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THE FINDING OF PACIFIC TRANSVENID ACANTHOCEPHALAN IN THE ARABIAN GULF, WITH THE DESCRIPTION OF *PARATRAJECTURA LONGCEMENTGLANDATUS* N. GEN., N. SP. FROM PERCIFORM FISHES AND EMENDATION OF TRANSVENIDAE

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ABSTRACT: The acanthocephalan *Paratrajectura longcementglandatus* n. gen., n. sp. (Transvenidae) is described from specimens of 2 perciform fish species, *Nemipterus japonicus* Bloch (Nemipteridae) and *Otolithes ruber* Bloch and Schneider, collected in the marine territorial waters of Iraq and Iran in the Arabian Gulf. Metal analysis of hook tip, middle, and base is also described using energy disruptive analysis for X-ray. The new genus is distinguished from the closely related genus *Trajectura* Pichelin and Cribb, 2001 described from wrasses (Labridae) (Perciformes) in the Pacific off Australia and Japan by having a proboscis with apical epidermal cone, long rhadinorhynchid-like tubular cement glands, relatively short and lobulated lemnisci, all proboscis hooks with prominent roots, females with subterminal gonopore and a rounded projection on the antero-dorsal end of the trunk, and males with elongate pre-equatorial testes reaching proboscis receptacle. In *Trajectura*, the proboscis lacks apical epidermal cone, the cement glands are pyriform or ovoid, the lemnisci are digitiform and considerably longer than the receptacle, the posterior proboscis hooks are rootless, the females have prominent finger-like trunk projection and terminal gonopore, and males with equatorial testes that may not be elongate and may be distant from the receptacle. The importance of cement glands in the diagnosis of genera and families in acanthocephalan taxonomy is stressed. Other features especially the type and arrangement of hooks on the proboscis, but not hook roots, are comparable in the 2 genera. Diagnosis of the family Transvenidae is emended.

Pichelin and Cribb (2001) described a new acanthocephalan family, Transvenidae, with 2 genera: *Transvena* with 1 species, *Transvena annulospinosa* Pichelin and Cribb, 2001 and *Trajectura* with 2 species, *Trajectura ikedai* (Machida, 1992) Pichelin and Cribb, 2001 and *Tajectura perinsolens* Pichelin and Cribb, 2001. Their inclusion of the genus *Pararhadinorhynchus* Johnston and Edmonds, 1947 in Transvenidae was not accepted by Amin (2013). Specimens of *Transvena* and *Trajectura* were recovered from wrasses (Labridae) in the Pacific off southern Australia and southern Japan. The present report is based on the examination of 2 species of percid fish: the Japanese threadfin bream, *Nemipterus japonicus* Bloch (Nemipteridae), and the tigertooth croacker, *Otolithes ruber* Bloch and Schneider (Sciaenidae); they were collected in the marine territorial waters of Iraq and Iran in the Arabian Gulf, respectively. In this study, we describe and establish a new genus *Paratrajectura* and its type species *P. longcementglandatus* n. gen., n. sp, from percid fish in the Arabian Gulf. We also provide an emended diagnosis of Transvenidae. This report extends the geographical range of transvenid acanthocephalans into the Indian Ocean and the Arabian Gulf via the Red Sea. The present report expands the range of variability of diagnostic traits of Transvenidae, and an X-ray analysis of the proboscis hooks of the new species was also used after the hooks had been cut with a gallium bean using a dual-beam scanning electron microscope.

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MATERIALS AND METHODS

Collections

Specimens of a new species and genus of a transvenid acanthocephalan were collected from *N. japonicus* in the marine territorial waters of Iraq in Khor Al-Ummia (29°46′N, 48°48′E), Basrah, northwestern Arabian Gulf, Iraq between 2011 and 2016 (Table I), and from *O. ruber* in Iran off the Arabian Gulf in 2015 throughout the year. Fish were dissected shortly after capture and parasites were collected using routine procedures. Specimens from the Iraqi collection were deposited in the Harold W. Manter Laboratory (HWML) parasitology collection.

Microscopical examination

Freshly collected acanthocephalans were usually placed in water overnight or until fully extended then fixed in cold 70% ethanol. Worms were punctured with a fine needle and subsequently stained in Mayer's acid carmine, destained in 4% hydrochloric acid in 70% ethanol, dehydrated in ascending concentrations of ethanol (24 hr each), and cleared first in 100% xylene and then in Canada balsam and xylene (1:1) (24 hr each). Whole worms were then mounted in Canada balsam. Measurements are in micrometers, unless otherwise noted; the minimum and maximum values are followed by the mean values between parentheses. Width measurements represent maximum width. Trunk length does not include proboscis, neck, or bursa.

Line drawings were created by using a Ken-A-Vision microprojector (Ward's Biological Supply Co., Rochester, New York) that uses cool quartz iodine 150-W illumination. Worms were examined using ×110, ×200, and ×430 magnification. Images of stained whole-mounted specimens were projected vertically on 300 series Bristol draft paper (Starthmore, Westfield, Massachusetts) and then traced and inked with India ink. Projected images were identical to the actual specimens being projected. The

TABLE I. Specimens of *Paratrajectura longcementglandatus* collected from *Nemipterus japonicus* in the Arabian Gulf near Basrah, Iraq.

Month, year	Fish examined	Total length (cm)	Fish infected	Prevalence (%)	No. of range (mean) worms
November 2011	24	21–23	2	8.3	21 10–11 (10.5)
June 2012	25	21–30	2	8.0	5 1–4 (4.0)
August 2013	28	20–29	0	—	—
May 2014	14	22–28	0	—	—
June 2014	15	24–28	0	—	—
August 2014	15	23–27	0	—	—
September 2014	22	15–28	4	18.2	6 1–2 (1.2)
April 2015	20	17–19	0	—	—
August 2015	12	17–22	1	8.3	1 1 (1.0)
October 2015	11	21–23	0	—	—
April 2016	28	19–29	0	—	—
November 2016	14	17–27	8	57.1	105 1–26 (13.1)
Total	228	15–30	17	7.5	138 1–26 (6.6)

completed line drawings were subsequently scanned at 600 pixels on a USB and later downloaded on a computer.

Type specimens were deposited in the University of Nebraska's State Museum's HWML collection in Lincoln, Nebraska.

