle reach (SVR%).
5. The distance from the anterior most extent of the vitellarium to the anterior extremity as a % of body-length, or pre-vitelline region (PVR%).
6. The distance from the ovary to the anterior extremity as a % of body-length, or pre-ovarian region (POvR%).
7. The distance from the ventral sucker to the ovary as a % of body-length (VS-Ov%).
8. Ovary lobation, whether entire, irregular or distinctly lobed.
9. Testicular lobation, whether entire, irregular or distinctly lobed.
10. The distance from the posterior extent of the uterus to the posterior extremity of the body as a % of body-length, or post-uterine region (PostUtR%).
11. The distance from the posterior extent of the posterior testis to the posterior extremity of the body as a % of body-length (PTR%).

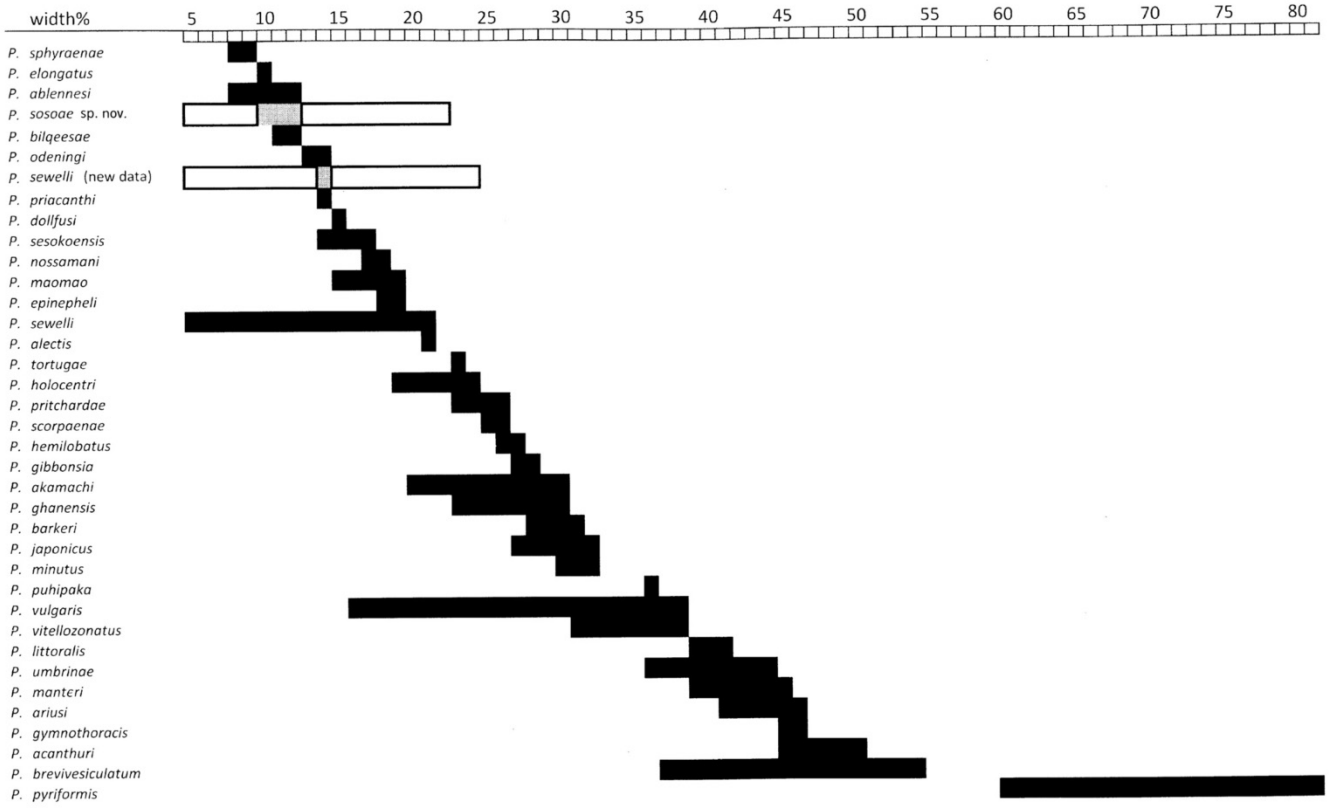


Fig. 1. Graph showing width as % of length of described species of *Pseudopecoelus*, including data from new worms. Horizontal black columns indicate ranges for described species. Gray columns indicate known ranges for new material. Columns outlined indicate artificially extended ranges

