Syst Parasitol (2020) 97:99–106
https://doi.org/10.1007/s11230-019-09899-z

Pseudorhabdosynochus kasetsartensis n. sp. (Monogenea: Diplectanidae) from the cloudy grouper *Epinephelus erythrurus* (Valenciennes) (Perciformes: Serranidae) in the lower Gulf of Thailand

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Received: 18 June 2019 / Accepted: 7 December 2019 / Published online: 7 January 2020

Abstract *Pseudorhabdosynochus kasetsartensis* n. sp. is described from the gills of the cloudy grouper *Epinephelus erythrurus* (Valenciennes) caught in the lower Gulf of Thailand. The new species is distinguished from other species assigned to the genus by the structure of its sclerotised vagina which has a wide and prominent sclerotised trumpet, long, thin, coiled or curved primary canal, short secondary canal, and primary and secondary chambers that are blind extremities of the primary and secondary canals, respectively. This is the first species of *Pseudorhabdosynochus* Yamaguti, 1958 described from *E. erythrurus* and the first record of a species of *Pseudorhabdosynochus* in Thailand.

This article was registered in the *Official Register of Zoological Nomenclature* (ZooBank) as 6DFF0D7C-9912-479C-8D75-E47824877E8C. This article was published as an Online First article on the online publication date shown on this page. The article should be cited by using the doi number. This is the Version of Record.

This article is part of the Topical Collection Monogenea.

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Introduction

The cloudy grouper *Epinephelus erythrurus* (Valenciennes) (Perciformes: Serranidae) has a geographical distribution is known from the Indian Ocean (off Pakistan, India, Laccadive Island, Sri Lanka, Indonesia, Thailand) and the Pacific Ocean (off Indonesia, Singapore, Borneo, Thailand) (Heemstra & Randall, 1993; Satapoomin, 2011). In Thailand, the cloudy grouper is commonly found in coral reefs, seagrass beds, other coastal and offshore areas (Satapoomin, 2011). Species of *Pseudorhabdosynochus* Yamaguti, 1958 which parasitise marine fishes in warm seas (Justine, 2005a) and deep seas (Justine, 2008, 2009; Justine & Henry, 2010; Kritsky et al., 2015; Chaabane et al., 2016a) are the most abundant monogeneans found on the gills of epinephelin fishes (family Serranidae, subfamily Epinephelinae) (Sigura & Justine, 2008; Kritsky et al., 2015). They often show strict specificity to their host species (Justine, 2010; Justine et al., 2010) and have a worldwide distribution (Santos et al., 2000). Morphologically, *Pseudorhabdosynochus* is unique amongst other diplectanid genera in having a sclerotised male copulatory organ (male quadriloculate organ) with four chambers (Justine, 2005a, 2005b, 2009; Yang et al., 2005b; Hinsinger & Justine, 2006a; Neifar & Euzet, 2007). *Pseudorhabdosynochus* currently contains more than 90 valid species (Gibson, 2019) which have mostly been reported from epinephelin fish belonging to seven genera, namely, *Alphestes* (Bloch & Schneider),

Cephalopholis (Bloch & Schneider), *Epinephelus* (Bloch), *Hyporthodus* (Gill), *Mycteroperca* (Gill), *Paranthias* (Guichenot) and *Variola* (Swainson) (see Justine et al., 2010; Knoff et al., 2015; Kritsky et al., 2015). However, three species of *Pseudorhabdosynochus* were reported from non-epinephelin fish hosts: including *P. caballeroi* (Oliver, 1984) Kritsky & Beverley-Burton, 1986 from *Stereolepis gigas* (Ayres) (family Polyprionidae) (see Oliver, 1984); *P. magnisquamodiscum* (Aljoshkina, 1984) Dyer, Williams & Bunkley-Williams, 1995 from *Chaetodon hoefleri* (Steindachner) (family Chaetodontidae) (see Aljoshkina, 1984) and *P. serrani* (Yamaguti, 1953) Kritsky & Beverley-Burton, 1986 from *Serranus* sp. (family Serranidae, subfamily Serraninae) (see Yamaguti, 1953). Herein, we describe a new species of *Pseudorhabdosynochus* found on the gills of *E. erythrurus* from the lower Gulf of Thailand. This is the first diplectanid monogenean reported from this fish and the first record of a species of *Pseudorhabdosynochus* in Thailand.