Scanning electron microscopy

Samples of parasites that had been fixed and stored in 70% ethanol were processed following standard methods (Lee, 1992) that included critical point drying in sample baskets and mounted on scanning electron microscopy (SEM) sample mounts (stubs) by using conductive double-sided carbon tape. Samples were coated with gold and palladium for 3 min by using a Polaron #3500 sputter coater (Quorum [Q150 TES], www.quorumtech.com), establishing an approximate thickness of 20 nm. Samples were placed and observed in a Helios Dual Beam Nanolab 600 scanning electron microscope (FEI, Hillsboro, Oregon) with digital images obtained in the Nanolab software system (FEI). Images were taken at various magnifications. Samples were received under low vacuum conditions using 10 kV, spot size 2, and 0.7 Torr by using a GSE detector.

X-ray microanalysis

Standard methods for SEM preparation were used. Coated specimens were examined with a Helios dual beam scanning electron microscope equipped with a Phoenix energy-dispersive x-ray analyzer (FEI). X-ray spot analysis and live scan analysis were performed at 15 kV with a spot size of 5, and results were recorded in charts on digital imaging software attached to a computer. The TEAM (Texture and Elemental Analytical Microscopy) software system (FEI) was used. The data included weight percent and atom percent of the detected elements following correction factors. The hooks were cut with a gallium beam (liquid ion metal source) at 3 levels (tip, middle, base) and analyzed for chemical elements by using energy disruptive analysis for X-ray (EDAX). Two scans for most areas were completed.

RESULTS

Infections

Seventeen of 228 examined specimens of *N. japonicus* (7.5%) were infected with 138 acanthocephalans (range 1–26, mean 8.2). Fish (15–30 cm long) were sampled throughout the year between November 2011 and November 2016 (Table I). Highest prevalence (57.1%) and mean intensity (13.1) rates were noted in November. An additional 318 specimens of *O. ruber* were collected from the Arabian Gulf off the Iranian coastline in 2015, but yielded only 5 acanthocephalans of the same species also during the fall. Acanthocephalans of the new species were infrequently found in these hosts in the Arabian Gulf, especially in *O. ruber*.

DESCRIPTION

Family Transvenidae Pichelin and Cribb, 2001 (changes to the existing diagnosis are in bold font).

Emended diagnosis: Echinorhynchida. Small-to-medium sized worms. Fusiform or cylindrical trunk with or without single ring of anterior spines. **Antero-dorsal conical or rounded trunk projection** in females or paired ventro-posterior trunk protrusions in males may be present. Proboscis claviform with longitudinal rows of **2 types of hooks and may have apical apidermal cone. Larger anterior hooks fully or partially rooted and smaller posterior spiniform hooks may or may not be rooted**. Proboscis receptacle double walled with ganglion at middle. **Lemnisci about as long as receptacle** or extending to anterior testis. **Male reproductive system in more than half of trunk. Testes ovoid to elongate, contiguous or overlapping, may reach receptacle or distant from it.** Two cement glands, pyriform or tubular. Seminal vesicle and Seafftigen's pouch present. **Female reproductive system short or long, vagina and uterine bell simple or complex with multiple chambers. Female gonopore terminal or subterminal. Eggs** fusiform **with polar prolongation to fertilization membrane.** Parasites in the intestine of marine fishes.

Paratrajectura n. gen.

(Figs. 1–5)

Diagnosis: Transvenidae. Trunk aspinose, slender, cylindrical, gradually tapering towards both ends (Figs. 1A, B, 2A, B), with antero-dorsal projection in females (Figs. 1B, 4A). Proboscis slightly claviform (Figs. 1C, 2C) with apical epidermal cone (Fig. 2D). Proboscis hooks of 2 types; anterior hooks gradually decrease in size posteriorly and transitioning into sharply curved