12. The egg-length in micrometres.

For each described species these data are taken from dimensions or ratios given in the original description or are derived from original illustrations. As many of the data come from illustrations, little estimate of variation is available in many cases. These metrical data are presented as a histogram produced in Excel (an example, the width as % of length is shown in Fig. 1). The Excel file is available to download on http://www.nhm.ac.uk/bray2010. The details of the system were discussed by Bray and Palm (2009). The dimensions of the newly studied specimens were included in the diagram and in the present case because only a few specimens were available, the range of the dimensions was increased by 10 units at each extremity, to compensate for lack of knowledge of variation in the species under study and in the described species. All of the species whose complete data-set lie outside these extended ranges are marked as a black square in the comparison diagram (Fig. 2) for the relevant character. Perusal of the comparison diagram will immediately show the features which differentiate the species and will suggest which species are most similar to or indistinguishable from the new material.

Family Opecoelidae Ozaki, 1925
Subfamily Opecoelinae Ozaki, 1925
Genus *Pseudopecoelus* von Wicklen, 1946

***Pseudopecoelus sosoae* sp. nov.** (Figs 3 and 4)

Type-host: *Neoscombrops pacificus* Mochizuki, 1979, Acropomatidae, Perciformes.

Type-locality: Deep-sea off Nouméa, New Caledonia (coordinates not available, 01/10/2008).