Materials and methods

Thirty specimens of *Epinephelus erythrurus* (Valenciennes) (total length 200–300 mm, weight 150–400 g) were obtained from a jetty in Surat Thani Province, southern Thailand, in October 2018. All the fish were dead and were immediately transported in a cool box to the laboratory. Gills were removed and placed in Petri dishes containing seawater. Monogeneans were individually collected from the gills with a fine needle under a stereomicroscope, and were mounted in ammonium picrate-glycerine; some specimens were mounted on permanent slides in Canada balsam. Specimens were observed and photographed using an Olympus DP 70 microscope. The sclerotised parts were measured according to Fig. 1. The nomenclature of the different vaginal parts follows Justine (2007a). All measurements are given in micrometres as the range followed by the mean and number of specimens in parentheses.

Pseudorhabdosynochus kasetsartensis n. sp.

Type-host: *Epinephelus erythrurus* (Valenciennes) (Perciformes: Serranidae).

Type-locality: The lower Gulf of Thailand (9°48′10.1″N, 99°54′31.1″E), October 2018.

Type-material: Holotype: Zoological Museum, Kasetsart University (ZMKU), Bangkok, Thailand (ZMKU-PM-002010); 28 paratypes: ZMKU-PM-002011-38; 1 paratype: Natural History Museum, London, UK (NHMUK 2019.11.25.1).

Site in host: Gills.

Prevalence and intensity: 100% (30/30); mean intensity: 38 individuals/fish (1,140/30).

Etymology: The species name honors Kasetsart University and the Kasetsart University Research and Development Institute, the institute that has funded our aquatic parasitology studies for many years.

Description (Figs. 2, 3)

[Based on 30 specimens.] Body length including haptor 667–1,195, (902; n = 30), maximum width 93–245 (150; n = 30). Tegument smooth. Anterior region with 3 pairs lateral head organs and 3 pairs eyespots; anterior pair smaller than posterior pair. Pharynx median, spherical 33–49 × 34–47 (39 × 38; n = 30). Oesophagus apparently absent; intestinal bifurcation immediately posterior to pharynx.

Haptor differentiated from rest of body, 160–213 (182; n = 30) wide, with 2 similar squamodiscs, 2 pairs of hamuli, 3 bars and 14 marginal hooklets. Dorsal and ventral squamodiscs round, made up of rows of rodlets; central rows oval, closed. Dorsal squamodisc 76–108 (85; n = 30) long, 67–83(77; n = 30) wide, with 18–21 (n = 30) rows of rodlets; innermost row closed, oval. Ventral squamodisc 77–97 (84; n = 30) long, 62–90 (76; n = 30) wide, with 17–21 (n = 30) rows of rodlets; innermost row closed, oval. Ventral hamulus with distinct guard and expanded deep root, elongate shaft, which is slightly arced and recurved toward tip, outer length 61–69 (64; n = 30), inner length 41–45 (42; n = 30). Dorsal hamulus with indistinct guard and expanded deep root, elongate straight shaft than ventral hamulus (Fig. 2D, E) and recurved toward tip, outer length 48–52 (50; n = 30), inner length 31–34 (33; n = 30). Dorsal (lateral) bars with wide, flattened medial extremity and cylindrical lateral extremity, 50–57 (54; n = 30) long, 11–20 (17; n = 30) wide. Ventral bar elongate, with constricted median portion, tapered ends, 67–75 (72; n = 30) long, 12–21 (15; n = 30) wide.