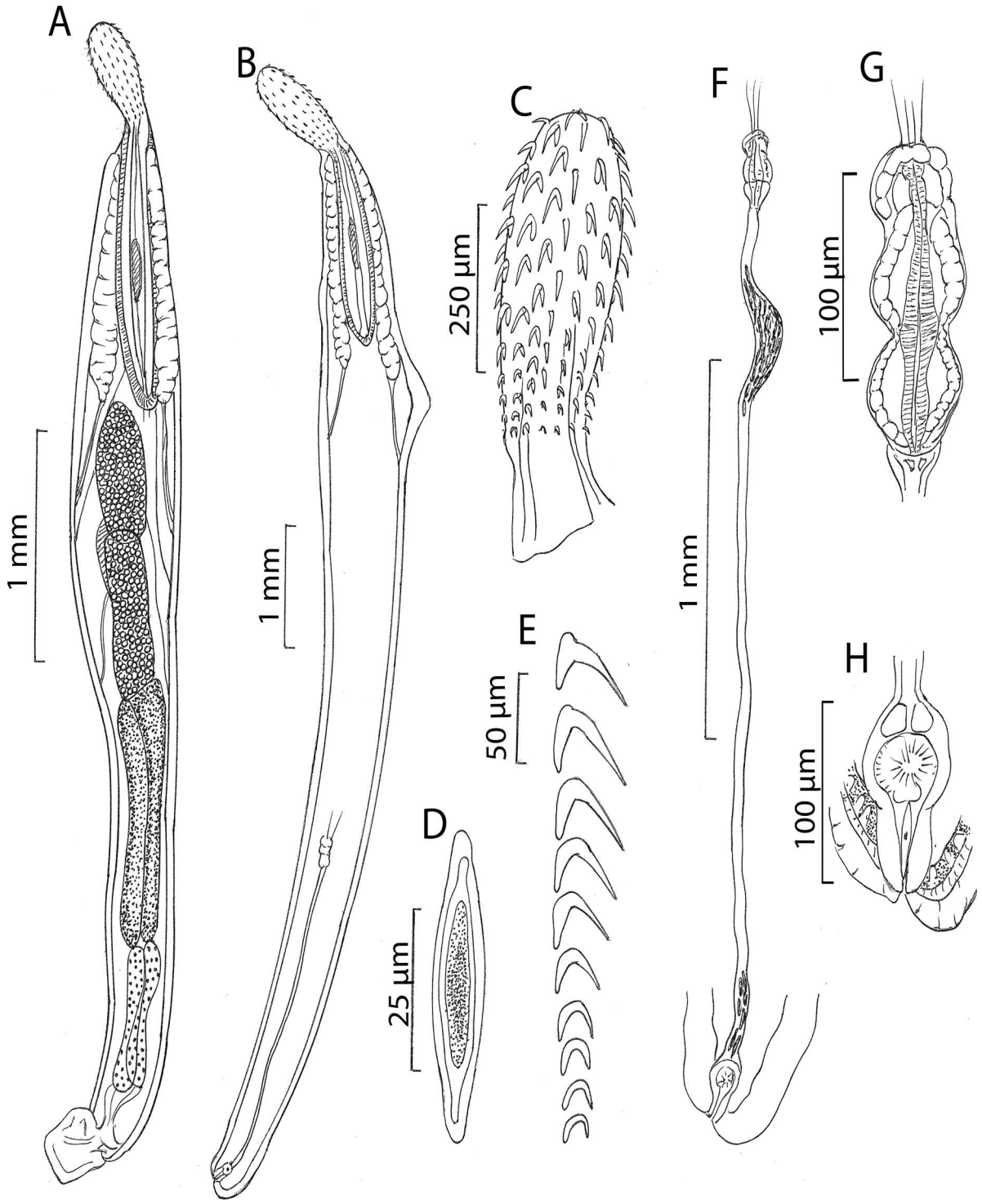


FIGURE 1. Line drawings of specimens of *Paratrajectura longcementglandatus* from *Nemipterus japonicus* collected from the Arabian Gulf near Basrah, Iraq. (**A**) Paratype male; note the lobulated lemnisci, central position of the cephalic ganglion, paired tubular cement glands and cement gland ducts. (**B**) Paratype female; note the anterio-dorsal projection of the body wall and the long reproductive system. (**C**) Proboscis of a paratype female. (**D**) Egg. (**E**) One longitudinal row of well rooted proboscis hooks. (**F**) Reproductive system of the female shown in Figure B. (**G**) Complex 3-chambered uterine bell of the female reproductive system shown in Figure F. (**H**) Detail of the vagina of the female reproductive system shown in F.

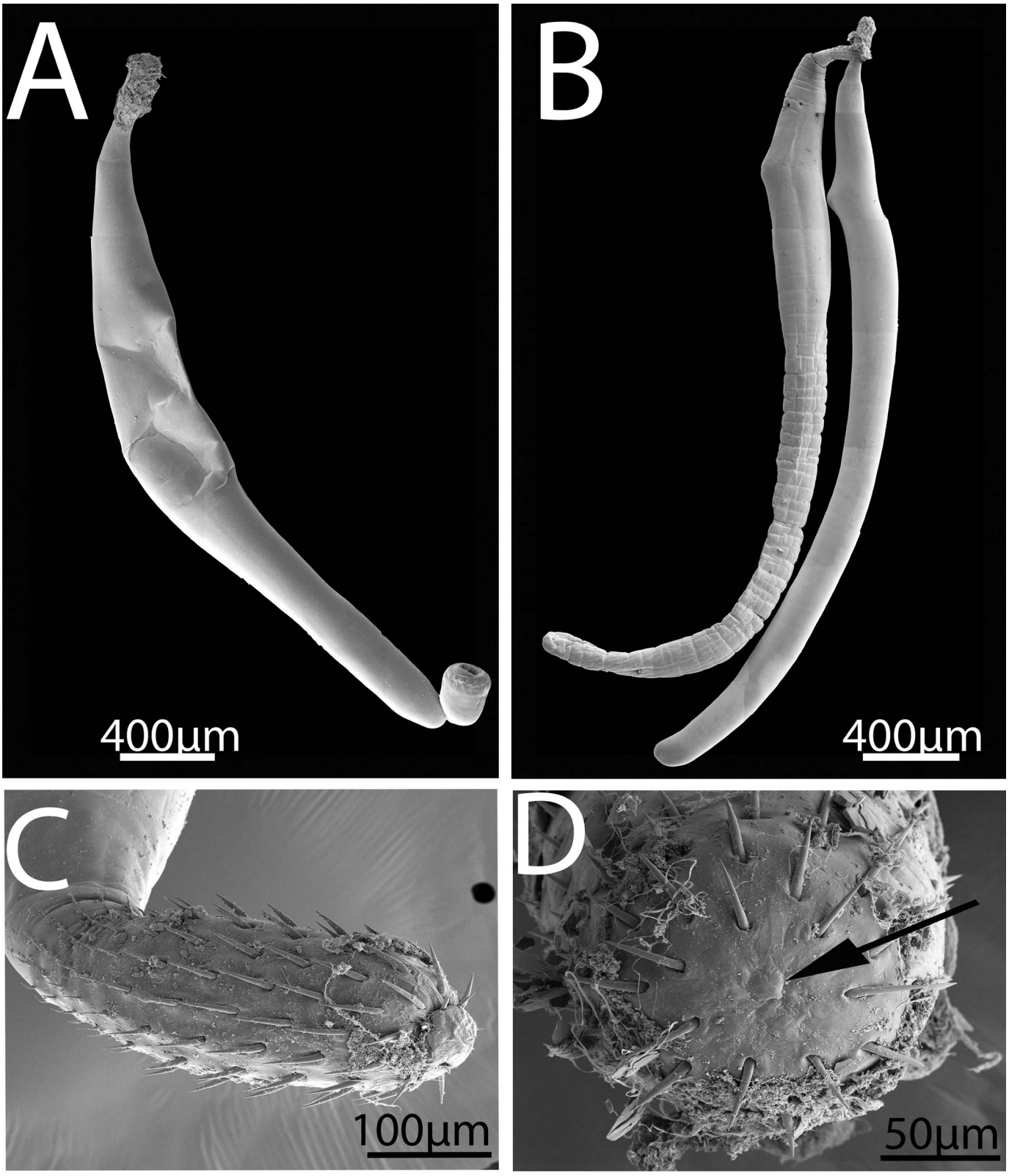


FIGURE 2. Scanning electron micrograph of specimens of *Paratrajectura longcementglandatus* from *Nemipterus japonicus* collected from the Arabian Gulf near Basrah, Iraq. (**A**) Paratype male. (**B**) Two paratype females. (**C**) Proboscis of a paratype female. (**D**) Apical end of a proboscis showing the epidermal cone (arrow).