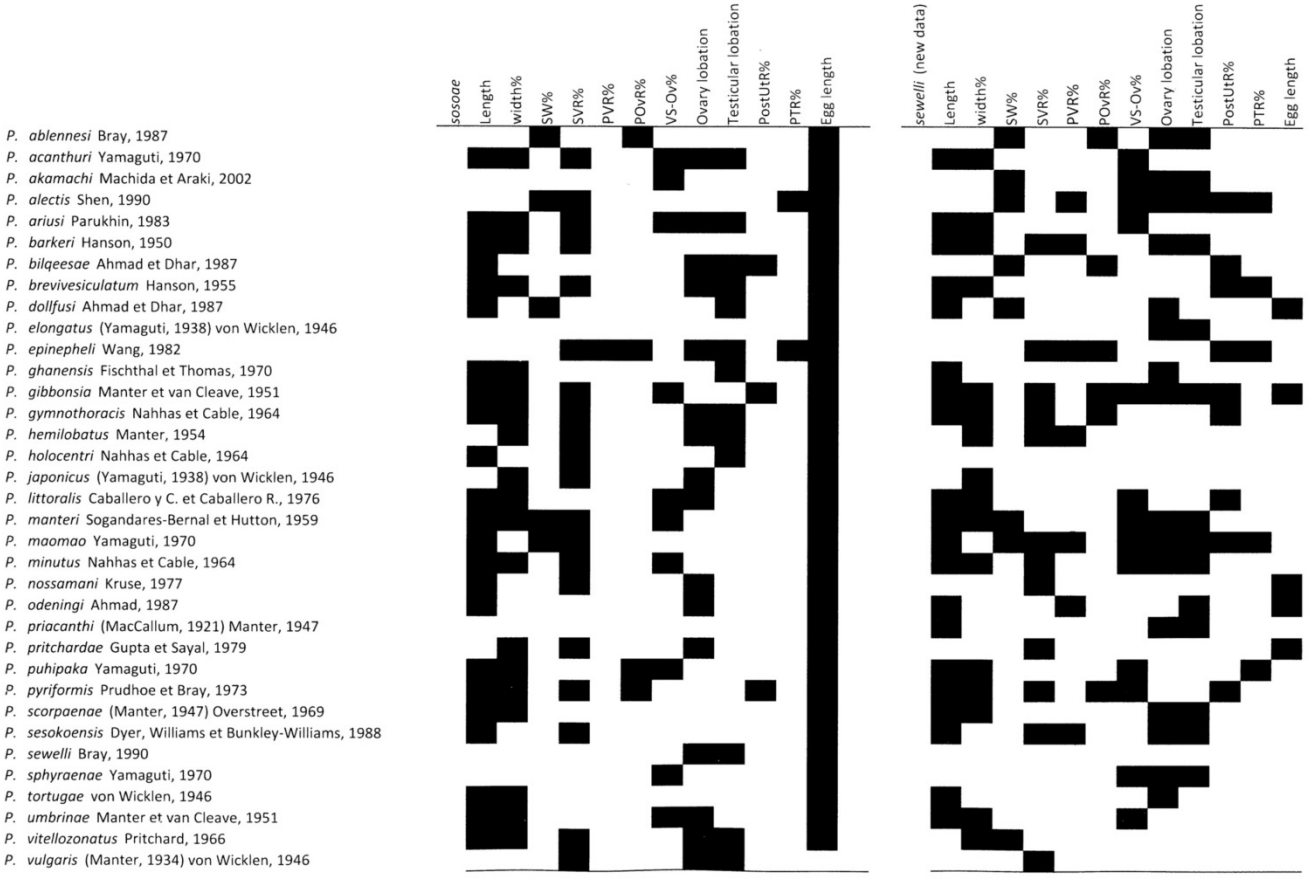


Fig. 2. Comparison diagram for *P. sosoae* sp. nov. and a new specimen of *P. sewelli*. All of the species whose complete data-set range, for a given parameter, lies outside the extended ranges of the new specimens are marked as a black square. Column headings: Length = Length in micrometres; width% = Width as a % of body-length, an indication of shape; SW% = Ventral sucker width as % of oral sucker width; SVR% = The distance from the posterior extremity of the seminal vesicle to the anterior extremity as a % of body-length, or seminal vesicle reach; PVR% = The distance from the anterior most extent of the vitellarium to the anterior extremity as a % of body-length, or pre-vitelline region; POvR% = The distance from the ovary to the anterior extremity as a % of body-length, or pre-ovarian region; VS-Ov% = The distance from the ventral sucker to the ovary as a % of body-length; Ovary lobation, whether entire, irregular or distinctly lobed; Testicular lobation, whether entire, irregular or distinctly lobed. PostUtR% = The distance from the posterior extent of the uterus to the posterior extremity of the body as a % of body-length; PTR% = The distance from the posterior extent of the posterior testis to the posterior extremity of the body as a % of body-length; Egg-length in micrometres

Site: Digestive tract.

Type-material: Holotype MNHN JNC 2653-1, paratypes MNHN JNC2653-2, BMNH 2009.7.17.1-2.

Etymology: Named after Sophie Olivier (nickname Soso), a former student of JLJ and sister of J.R. Olivier who caught the fish.

Description

Based on four specimens, 2 measured, 2 damaged. Measurements in Table I. Body elongate, narrow. Pre-oral lobe very short or not seen. Oral sucker oval to subglobular, subterminal. Ventral sucker on slight protuberance. Prepharynx apparently absent to short. Pharynx oval. Oesophagus long. Intestinal bifurcation dorsal to anterior part of ventral sucker. Caeca reach close to posterior extremity, terminate blindly, termination often obscured by vitelline follicles.

Testes 2, smooth, oval with long axis oriented along worm, tandem, in anterior part of posterior half of hindbody, distinctly separated. Seminal vesicle elongate, wider proximally, encroaches distinctly into hindbody, coiled dorsally to ventral sucker and into forebody. Pars prostatica vesicular, narrow, lined with anuclear cell-like bodies, surrounded by gland-cells. Ejaculatory duct short. Cirrus-sac absent. Genital atrium small. Genital pore at level of anterior part of oesophagus, sinistrally about halfway between median line and body margin.