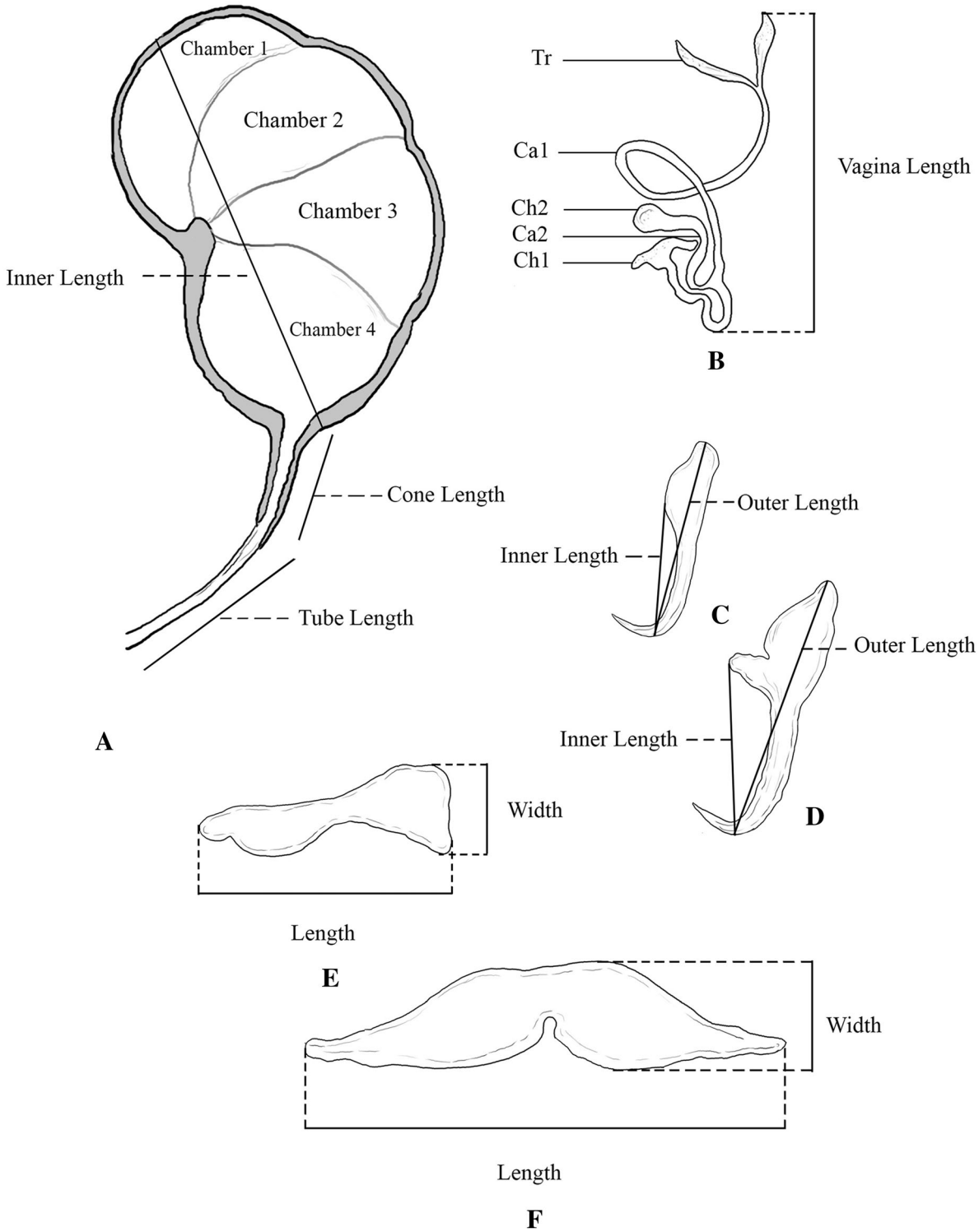

Fig. 1 Schematic illustration for the measurements used for sclerotised organs of *Pseudorhabdosynochus kasetsartensis* n. sp. A, Male quadriloculate organ; B, Sclerotised vagina C, Dorsal hamulus; D, Ventral hamulus; E, Dorsal (lateral) bar; F, Ventral bar. *Abbreviations*: Tr, trumpet; Ca1, primary canal; Ca2, secondary canal; Ch1, primary chamber; Ch2, secondary chamber