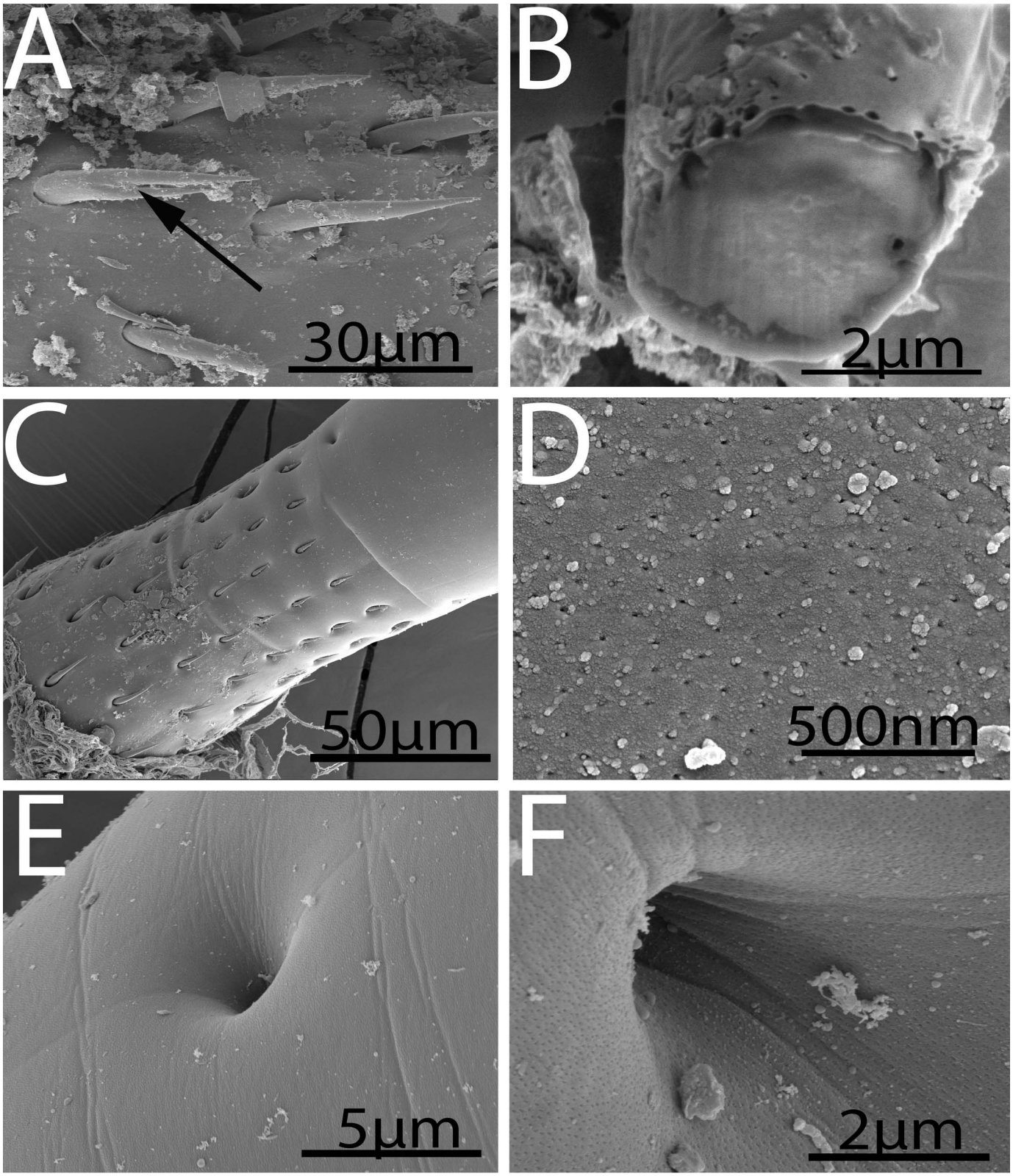


FIGURE 3. Scanning electron micrograph of specimens of *Paratrajectura longcementglandatus* from *Nemipterus japonicus* collected from the Arabian Gulf near Basrah, Iraq. (**A**) Proboscis hooks in the middle of the proboscis showing a branched hook (arrow). (**B**) Gallium-cut section of a proboscis hook showing its thin cortical layer and prominent solid core. (**C**) Posterior part of a proboscis showing the decreasing size of hooks and 1 of the 2 sensory pores in the neck. (**D**) Micropores on the epidermis of the proboscis. (**E**) Sensory pore at the base of the proboscis of a specimen. (**F**) One of several sensory pores around the female gonopore.