Ovary sub-oval, entire, in mid-hindbody, contiguous with or slightly separated from anterior testis. Uterine seminal receptacle in proximal uterus, not clear in all specimens. Mehlis' gland immediately pre-ovarian. Laurer's canal not seen. Uterus pre-ovarian, mainly intercaecal, passes dorsally to ventral sucker. Eggs numerous, tanned, operculate, very large. Metraterm not distinctly differentiated. Vitellarium follicular; fields run from close to posterior extremity to anterior hindbody, not reaching to ventral sucker, lie dorsal, ventral and lateral to caeca, confluent in post-testicular region, encroach closely but not quite confluent between gonads.

Excretory pore ventrally subterminal. Excretory vesicle not traced, obscured by vitelline follicles.

Discussion

The comparison diagram (Fig. 2) indicates that this form is not identical to any described species in terms of the twelve criteria used. Most notably it differs from all except one species in the large size of the eggs. Three specimens have extraordinarily large eggs (n = 30) at 135–153 × 55–86 (144 × 71) and the other specimen has slightly smaller, but still very large, eggs (n = 10) at 104–128 × 43–60 (116 × 54).

Only *Pseudopecoelus vulgaris* (Manter, 1934) von Wicklen, 1946, from a wide variety of deep-sea fishes of several orders, has any overlap of egg-size (78–127 × 40–72) (Manter 1934), but it differs in seminal vesicle reach% (about 41–50% vs 24–25%) and distinct ovarian and testicular lobation. *P. vulgaris* is usually described as a much broader worm (width 16–38% of body-length vs 10–12%).

According to the comparison diagram only two species are distinguished from *Pseudopecoelus sosoae* sp. nov. by egg-size alone. *P. elongatus* (Yamaguti, 1938) von Wicklen, 1946 originally described from the gnomefish *Scombrops boops* (Houttuyn, 1782) (Scombropidae), has eggs measuring 54–60 × 33–36 (Yamaguti 1938). In the illustration the intestinal bifurcation is in the forebody, rather than dorsal to the anterior part of the ventral sucker. In general, however, it is similar to *P. sosoae*.

Pseudopecoelus priacanthi (MacCallum, 1921) Manter, 1947 originally from the Atlantic bigeye *Priacanthus arenatus* Cuvier, 1829 (Priacanthidae) off Key West, Florida is generally longer (5,000–11,000 vs 4,307–5,878) and has a relatively larger ventral sucker width (233–267% of oral sucker width according to published measurements, about 400% in illustration, vs 172–176%) (MacCallum 1921). Corrêa Gomes *et al*. (1974) illustrated a worm identified as *P. priacanthi* from *Epinephelus* sp. (as *Garrupa* sp.) from off Brazil, suggesting that *P. elongatus* is probably a synonym. The ventral sucker in their illustration is not of the 'filmy' structure or the size as illustrated by MacCallum (1921).

Two species differ in one character in addition to egg-size.

Pseudopecoelus akamachi Machida et Araki, 2002, from the flame snapper *Etelis coruscans* Valenciennes, 1862 (Lutjanidae) from off Japan and Palau in Micronesia, differs in the ventral sucker to ovary distance (about 10% of body-length vs 22–29%). From the illustration it appears to be a broader species (width 20–30% of body-length vs 10–12%) and the seminal vesicle is divided into a saccular distal portion and a proximal tubular part (Machida and Araki 2002).

Pseudopecoelus sphyraenae Yamaguti, 1970, from *Sphyraena* spp. off Hawaii, differs in the ventral sucker to ovary distance (about 9.6% of body-length vs 20%). It also has a 'thin-walled' ventral sucker with a 'deep notch on each lateral margin' and, judging from the illustration, the ventral sucker is flared and strongly protuberant (Yamaguti 1970).

One species, *P. japonicus* (Yamaguti, 1938), has been reported in an acropomatid, namely the Japanese splitfin *Synagrops japonicus* (Döderlein, 1883), amongst several other non-acropomatid species, off Japan (Yamaguti 1938). It differs from *P. sosoae* in its shape (width 27–32% of body-length vs 10–12%), seminal vesicle reach% (about 37% of body-length vs 24–25%) and in its distinctly trilobed ovary.

