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Redescription of *Faustula gangetica* (Srivastava, 1935) (Plagiorchiida: Faustulidae) in the Hilsa Shad, *Tenualosa ilisha* (Hamilton) (Clupeidae), from the Arabian Gulf off Iraq

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ABSTRACT: *Faustula gangetica* (Srivastava, 1935) Yamaguti, 1958 (Plagiorchiida: Faustulidae) from the Hilsa shad, *Tenualosa ilisha* (Hamilton) (Clupeiformes: Clupeidae), collected in the Arabian Gulf off Iraq between June and October 2014 is redescribed. We include details of the structures within the cirrus sac and provide further basic morphology for this species not previously available. *Faustula ilishii* (Srivastava, 1935) Yamaguti, 1958 is synonymized with *F. gangetica*. This is the first report of *F. gangetica* from the Hilsa shad in the Arabian Gulf.

KEY WORDS: Arabian Gulf, Clupeidae, Digenea, *Faustula gangetica*, *Faustula ilishii*, Faustulidae, *Orientophorus*, Hilsa Shad, Iraq, *Tenualosa ilisha*, Trematoda.

Faustula gangetica (Srivastava, 1935) Yamaguti, 1958 (Plagiorchiida: Faustulidae) was originally described as *Orientophorus gangetica* Srivastava, 1935 from the intestine of the Hilsa shad, *Tenualosa ilisha* (Hamilton) (Clupeiformes: Clupeidae) (syns. *Clupea ilisha* [Hamilton]; *Hilsa ilisha* [Hamilton]), collected from a river near Allahabad, India (likely the Ganges River) by Srivastava (1935). Hafeezullah and Siddiqi (1970) reported *F. gangetica* from the kelee shad or fivespot herring, *Hilsa kelee* (Cuvier) (Clupeidae), collected from off Mumbai, India (previously Bombay). Yamaguti (1958), Bray (2008), and the World Register of Marine Species (WoRMS, 2018) recognized the synonymy of *Orientophorus* Srivastava, 1935 with *Faustula* Poche, 1926, and WoRMS (2018) accepted *O. gangetica* Srivastava, 1935 as a species of *Faustula*. Like most clupeids, *T. ilisha* is mainly marine. It is frequently found in the Indian Ocean and Arabian Gulf (also known as the Persian Gulf) and it is known to be anadromous and/or a migrant, entering rivers to breed. It is an important food fish in the region and is used extensively in aquaculture (Froese and Pauly, 2018). Recent natural population declines of this fish species have occurred that have been attributed to overfishing and the erection of dams along rivers which obstruct access of clupeid fishes to their breeding grounds (Freyhof, 2014). *Faustula gangetica* from the Hilsa shad, *T. ilisha*, collected in the Arabian Gulf off Iraq is redescribed to include details of the structures within the cirrus sac and provide further information on the basic morphology of this species that is not currently available in existing descriptions.

MATERIALS AND METHODS

Specimens used in this study were collected from 100 Hilsa shad netted in the Arabian Gulf off Iraq (29°58′33″N; 48°28′20″E) by two of us (M.B. and E.M.) from June to October, 2014 in conjunction with the Species Diversity Program based at the Marine Science Center, University of Basrah, Iraq. Specimens were examined alive, relaxed in saline, heat fixed, preserved in formalin or AFA (alcohol-formalin-acetic acid), stored in 70% ETOH and sent to the Laboratory of Parasitology, Department of Wildlife and Fisheries Sciences, Texas A&M University in College Station for further evaluation. Specimens were stained in Semichon's carmine, mounted in Canada balsam, and examined using an Olympus BX 40 compound microscope. Drawings were done using a Zeiss Universal compound microscope, Pixera Pro 150ES imaging system, and a drawing tube. All measurements are in micrometers (μm) and are given with the mean followed by the range in parentheses; length is followed by width for 2-dimensional structures, unless otherwise stated. Critical morphometric

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percentages based on measurements as a percentage of body length and morphometric ratios are provided where necessary. Comparative measurements of species in *Faustula* were taken from original descriptions (when possible) or vouchered museum specimens. Measurements either not provided or obviously in error in existing descriptions were calculated from the original figures where necessary. Ecological terms followed Bush et al. (1997).Voucher specimens were deposited in the Parasite Collection, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution (USNM). Fish classification and authorities follow FishBase (Froese and Pauly, 2018). The following specimens of species of *Faustula* were examined from the Smithsonian Parasite Collection, USNM: *Faustula basiri* Hafeezullah and Siddiqi, 1970 (holotype 1358919); *F. gangetica* (voucher 1358920); *Faustula gasterostei* Schell, 1973 (holotype 1368020); and *Faustula keksooni* (MacCallum, 1918) Poche, 1926 (type 1337171).