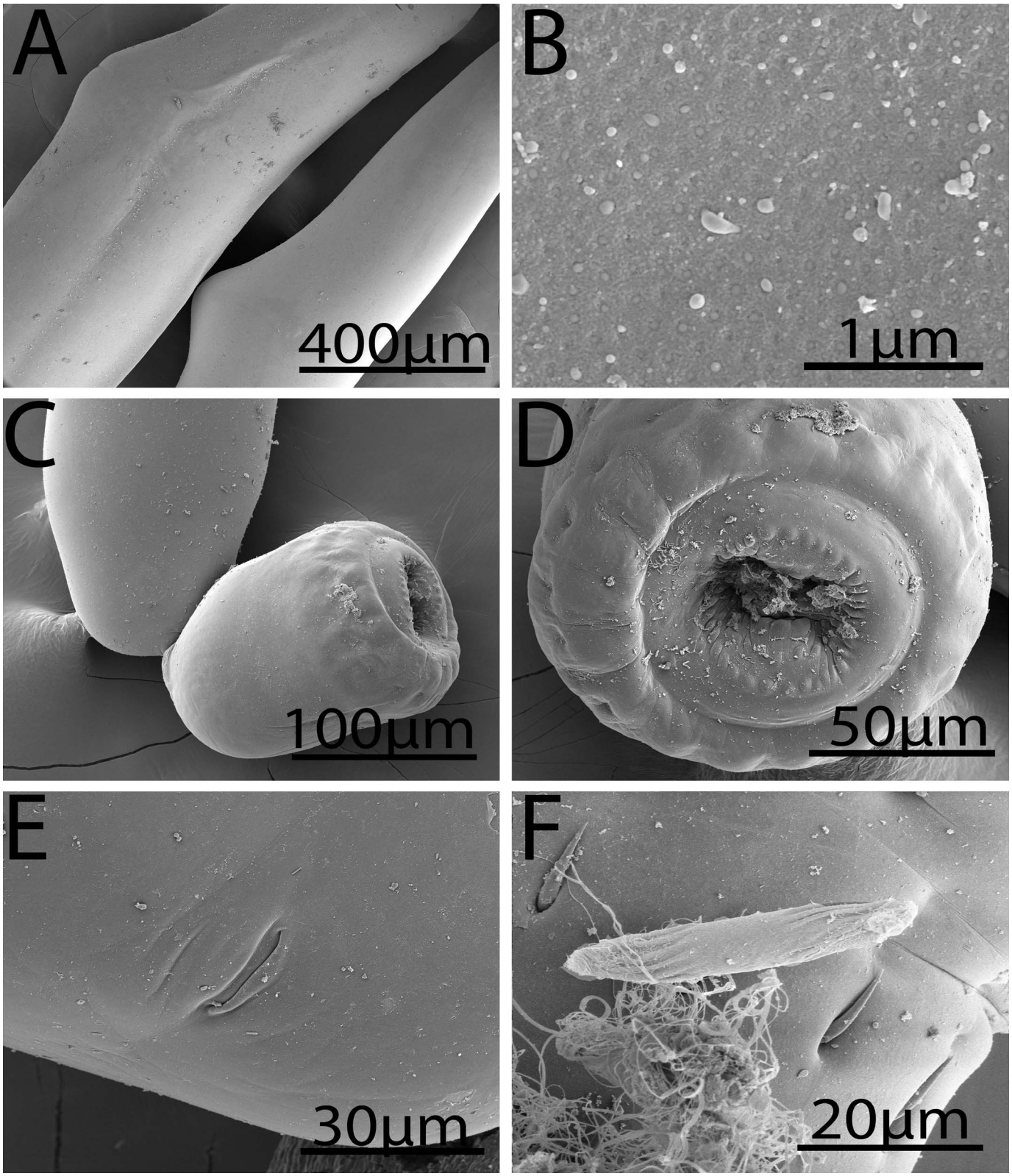
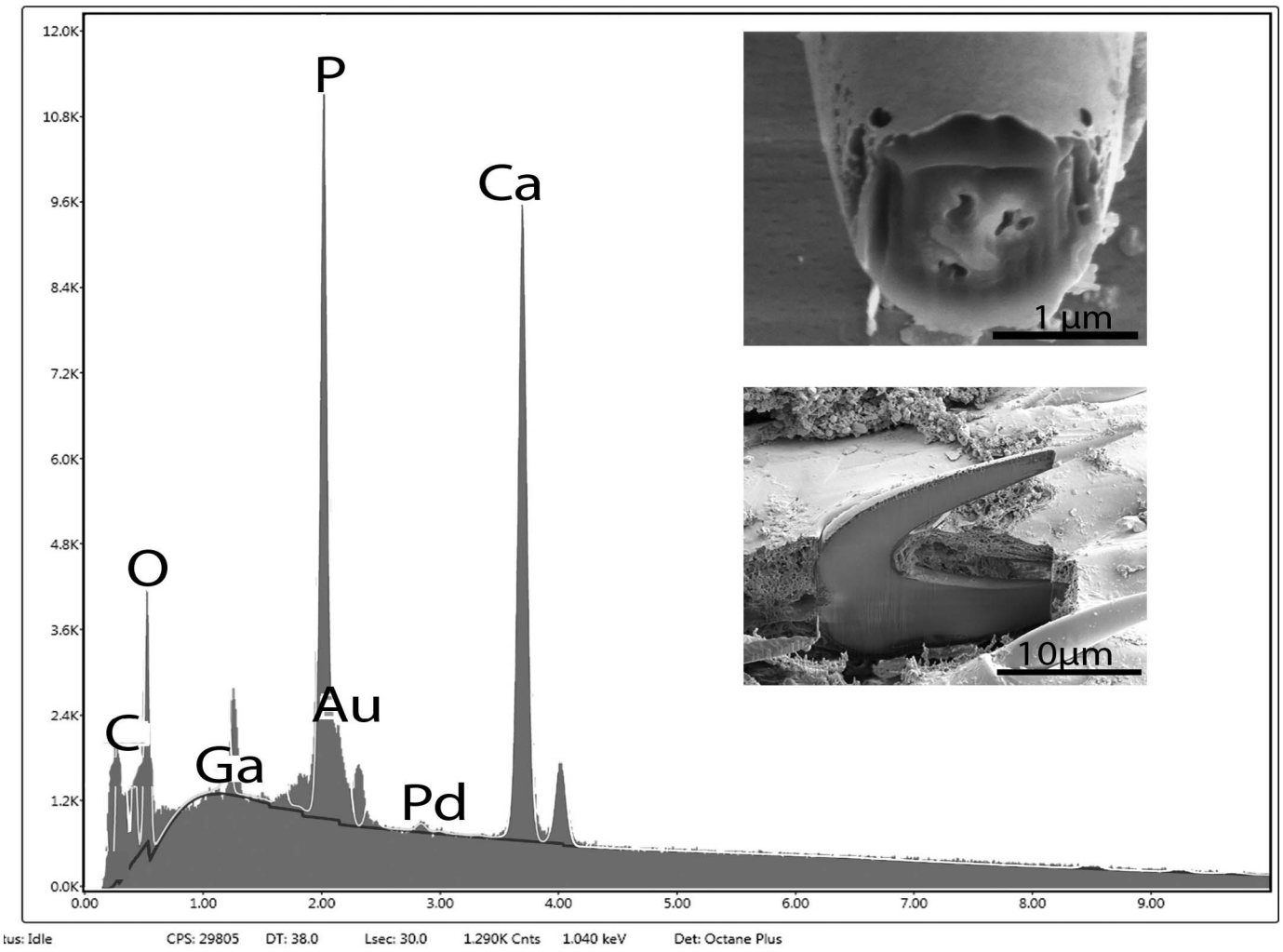


FIGURE 4. Scanning electron micrograph of specimens of *Paratrajectura longcementglandatus* from *Nemipterus japonicus* collected from the Arabian Gulf near Basrah, Iraq. (**A**) Anterior end of 2 female specimens showing variations in the shape of the antero-dorsal projections. (**B**) Micropores on the epidermis of the mid-trunk. (**C**) Lateral view of a male bursa. (**D**) Posterior view of the same bursa in C showing the mildly serrated thick muscular rim and an internal ring of sensory papillae (arrow). (**E**) Slit-like sub-ventral female gonopore. (**F**) Ripe egg showing the polar sub-surface fibrous protrusions.