***Pseudopecoelus sewelli* Bray, 1990** (Figs 5 and 6)

Host: *Neoscombrops pacificus* Mochizuki, 1979, Acropomatidae, Perciformes.

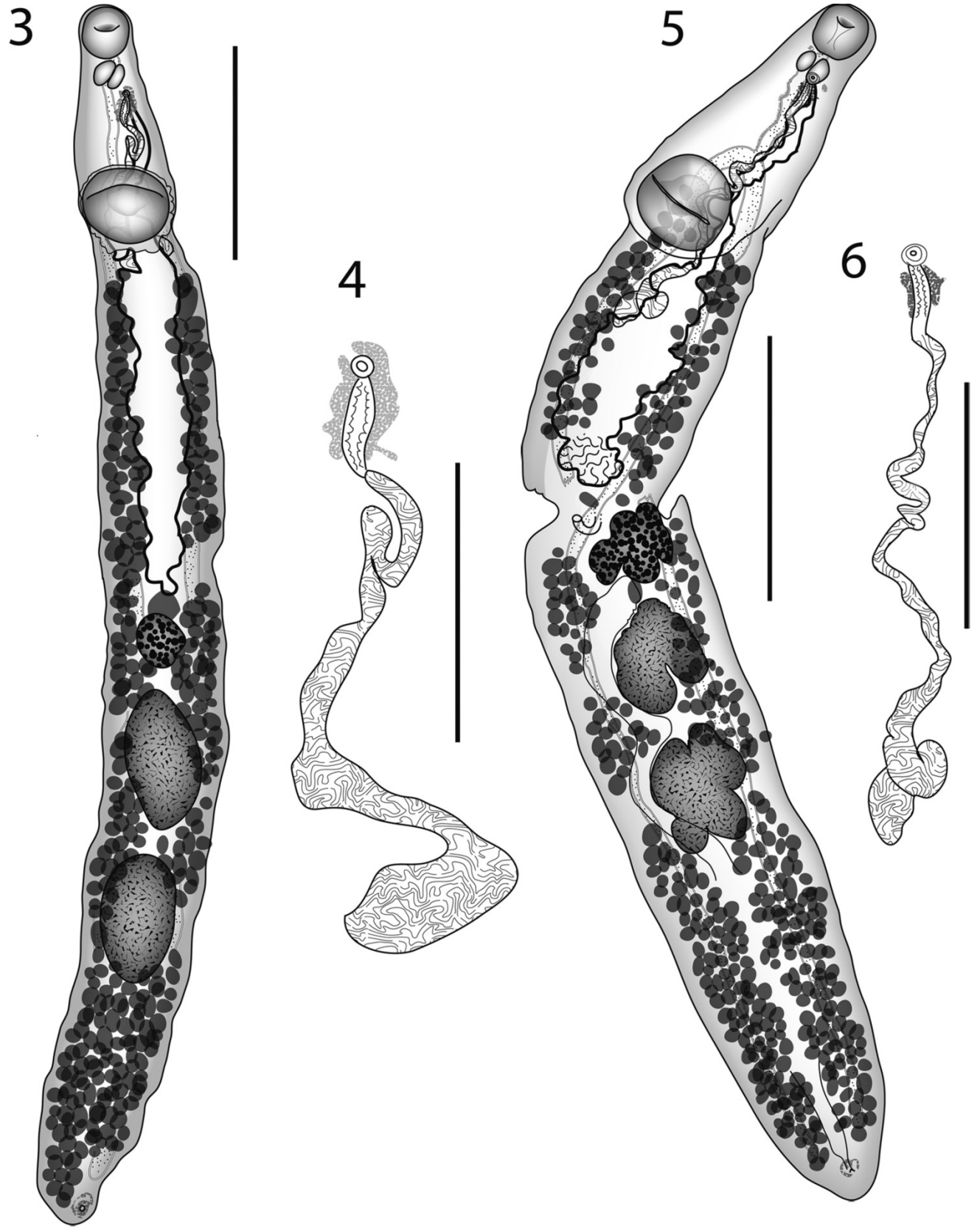
Locality: Deep-sea off Nouméa, New Caledonia (coordinates not available, 01/10/2008).