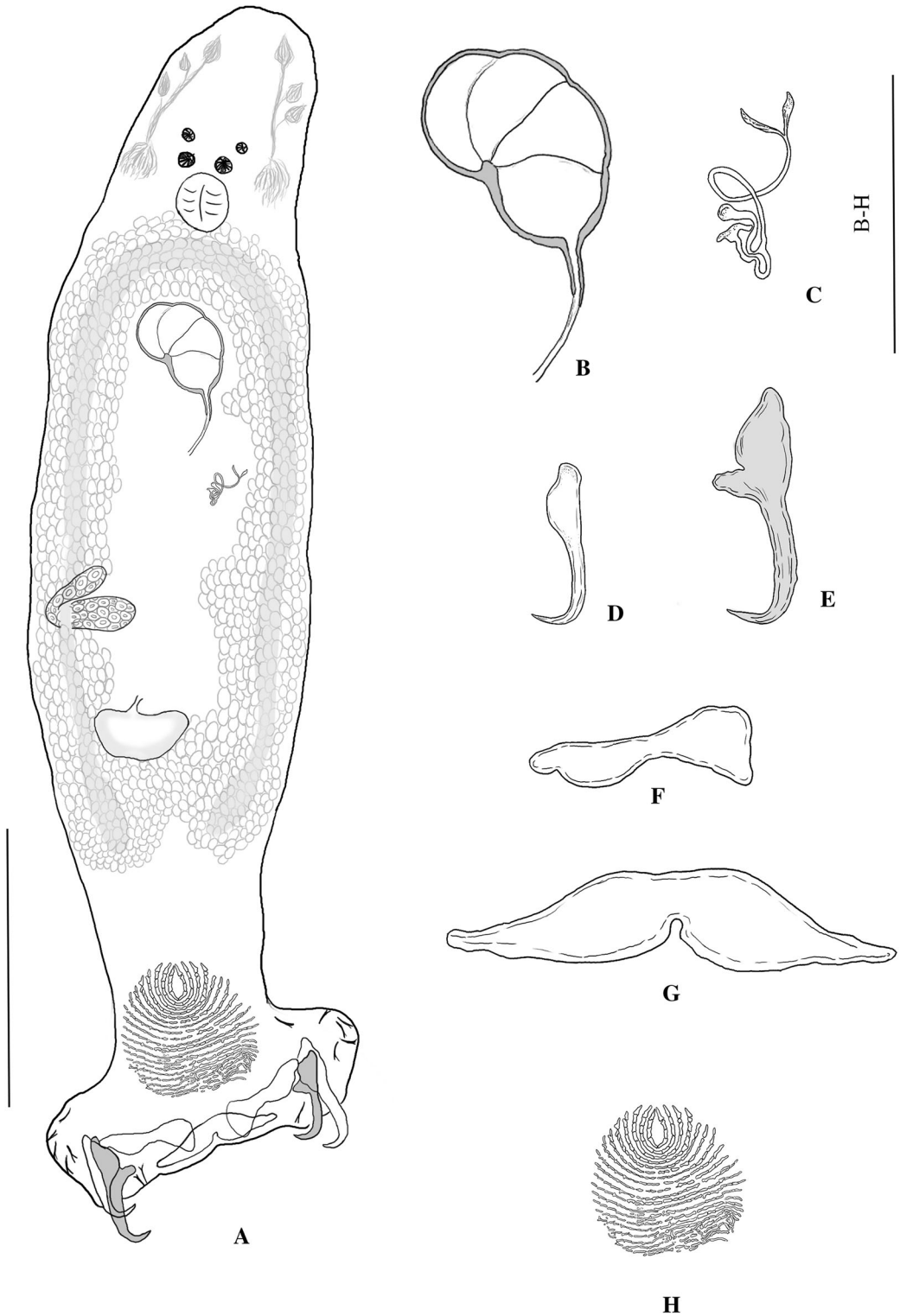

Fig. 2 *Pseudorhabdosynochus kasetsartensis* n. sp. A, Composite drawing (mainly from the holotype), ventral view; B, Male quadriloculate organ, ventral view; C, Sclerotised vagina, ventral view; D, Dorsal hamulus; E, Ventral hamulus; F, Dorsal bar; G, Ventral bar; H, Squamodisc. *Scale-bars*: A, 200 µm; B–H, 50 µm