Element	Weight %	Atomic %	Error %	Net Int.	K Ratio	Z	R	A
C	13.43	25.5	10.53	331.1	0.0367	1.1469	0.9241	0.2381
O	28.34	40.39	10.33	883.74	0.0501	1.0949	0.9472	0.1616
Ga	0.05	0.02	6.46	3.01	0.0003	0.7848	1.1288	0.7977
P	18.13	13.35	2.76	3093.97	0.1573	0.9503	1.0041	0.9061
Au	4.11	0.48	8.14	344.39	0.0406	0.6233	1.3599	1.2701
Pd	0.48	0.1	41.32	32.45	0.0036	0.7197	1.1966	1.0273
Ca	35.46	20.17	2.4	3362.62	0.3201	0.9306	1.0314	0.964

FIGURE 5. Panel representing the x-ray microanalysis of the mid cut of hooks of *Paratrajectura longcementglandatus*. The 2 insets show gallium-cut hooks; note prominent core of upper section and strong root in lower inset.

posterior spine-like hooks (Figs. 1C, 2C). All hooks with prominent roots (Figs. 1E, 5). Proboscis receptacle double-walled with elliptic cephalic ganglion near middle. Lemnisci equal, about as long as receptacle (Fig. 1A, B). Elongate testes in tandem, pre-equatorial, reaching receptacle, and contiguous with 2 prominent tubular rhadinorhynchid-like cement glands adjoining slightly shorter tubular cement gland ducts posteriorly (Fig. 1A). Saefftigen's pouch present. Uterus long and tubular (Fig. 1F), vagina (Fig. 1H) and uterine bell (Fig. 1G) complex. Gonopore terminal in males and subterminal in females. Eggs elongate with polar prolongation of fertilization membrane Fig. 1D, 4F).

Type species: Paratrajectura longcementglandatus.

Etymology: The name associates the new genus with *Trajectura* which also has females with antero-dorsal projection on the trunk.

Remarks

Amin (2013) recognized 2 genera in the family Transvenidae: *Trajectura* with 2 species, *T. ikedai* and *T. perinsolens*, and *Transvena* with 1 species, *T. annulospinosa*. The inclusion of *Pararhadinorhynchus* in Transvenidae by Pichelin and Cribb (2001) was rejected by Amin (2013), but it did contribute to their family diagnosis.

Our specimens clearly belong in the family Transvenidae because of the presence of hooks of 2 types on the proboscis, a cephalic ganglion at the middle of the receptacle, 2 cement glands in males, and a long tubular uterus in females. They do not belong in the genus *Transvena* Pichelin and Cribb, 2001 that has 1 ring of anterior trunk spines, paired protrusions at posterior end of male trunk, and no antero-dorsal projection on the trunk of females. Our specimens are close to the only other genus of the family, *Trajectura* Pichelin and Cribb 2001, that has no trunk spines or paired protrusions at posterior end of male trunk, but has an antero-dorsal trunk projection in females. The paired protrusions in *Transvena* seem to correspond to the prominent muscles associated with the genital terminalia similar to those described in females of *Neoechinorhynchus buckneri* Amin and Heckmann, 2009. Amin and Heckmann (2009) indicated an association between the prominence of these paired protrusions and the reproductive activity of specimens of *N. buckneri* and other species quoted therein.

In addition, our specimens feature apical proboscis epidermal cone (Fig. 1D) as in *Tenuisentis niloticus* (Meyer, 1932) Van Cleave, 1936 (see Amin et al., 2016), evident in slightly retracted proboscides similar to that reported in *Paratenuisentis ambiguus* (Van Cleave, 1921) by Herlyn (2001; see fig. 1D). The presence of the apical epidermal cone in the Eoacanthocephala Van Cleave, 1936 was interpreted as an evolutionary innovation supporting the monophyly of the Eoacanthocephala (see Herlyn, 2001). However, its presence in our new transvenid acanthocephalan represents a departure from this proposal and an additional new feature separating it from the genus *Trajectura* where such a structure was not evident (Pichelin and Cribb, 2001).

The new genus and the genus *Trajectura* share the following traits: antero-dorsal trunk projection and long tubular uterus in females; cephalic ganglion at middle of the receptacle; 2 cement glands in males; absence of anterior ring of trunk spines; and similar type of proboscis hooks, but not roots. It is however distinguished from genus *Trajectura* by having a proboscis with apical epidermal cone and all hooks rooted, elongate pre-equatorial testes approaching the receptacle and contiguous posteriorly with rhadinorhynchid-like tubular cement glands, long tubular cement gland ducts, lemnisci lobulated and about as long as receptacle, subterminal gonopore in females, and complex uterine bell and vagina. In the genus *Trajectura*, the proboscis lacks an apical epidermal cone and has rootless posterior hooks, testes may not be elongate and may be distant from receptacle, the cement glands are pyriform or ovoid, cement gland ducts are not distinguished, lemnisci digitiform and considerably longer than receptacle, the female gonopore is terminal, and uterine bell and vagina are simple.

Paratrajectura longcementglandatus n. sp.