Site: Digestive tract.

Material: Voucher MNHN JNC 2653-3.

Description

Based on 1 specimen, folded and damaged at level of ovary. Measurements in Table I. Body elongate, narrow. Pre-oral lobe



Figs 3 and **4.** *Pseudopecoelus sosoae* sp. nov. **3.** Ventral view, uterus in outline. **4.** Male terminal genitalia. Scale bars = 500 µm (3); 200 µm (4).
Figs 5 and **6.** *Pseudopecoelus sewelli* Bray, 1990. **5.** Ventral view, uterus in outline, specimen broken and twisted in region of ovary. **6.** Male terminal genitalia. Scale bars = 500 µm (5); 200 µm (6)

very short. Oral sucker oval to subglobular, subterminal. Ventral sucker on protuberance, possibly a small peduncle. Prepharynx short. Pharynx oval. Oesophagus long. Intestinal bifurcation in posterior forebody. Caeca reach close to posterior extremity, terminate blindly.

Testes 2, deeply lobate, in mid-hindbody, distinctly separated. Seminal vesicle elongate, wider proximally, encroaches distinctly into hindbody, coiled dorsally to ventral sucker and forebody. Pars prostatica vesicular, narrow, lined with anuclear cell-like bodies, surrounded by thin sleeve gland-cells. Ejaculatory duct short. Cirrus-sac absent. Genital atrium small. Genital pore at level of posterior part of pharynx, sinistrally submedian.

Ovary deeply and irregularly 5-lobed, in mid-body, slightly separated from anterior testis. Uterine seminal receptacle prominent in posterior uterus. Mehlis' gland immediately pre-ovar-

Table I. Dimensions and ratios of *Pseudopecoelus* spp. from *Neoscombrops pacificus*

Species **n**	***Pseudopecoelus sosoae*** **2 fully measured**	***Pseudopecoelus sewelli*** **1**
Length	4,307–5,878	4,093
Width	470–587	576
Forebody	448–798	648
Pre-oral lobe	0–7	6
Oral sucker	212–264 × 195–237	164 × 150
Prepharynx	0–21	22
Pre-pharyngeal region	221–254	183
Pharynx	105–127 × 121–153	86 × 101
Oesophagus	222–442	291
Pre-genital pore region	345–399	258
Intestinal bifurcation to VS	0	107
Pre-vitelline region	833–1,393	722
Vitellarium to VS	32–191	0
Ventral sucker	303–368 × 343–422	292 × 283
Seminal vesicle encroachment into hindbody	171–207	281
Seminal vesicle reach	1,061–1,404	1,216
Ventral sucker to ovary	951–1,716	879
Pre-ovarian region	1,861–2,933	1,846
Ovary	221–236 × 193–251	227 × 256
Ovary to anterior testis	0–85	38
Anterior testis	371–663 × 224–369	359 × 283
Distance between testes	56–98	78
Posterior testis	432–603 × 308–383	381 × 294
Post-testicular region	1,260–1,80	1,095
Post-uterine region	2,441–3,077	2,274
Post-caecal region	212	189–193
Eggs	104–153 × 43–86 (137 × 67) (n = 40)	60–68 × 29–38 (64 × 35) (n = 10)
Width%	10–12 (11)	14
Forebody%	13–14 (13)	16
Sucker-length ratio	1:1.3–1.6	1:1.8
Sucker-width ratio	1:1.7–2.0	1:1.9
Oral sucker: pharynx	1:1.5–1.6	1:1.5
VS-Ov%	22–29	21
VS-ESV%VS-Ov	12–18	32
Post-testicular region%	22–29	27
Oesophagus%	6.5–7.5	7.1
Intestinal bifurcation to VS%	0	2.6
Vit-VS%	0.7–3.3	0
Ov-AT%	0–1.5	0.9
Distance between testes%	1.7–1.8	1.9
Pre-pharyngeal region%	4.9–5.1	4.5
Prebifurcal%	13–14	13
Pre-genital pore region%	6.8–8.0	6.3
Seminal vesicle reach%	24–25	30
Pre-vitelline region%	19–24	18
Pre-ovarian region%	43–50	45
Post-uterine region%	52–57	56