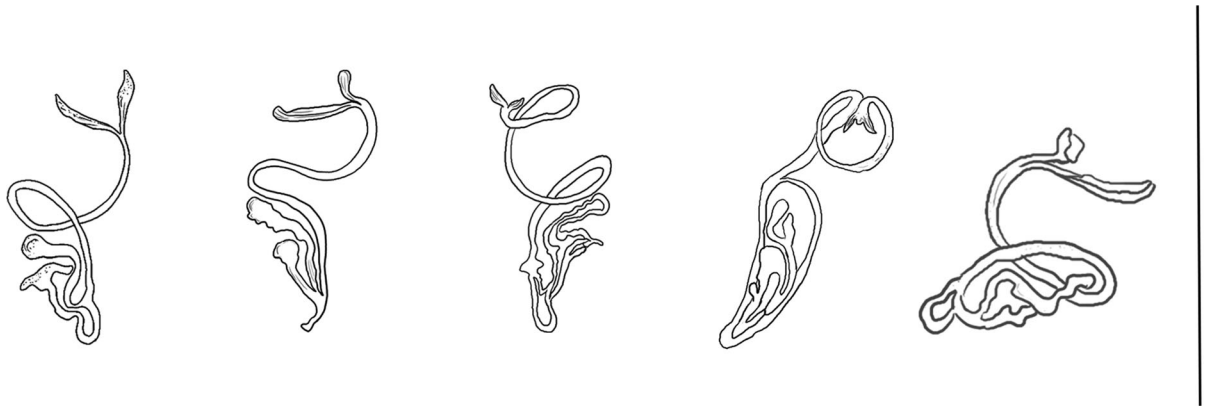

Fig. 3 *Pseudorhabdosynochus kasetsartensis* n. sp. Variation of sclerotised vagina depending on orientation. *Scale-bar*: 50 µm

Testis subspherical, intercaecal. Male quadriloculate organ is comma-shaped (Fig. 2B) with inner length 53–68 (61; n = 30), divided into 4 chambers; chamber 4 ends in sclerotised cone. Sclerotised cone 11–14 (12; n = 30) long, prolonged by sclerotised tube, 15–27 (23; n = 30) long; end of tube prolonged by filament of variable length. Ovary dextral, pretesticular, encircles right intestinal caecum. Vitelline follicles in 2 lateral fields coextensive with intestinal caeca, confluent posterior to testis, terminate anterior to peduncle. Egg not seen. Sclerotised vagina with a complex structure; aspect slightly changes depending on orientation (Fig. 3). Sclerotised vagina with wide, thick-walled anterior trumpet, followed by primary canal, secondary canal, primary chamber and secondary chamber; trumpet in continuity with primary canal long, with narrow lumen and thin wall, coiled or curved at around mid-length or double coiled (Fig. 3), forms a bend in its posterior region and progressively into primary chamber; secondary chamber communicates with primary canal by short secondary canal inserted laterally to primary canal. Total length of sclerotised vagina (measured from extremity of trumpet to base of vagina, not taking into account curved length along coils or primary canal bends) 23–41 (37; n = 30), length very variable because of variation of coil or curvature of primary canal.