Description: General. Transvenidae, with characters of the genus *Paratrajectura*. Small cylindrical aspinose worms with widest diameter at middle of trunk. Trunk and all shared structures larger in females than in males. Antero-dorsal trunk with rounded protrusion that vary in degree of prominence in females (Fig. 4A). Proboscis and trunk with micropores (Figs. 3D, 4B). Proboscis slightly claviform, sometimes directed ventrad, with 13 or 14 (usually 13) longitudinal rows of 10 or 11 (usually 10) hooks each. Hooks in adjacent rows alternating except basal hooks being in perfect circle (Figs. 1C, 2C). Hooks of 2 types. First 5 hooks normal, largest anteriorly, except anterior-most hook, with straight blades directed posteriorly transitioning to progressively smaller and strongly curved 5 spine-like posterior hooks. Hooks with thin cortical layer and prominent central core (Fig. 3B) and occasionally branched (Fig. 3A). All hooks with prominent roots slightly shorter than blades. Roots more robust anteriorly becoming more slender posteriorly with basal hooks in complete ring (Figs. 1C, 3C). Roots of anterior 2 hooks with anterior stubby rounded manubria (Fig. 1E). Two sensory pores in anterior neck (Fig. 3C, E) of males and females and a few near gonopore of all females (Fig. 3F). Proboscis receptacle double-walled, inserted at base of proboscis, with cephalic ganglion near its middle. Lemnisci equal, lobulated, about as long as receptacle or slightly longer, attached to body wall posteriorly with short ligaments (Fig. 1A, B).

Males (based on 19 mature specimens with sperm): Trunk 2.78–5.00 (4.00) mm long by 0.27–0.62 (0.44) mm wide at middle. Proboscis 425–572 (487) long by 112–200 (137) wide near middle. Length of hook blades and roots from anterior in proboscides with 10 hooks per row: [1]: 37–57 (50) and 35, [2]: 50–57 (53) and 37, [3]: 52–62 (60) and 37–42 (39), [4]: 50–57 (53) and 30–40 (36), [5]: 36–47 (41) and 30–35 (32), [6]: 27–35 (32) and 25–30 (27), [7]: 27–35 (28) and 25, [8]: 20–27 (23) and 17–20 (19), [9]: 17–25 (21) and 12–25 (18), [10]: 17–25 (21) and 17–20 (18). Length of hook blades and roots from anterior in proboscides with 11 hooks per row: [1]: 37–47 (42) and 25, [2]: 50–52 (51) and 32, [3]: 55–57 (56) and 37, [4]: 60 and 37, [5]: 60–65 (62) and 37, [6]: 55–57 (56) and 42, [7]: 43–45 (44) and 30, [8]: 32–35 (33) and 20, [9]: 25–30 (27) and 20, [10]: 25 and 20, [11]: 20–22 (21) and 20. Proboscis receptacle 686–1,040 (867) long by 106–177 (142) wide. Lemnisci slightly longer than receptacle, 780–1,040 (918) long by 65–240 (121) wide. Reproductive system about 75% of trunk length reaching and occasionally overlapping proboscis receptacle (Fig. 1A). Testes elongate. Anterior testis 312–832 (573) long by 125–395 (232) wide. Posterior testis relatively longer than anterior

testis, 312–988 (607) long by 125–312 (206) wide. Tubular cement glands 572–1,300 (936) long by 73–250 (129) wide. Cement gland ducts contiguous with cement glands and about half as long, 312–884 (487) long and 62–146 (98) wide. Saefftigen's pouch 260–520 (335) long by 62–156 (92) wide (Fig. 1A). One bursa 270 long by 302 wide (Fig. 4C, D).

Females (based on 17 worms with eggs at different degrees of development): Trunk 5.00–10.50 (7.71) mm long by 0.33–0.72 (51) wide. Proboscis 447–572 (516) long by 125–187 (159) wide. Length of hook blades and roots from anterior in proboscides with 10 hooks per row: [1]: 50–57 (53) and 27–40 (33), [2]: 50–62 (55) and 32–42 (37), [3]: 45–62 (53) and 31–42 (38), [4]: 42–65 (51) and 27–42 (37), [5]: 35–52 (47) and 30–40 (35), [6]: 27–47 (36) and 25–35 (30), [7]: 25–32 (29) and 20–27 (24), [8]: 22–27 (25) and 15–22 (19), [9]: 18–25 (22) and 15–17 (16), [10]: 15–25 (21) and 12–17 (15). Proboscis receptacle 707–1,200 (970) by 114–187 (150). Lemnisci 780–1,460 (1,110) by 30–135 (81). Reproductive system (Fig. 6) 2.08–3.54 (2.73) mm long. Length proportional to trunk length (29–42% averaging 35%) of trunk; higher percentage in smaller worms. System with well-developed vagina (Fig. 1H) 125–150 (137) long, long uterus, and complex uterine bell 132–192 (160) long without associated large uterine bell cells. Uterine bell with 3 chambers lined cortically with a prominent layer of lobulated cells, and with heavily muscular central canal (Fig. 1G). Gonopore subterminal (Fig. 1F, 4E) or occasionally near subterminal. Eggs elongate with polar prolongation of fertilization membrane (Fig. 1D) and prominent subcortical polar fibers (Fig. 4F), 50–67 (58) long by 11–15 (13) wide.

Taxonomic summary

Type host: Nemipterus japonicus Bloch (Nemipteridae: Perciformes).

Other host: Otolithes ruber Bloch and Schneider (Sciaenidae: Perciformes).

Type locality: Marine territorial waters of Iraq in Khor Al-Ummia (29°46′N, 48°48′E), Basrah, northwestern Arabian Gulf, Iraq.

Other locality: The Arabian Gulf off the coast of Iran.

Site of infection: Intestine.

Type specimens: HWML 103067 (holotype male and paratypes on 1 slide), 103068 (allotype female and paratypes on 1 slide), and 103069 (additional paratypes).

Etymology: The name of the new genus indicates its closeness to the genus *Trajectura* Pichelin and Cribb, 2001. The name of the new species describes its tubular cement glands that distinguishes it from the genus *Trajectura*.

Remarks

Paratrajectura longcementglandatus n. gen., n. sp. is the only species of the new transvenid genus *Paratrajectura* known to date. It is distinguished from the 2 known species of the related genus *Trajectura*, *T. ikedai* and *T. perinsolens*, by having the characters of tubular cement glands and cement gland ducts, proboscis with all hooks rooted and apical epidermal cone, lemnisci lobulated and about as long as receptacle, subterminal gonopore in females, and complex uterine bell and vagina as has been noted above. In addition, the development of proboscis hook roots seems variable. In *T. ikedai*, anterior hooks have well developed roots, but the roots of posterior hooks are barely discernible (Machida, 1992; fig. 3). In *T. perinsolens*, all hooks on 1 side (probably the dorsal side) lack roots, and only the second and third hooks on the presumed ventral side have moderately developed roots, with the latter hook root having a distinct anterior manubrium (Pichelin and Cribb, 2001; fig. 13); the latter authors state that "roots not observable."