RESULTS

Plagiorchiida La Rue, 1957
Faustulidae Poche, 1926
Faustula gangetica (Srivastava, 1935) Yamaguti, 1958
(Figs. 1–5)

(Syn. *Orientophorus gangeticus* Srivastava, 1935)

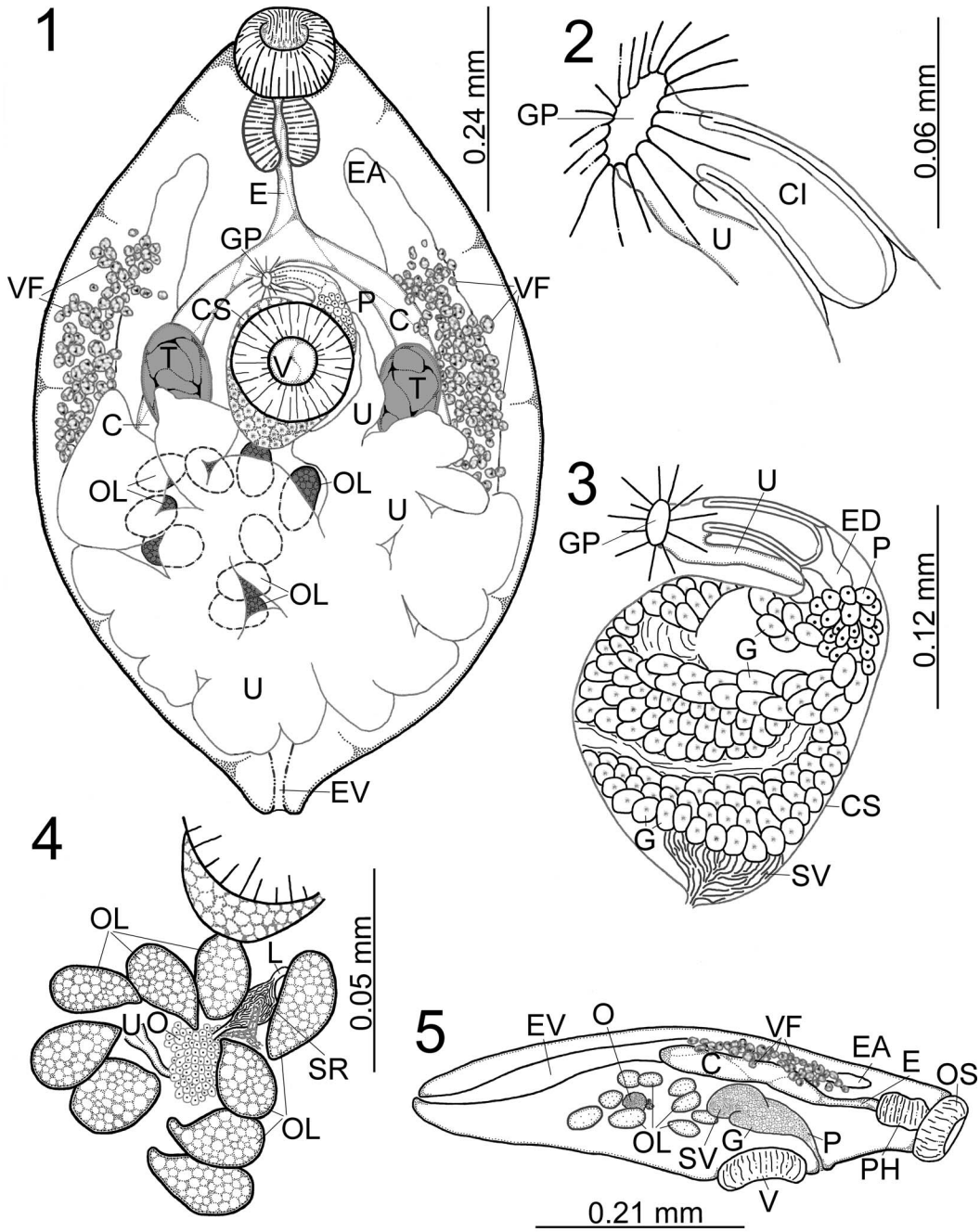
Redescription

Based on 15 adult specimens. Body small, delicate, spinose, ovoid with broadly tapering extremities (lemon-shaped) as originally illustrated in fig. 2 for *F. gangetica* by Srivastava (1935) to more elongate–oval, with gradually tapering anterior and posterior ends similar to *F. gangetica* as illustrated in fig. 2 by Hafeezullah and Siddiqi (1970), 1,049 (890–1,213) × 574 (520–630) at broadest point; body spines easily dislodged. Forebody 335 (267–403) long (27–36% of body length). Oral sucker slightly subterminal, spherical to subspherical, 94 (52–113) ×123 (87–150) (width 7–15%). Prepharynx absent. Pharynx spherical, 81 (62–104) × 79 (57–103) (width 5–10%); oral sucker/pharynx width ratio 1:1.6 (1:1.4–1:1.9). Esophagus variable in length, 54 (40–156) (length 4–13%). Intestinal bifurcation approximately 1/4–1/3 distance from anterior end. Ceca relatively short, extending into hindbody, terminate short distance posterior to body midlevel. Ventral sucker near midbody, spherical, 134 (87–188) × 129 (112–148) (width 12–13%); ventral sucker/oral sucker width ratio 1:1.0 (1:0.9–1:1.3). Cirrus sac broadly oval, overlaps ventral sucker dorsally, surpasses ventral sucker short distance into postacetabular space, 222 (172–270) × 125 (72–158) (length 17–26%), encloses short cirrus, short ejaculatory duct surrounded by prostate cells posteriorly, wide pars prostatica, and long, relatively narrow seminal vesicle. Cirrus short, somewhat thick-walled (thick walls can be confused with concentric muscular semicircles on ventral surface when cirrus inverted); pars prostatica short chamber; seminal vesicle elongate, upper aspect narrow canal that spirals throughout middle 1/3 of cirrus sac, containing minimal amounts of sperm, terminates in wider oval sac at posterior extreme of cirrus sac containing bulk of sperm; pars prostatica and seminal vesicle embedded in thick layers of large glandular cells. Genital pore generally submedian, appearing near midline of body in some specimens, immediately postbifurcal in specimens where contraction was minimal. Testis smooth, oval to elongate-oval, symmetrical at level of ventral sucker; right testis 121 (100–169) × 75 (35–108); left testis 137 (97–179) × 80 (50–100); mean testes/ovary width ratio 1:0.4 (1:0.1–1:0.6). Ovary