Remarks

Pseudorhabdosynochus kasetsartensis n. sp. is easily distinguished from other species of *Pseudorhabdosynochus* by the size and morphology of the sclerotised vagina and the number of rows of rodlets in each squamodisc. The sclerotised vagina has a long, thin-walled and coiled (or curved) primary canal. Ten species of *Pseudorhabdosynochus* [i.e. *P. epinepheli* (Yamaguti, 1958) Kritsky & Beverley-Burton, 1986 from the Inland Sea of Japan; *P. hirudineus* Justine, 2005 from the barrier reef off Nouméa, New Caledonia; *P. summanoides* Yang, Gibson & Zeng, 2005 from Dapeng Bay, South China Sea, off Nan'ao, Shenzhen, Guangdong Province, China; *P. argus* Justine, 2007 from the barrier reef off Nouméa, New Caledonia; *P. euitoe* Justine, 2007 from the barrier reef off Nouméa, New Caledonia; *P. maaensis* Justine & Sigura, 2007 from a lagoon, New Caledonia; *P. dolicocolpos* Neifar & Euzet, 2007 from the Gulf of Gabès, off Sfax, Tunisia; *P. variabilis* Justine, 2008 from the outer slope of the barrier reef off Nouméa, New Caledonia; *P. chauveti* Sigura & Justine, 2008 from a lagoon, Nouméa, New Caledonia; and *P. viscosus* Schoelinck & Justine, 2011 from a lagoon, Nouméa, New Caledonia] have a sclerotised vagina similar to that of *P. kasetsartensis* n. sp., characterised by a long primary canal, but they differ in terms of the general morphology of the primary canal (long) (Kritsky & Beverley-Burton, 1986; Justine, 2005b; Yang et al., 2005a; Justine, 2007a, 2007b, 2008; Justine & Sigura, 2007; Neifar & Euzet, 2007; Sigura & Justine, 2008; Schoelinck & Justine, 2011a). *Pseudorhabdosynochus cupatus* (Young, 1969) Kritsky & Beverley-Burton, 1986, *P. calathus* Hinsinger & Justine, 2006, *P. cyathus* Hinsinger & Justine, 2006 and *P. melanesiensis* (Laird, 1958) Kritsky & Beverley-Burton, 1986 have a sclerotised vagina similar to that of *P. kasetsartensis* n. sp., characterised by a heavily sclerotised trumpet, followed by a long canal, but they differ by the

squamodisc made up of central telescopic rings and peripheral open row of rodlets (lamellosquamodiscs) (Kritsky & Beverley-Burton, 1986; Hinsinger & Justine, 2006b). *Pseudorhabdosynochus kasetsartensis* n. sp. has 17–21 rows of rodlets in each squamodisc, with the innermost row closed, oval, which is dissimilar to other species within the genus (possessing usually 8–17 rows of rodlets). *Pseudorhabdosynochus guerreroensis* Mendoza-Franco, Violante-González & Herrera, 2011 and *P. tabogaensis* Mendoza-Franco, Violante-González & Herrera, 2011 both have a shape and a number of rows of rodlets in each squamodisc (usually 15–23, with 0–1 innermost row forming closed ovals; see Mendoza-Franco et al., 2011), similar to those of *P. kasetsartensis* n. sp., but they differ in the structure of the sclerotised vagina.

Discussion

The structure of the sclerotised vagina of species of *Pseudorhabdosynochus*, which is a primary character for species identification, appear very characteristic for each species (Justine, 2005b, 2007a; Justine & Vignon, 2009; Mendoza-Franco et al., 2011; Schoelinck & Justine, 2011a, b; Knoff et al., 2015; Chaabane et al., 2016b). However, the male quadriloculate organ and haptoral hard parts, including squamodiscs, also provide characters useful for species identification (Justine, 2005a; Hinsinger & Justine, 2006b; Neifar & Euzet, 2007; Mendoza-Franco et al., 2011). The structure of the sclerotised vagina of *P. kasetsartensis* n. sp. is a key characteristic; however, it shows variation in aspects depending on orientation (Fig. 3) which is a necessary precaution against misidentification (Justine, 2005b).

Acknowledgements We thank Mrs Eileen Harris (Senior Curator Parasitic Worms Invertebrate Division Department of Life Sciences Natural History Museum) for her help with depositing of a specimen in the Natural History Museum, London, UK, and thank the Department of Zoology, Faculty of Science, Kasetsart University, Bangkhen Campus, Bangkok, Thailand, for laboratory facilities.

Funding This study was funded by Graduate Scholarships from the Faculty of Science, Kasetsart University, and the Department of Zoology, Faculty of Science, Kasetsart University, Bangkhen Campus, Bangkok, Thailand. This study was also kindly financially supported by the Center of Excellence on Biodiversity (BDC), Office of Higher Education Commission (BDC-PG2-161004).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This research was approved by the Institutional Animal Care and Use Committee, Faculty of Science, Kasetsart University, Thailand under project number ACKU61-SCI-032.

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