The cuticular electron dense micropores have been shown to usually be of different diameters and distributional densities in various regions of the trunk and occasionally also in the neck, proboscis, and bursa in proportion to their involvement in nutrient uptake.

X-Ray microanalysis

Table II and Figure 5 represent the results of the X-ray scans. Table II represents the chemical composition of the hook at 3 levels emphasizing 3 key elements: calcium, phosphorus, and sulfur. The cytoplasmic elements were also present. Figure 5 is the x-ray printout for the mid cut taken in the center of the hook, and Table II displayed the mineralization pattern for the attachment structure. The mid cut of hooks (Fig. 5) showed the absence of sulfur, an element common throughout the other cuts, but high levels of calcium and phosphorus. Sulfur is critical for the edge and surface of the hook. The other areas of the hook showed varying levels of all 3 of these elements.

DISCUSSION

It is best to evaluate the new species in the context of its host–parasite relationships. The Japanese threadfin bream is a tropical, marine, demersal fish of Indo-Pacific distribution, but it has also been reported in the east Mediterranean, having invaded as a Lessepsian migrant through the Red Sea and the Suez Canal (Russell, 1990; Rodriguez and Suárez, 2001; Froese and Pauly, 2017b). It is a carnivorous bottom feeder, mostly on crustaceans (53%) and young fishes (23%), and to a lesser extent on polychaetes, among other food items. The fish feeds throughout the year but feeding intensity seems to be highest in October (Acharya et al., 1994; Sreekanth et al., 2012), the time when infections in fish were peaked.

The tigertooth croaker is a benthopelagic, amphidromous, brackish-marine fish of Indo-west Pacific distribution in east Africa including Madagascar (absent in the Red Sea), eastward to southern China and Queensland, Australia (Froese and Pauly, 2017a). It is a highly carnivorous fish that feeds primarily on crustaceans and fish. Fish of all size groups, especially the young, feed on crustaceans with the percentage of consumed fish in the diet increasing in larger fish (Pillai, 1983). The small (less than 20 cm long) croaker feeds on shrimp and crabs (72%) and on fish (28%) but larger preys on fish (80%) and shrimp (20%) (Mohamed et al., 1998). Comparable patterns were observed in related species of *Otolithes* Trewavas, i.e., *O. cuvieri* (Trewavas) (see Manojkumar, 2003).

The tigertooth croaker was scarcely infected with acanthocephalans of the new species off the coast of Iran and off the nearby coast of Iraq (Mhaisen et al., 2013, 2014; Ali et al., 2014; Moravec and Ali, 2014; Ghadam et al., 2018). However, it is reported to be commonly infected with other helminth parasite species in the same Arabian Gulf areas, ex., Haseli et al. (2010),

TABLE II. Chemical elements for *Paratrajectura longcementglandatus* observed at 3 cut levels for the proboscis hook (average of 2 scans separate hooks).*

	Hook tip			Hook middle						Hook base					
				Edge			Center			Edge			Center		
	Phosphorus	Sulfur	Calcium	Phosphorus	Sulfur	Calcium	Phosphorus	Sulfur	Calcium	Phosphorus	Sulfur	Calcium	Phosphorus	Sulfur	Calcium
Weight %	7.15	11.30	13.75	15.48	3.46	29.45	18.55	0.00	40.15	17.00	1.76	29.82	18.33	0.89	39.56
Atom %	4.89	7.23	7.34	12.23	2.80	27.85	14.33	0.00	24.13	12.40	1.26	16.81	14.05	0.67	23.57

* Common chemical elements (carbon, nitrogen, oxygen) for worms are not listed. Chemical elements used for processing the sample (gallium, gold, palladium) are not listed in the table.

Moravec et al. (2013), Pazooki et al. (2013), and Shohreb et al. (2014).

The micropores have been shown to vary in diameter and distribution in various body regions in proportion to their rate of absorption of nutrients through the body wall. We have documented this phenomenon in 16 species of acanthocephalans (Heckmann et al., 2013) and a few more since. The functional aspects of micropores in a few other acanthocephalan species including *Rhadinorhynchus ornatus* Van Cleave, 1918; *Polymorphus minutus* (Goeze, 1782) Lühe, 1911; *Moniliformis moniliformis* (Bremser, 1811) Travassos (1915); *Macracanthorhynchus hirudinaceus* (Pallas, 1781) Travassos (1916, 1917); and *Sclerocollum rubrimaris* Schmidt and Paperna, 1978 were reviewed earlier by Amin et al. (2009). The micropore canals seem to be continuous with canalicular crypts that constitute a huge increase in external surface area implicated in nutrient uptake (Amin et al., 2009).

Cement gland shape, number, structure, and organization have been regarded as pivotal diagnostic traits distinguishing acanthocephalan genera and families by taxonomists including Lühe (1911), Van Cleave (1916, 1949), and Meyer (1938). More recently, Amin and Redlin (1980) invalidated Petrochenko (1956) splitting up of the genus *Echinorhynchus* Müller, 1776 into the 3 genera *Echinorhynchus*, *Metechinorhynchus*, and *Pseudoechinorhynchus* and designated the latter 2 genera as junior synonyms of the first genus based on cement gland patterns.

As expected the tip and edges of the hooks contained sulfur (Heckmann et al., 2012). In previous studies the proboscis hooks were shown to have a consistent level of the 3 key ions (calcium, phosphorus, sulfur), with the sulfur concentrated in the cortical hook layer (Brazoa et al., 2014). It is assumed that the sulfur ions are found in the disulfide bonds linking the amino acid cysteine in the hardened protein of the outer layer. The bonds are in conjunction with calcium and phosphorus to establish the hardened apatite. This is similar to the tooth enamel of mammals. Variable amounts of sulphur could account for the hardened nature of the hook. Raynaud et al. (2000), using X-ray diffraction, demonstrated that the increased stability of protein (such as in the proboscis hook) is due to the amount of disulfide bonds in the product by using X-ray diffraction.

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