ian. Laurer's canal opens at level of anterior edge of ovary, specimen damaged in this region. Uterus pre-ovarian, mainly intercaecal, passes dorsally to ventral sucker. Eggs numerous, tanned, operculate. Metraterm not distinctly differentiated. Vitellarium follicular; fields run from close to posterior extremity to ventral sucker, lie dorsal, ventral and lateral to caeca, encroach but not confluent in post-testicular region and between gonads, slights gaps evident bilaterally at level of gonads.

Excretory pore ventrally subterminal (note, hindbody twisted relative to forebody). Excretory vesicle I-shaped, narrow posteriorly, passes to left of testes (note, hindbody twisted relative to forebody), reaches to level of ovary.

Discussion

According to the comparison diagram (Fig. 2), our specimen does not differ from *Pseudopecoelus sewelli* from the orange roughy, *Hoplostethus atlanticus* Collett, 1889 (Beryciformes, Trachichthyidae) from deep-waters off the Australian states of Tasmania, South Australia and Victoria (Bray 1990). This bathypelagic fish is, despite its name, very widespread in deeper waters (180–1809 m) (Froese and Pauly 2009). *Neoscombrops pacificus* is a demersal fish, with an overlapping bathymetric profile (60–500 m), so although the host species are phylogenetically distant, we think our worm is conspecific with *P. sewelli*.

Similarly, no features in the comparison diagram distinguish *Pseudopecoelus sosoae* sp. nov. and *P. holocentri* Nahhas et Cable, 1964, which is reported from the squirrelfish *Holocentrus adscensionis* (Osbeck, 1765) (Beryciformes, Holocentridae) off Curacao and Jamaica in the mid-western Atlantic (Nahhas and Cable 1964). It appears, however, that several features, such as width (20–24% of body-length vs 14%), the 'slightly irregular' ovary and the egg-length (52–54 vs 60–68), in addition to the geographical separation, indicate that these worms are not conspecific.

Two species differ, according to the comparison diagram, by one character.

Pseudopecoelus japonicus differs in body-shape (width 27–32% of body-length vs 14%) and probably in the regular, 3-lobed, ovary (vs irregularly 5-lobed).

Pseudopecoelus vulgaris differs in seminal vesicle reach (about 41–50% of body-length vs 30%), and probably width (16–38% of body-length vs 14%).

The two species described in this paper differ in the lobation of the gonads and egg-size.

Comments

Bray (2004) used, as a definition of the deep-sea, 'the area of water below the continental shelf/slope break … In most parts of the world this is at a depth of about 200 m'. In addition to the two species reported in this paper, several *Pseudopecoelus* species have been found in the upper reaches of this region. *P. vulgaris* has been reported in a variety of fishes at 50–315 fathoms (91–576 m) (Manter 1934), from synaphobranchid eels at 686–699 m (Overstreet and Martin 1974) and from nettastomatid eels at 500 m (Kuramochi 2001). *P. japonicus* was found in a chlorophthalmid at 450–600 m (Reimer 1987) and in a variety of fishes species at unspecified depths between 200 and 1000 m (Machida and Kamegai 1997). *P. tortugae* von Wicklen, 1946 was originally reported (as *Cymbephallus fimbriatus*) from a macrourid at 200 fathoms (366 m) (Manter 1934). Others which may well occur in this region, judging from their reported host species, include *P. hemilobatus* Manter, 1954, *P. nossamani* Kruse, 1977 and *P. akamachi* (Manter 1954, Kruse 1977, Machida and Araki 2002). Of the 36 known species of the genus, therefore, 8 (22%) probably occur in the deep-sea. As a genus, there is little indication of a host-preference as species are reported from 17 fish orders.

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