posttesticular, slightly dextral, 185 (155–213) × 169 (125–225) with 9, rarely 10 distinct lobes clustered in circle around oötype, canals connecting individual lobes to female reproductive system not visible. Individual ovarian lobes 57 (45–75) × 39 (27–50). Postovarian space 220 (length 24%). Oötype centrally located among ovarian lobes, embedded in Mehlis gland cells. Laurer's canal present, canal pore not observed, canal dilated to form small canalicular seminal receptacle immediately prior to entering oötype. Vitelline fields lateral, somewhat surrounding ceca, extend from level of intestinal bifurcation to cecal ends. Vitelline follicles relatively small, 21 (10–40) × 19 (11–38). Vitelline reservoir formed by intersection of 2 main collecting ducts, empties into oötype just distal to Laurer's canal. Uterus extensive, almost entirely confined to hindbody. Eggs small, oval, 18 (15–23) × 13 (10–15). Excretory vesicle V-shaped, approaches being Y-shaped with short stem; excretory arms extending anteriorly to level of posterior end of pharynx; excretory pore somewhat dorsally located.

Taxonomic summary

Host: Hilsa shad, *T. ilisha* (Hamilton, 1822); Clupeidae.

Other reported hosts: Kelee shad, *H. kelee* (Cuvier, 1829) (Clupeidae) by Hafeezullah and Siddiqi (1970).



Figures 1–5. *Faustula gangetica* (Srivastava, 1935) Yamaguti, 1958 from the Hilsa shad, *Tenualosa ilisha* (Hamilton) (Clupeidae), from the Arabian Gulf. **1.** Adult, ventral view. **2.** Genital pore and atrium, ventral view. **3.** Composite illustration of the male terminal genitalia, ventral view. **4.** Composite illustration of the female genital complex, ventral view. **5.** Immature specimen, side view. Abbreviations: C = cecum; CI = cirrus; CS = cirrus sac; E = esophagus; EA = excretory arm; ED = ejaculatory duct; EV = excretory vesicle; G = glandular cells; GP = genital pore; L = Laurers canal; O = oötype embedded in Mehlis gland cells; OL = ovarian lobe; OS = oral sucker; P = prostate glands; PH = pharynx; SR = seminal receptacle; SV = seminal vesicle; T = testis; U = uterus; V = ventral sucker; VF = vitelline follicles.

Locality: Arabian Gulf off Iraq, 29°58′33″N; 48°28′20″E.

Other reported localities: Ganges River near Allahabad, India by Srivastava (1935); off Mumbai, India (previously Bombay) by Hafeezullah and Siddiqi (1970).

Site of infection: Intestine.

Prevalence, mean intensity, relative density/abundance: Forty-four of 100 hosts infected (44%, 14.4 flukes per infected fish, 639 flukes/100 hosts = 6.4).

Specimens deposited: Voucher specimens (14 specimens on 6 slides) USNM 1480557 (3); USNM 1480558 (2); USNM 1480559 (2); USNM 1480560 (1); USNM 1480561 (3); USNM 1480562 (3).

DISCUSSION

Although our specimens are generally similar to *F. gangetica* in all basic morphological characteristics and ranges (Table 1), they were somewhat smaller (890–1,213 vs 1,340–1,650 long) than those used in the original description of this species by Srivastava (1935). Likewise, our specimens were taken from the Arabian Gulf, and *F. gangetica* originally was described from freshwater in India. Hafeezullah and Siddiqi (1970) reported *F. gangetica* from *H. kelee* collected from off Mumbai, India (previously Bombay). These authors provided neither a detailed description nor measurements of their specimens, and although their fig. 2 appears to indicate a somewhat more elongate body form, we have encountered similar body shapes in some specimens of *F. gangetica* and consider fig. 2 of Srivastava (1935) to represent *F. gangetica*. It also is our opinion that *Faustula ilishii* should be synonymized with *F. gangetica* as originally described. Originally, this species was distinguished from *F. gangetica* (syn. *O. gangeticus*) by the absence of an esophagus, having less extensive vitelline fields, the shape and size of the cirrus sac, and other "minute differences" in the sizes of the various organs. Although *F. ilishii* is somewhat smaller than *F. gangetica*, the "minute differences" in sizes of structures cited by Srivastava (1935) are not sufficient to justify the separation of these two species, especially given the similarities of measurements when considered relative to body length (Table 1). The number of specimens considered in the description of *F. ilishii* by Srivastava (1935) was not provided, but fig. 3 of the original description indicates that the specimen illustrated is distinctly contracted and somewhat distorted so that the oral sucker is displaced posteriorly and the pharynx is pulled anteriorly into the posterior end of the oral sucker. The ceca appear to have been unduly compressed; thus their width appears to have become laterally extended and the ceca were pulled towards the pharynx dramatically shortening the area from the pharynx to the intestinal bifurcation so that the esophagus appears to be nearly absent. The ventral sucker is moved off the midline of the body and displaced anteriorly; the cirrus sac is displaced to the right and away from the ventral sucker, and it appears to have been somewhat compressed. The vitelline fields also have been pulled anteriorly making them appear less extensive in their posterior extent.

Table 1. Comparative measurements, morphometric percentages, and morphometric ratios for *Faustula gangetica* (this study; column 2), *F. gangetica* (Srivastava, 1935) Yamaguti, 1958 (syn. *Faustula ilishii* [Srivastava, 1935] Yamaguti, 1958; column 3), and *F. ilishii* ([Srivastava, 1935] Yamaguti, 1958; column 4) described from marine/freshwater fishes. Ranges are given in parentheses and morphometric percentages relative to body length are given in brackets.

Metric*	*F. gangetica* ($n = 15$)	*F. gangetica* ($n =$ NG)	*F. ilishii* ($n =$ NG)
BL	(890–1,213)	(1,340–1,650)	(750–1,040)
FB	(267–403)	410†	275†
	[27–36%]	[30%]†	[27%]†
OSW	(87–150)	(170–180)	(120–140)
	[7–15%]	[10–13%]	[13–16%]
PW	(57–103)	(80–120)	(67–70)
	[5–10%]	[7–8%]	[6–9%]
OS:PW	(1:.1.4–1:1.9)	(1:1.5–1:2.2)	(1:1.7–1:2.0)
VSW	(112–148)	(170–200)	(140–150)
	[12–13%]	[12–13%]	[14–19%]
VS: OSW	(1:0.9–1:1.3)	(1:1.0–1:1.2)	(1:1.0–1:1.2)
CSL	(172–270)	(360–400)	(290–310)
	[17–26%]	[24–27%]	[29–39%]
OW	(125–225)	(240–260)	190
OVP	(9–10)	(9–10)†	(8–10)†
MTW	120	160	135
T:OW	1:0.1–1:0.6	1:0.6	1:0.7
EL	(15–23)	(16–25)	20
EW	(10–15)	12	12

*All measurements are reported as micrometer values. NG, not given; BL, body length; FBL, forebody length; OSW, oral sucker width; PS, pharynx width; OS:PW, oral sucker:pharynx width ratio; VSW, ventral sucker width; VS:OSW, ventral sucker:oral sucker width ratio; CSL, cirrus sac length; OW, ovary width; OLP, number of ovarian lobes present; MTW, mean testes width; T:OW, testes:ovary width ratio; EL, egg length; EW, egg width.

†Values estimated from original taxonomic description and/or figures.

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