

<https://doi.org/10.11646/zootaxa.4319.1.6>
<http://zoobank.org/urn:lsid:zoobank.org:pub:A5B104BA-1295-4BAE-A602-6EFF8CEBF4EB>

First record of ectoparasitic ciliates, of genus *Trichodina* (Ciliophora: Trichodinidae) parasiting cultured Oranda Gold Fish (*Carassius auratus auratus* L.) in India

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Abstract

Ornamental fish culture is considered as one of the most important source of home entertainment, because of its diversity and beauty of picturesque colors. Trichodiniasis of fishes causing harm and economic losses in this fish industry. There are many records of trichodinids ectoparasites infesting fish have been found throughout the World, but no such attempt has been made to study the parasitic group infesting ornamental fish, preferably oranda goldfish (*Carassius auratus auratus* L.) in India. A parasitological search in some ornamental fish farms have been revealed for the first time the occurrence of trichodinid species previously described so far from the oranda goldfish in India. They are *Trichodina reticulata*, *Trichodina mutabilis*, *Trichodina acuta*, *Trichodina ngoma*, *Trichodina nandusi* and *Trichodina domergui*. These parasites have not been reported earlier from the oranda goldfish in India. The paper deals with the diversity, distribution and taxonomic descriptions of these six trichodinid species based on the wet silver nitrate impregnated observations along with new host, locality and prevalence of infestation.

Key words: first record, prevalence, biodiversity, six species of *Trichodina*, Oranda Goldfish, India

Introduction

Trichodinids are the most devastating ectoparasites of cultured fish (Basson & Van As 1994). This ectoparasite causes serious damage, particularly under cultured condition. Ectoparasitic protozoa are considered as the major threat to the fish farms where high temperature and organic content accelerate the life cycles of parasites and promote their spread (Hassan 1999). These ciliates possess complicated denticles with adhesive disc. They often found and survive on and infect the external body surface like skin, fins and gills of both edible as well as ornamental fishes. They are regarded as one of the major cause of fish mortality (Abdel-Meguid 2001). Twelve trichodinids have so far been reported from *Carassius auratus* such as *Trichodina oviformis*, *Trichodina nobilis*, *Trichodina carassii*, *Trichodina paranigra*, *Trichodina pachyhamata*, *Trichodina subtilhamata*, *Trichodina brevicirra*, *Trichodina luzhoues*, *Trichodina mutabilis*, *Trichodina reticulata* and *Trichodina ngoma* (Hu *et al.* 2005; Tang *et al.* 2005; Tao & Zhao 2006; Tang *et al.* 2007; Tang & Zhao 2007; Tang & Zhao 2010; Hu 2012) have been reported from different part of the World.

Since in India very scanty and infrequent information are available from edible fishes in West Bengal and only five out of nine existing genera under the family Trichodinidae, namely *Trichodina* Ehrenberg 1838, *Paratrichodina* Lom 1963, *Trichodinella* Šramek-Hušek 1953, *Dipartiella* Stein 1961, *Tripartiella* Lom 1959 have so far been reported by various workers but no studies have been made on goldfish in India.

During the frequent ichthyoparasitological survey of the ectoparasites of Oranda goldfishes (*Carassius auratus auratus* L.) in West Bengal, *Trichodina reticulata* Hirschman & Partesh 1955, *Trichodina mutabilis* Kazubski & Migala 1968, *Trichodina acuta* Lom 1961, *Trichodina ngoma* Van & Basson 1992, *Trichodina nandusi* Mitra *et al.* 2013 and *Trichodina domergui* Wallengren 1897 have been described in this communication for the first time in India from the skin and gills of the fish.

Taxonomic description of these six species has been made based on the wet silver nitrate impregnation technique. For a certain description of the species, a comprehensive approach that combines morphological features, host, tissue tropism and molecular data should be applied in the taxonomy of trichodinid. Tang *et al.* (2013) indicate, gene sequence data are of growing importance in determining phylogenetic relationships among mobilians. However, due to difficult sampling, significant barrier to progress with sequence data being available for only 14 out of a possible 300 mobilian species. Till date, only six trichodinids have been available with their partial 18S rRNA gene sequences namely, *Trichodina modesta*, *Trichodina paraheterodontata*, *Trichodina cirhini*, *Trichodinella epizootica*, *Trichodina acuta* and *Trichodina hyperparasitis* (Tang *et al.* 2013, 2016; Fariya *et al.* 2017; Wang *et al.* 2017). However, although SEM and molecular evidence enriches our knowledge of trichodinids, silver-impregnation is still the basic and essential technique required for characterizing these highly specialized parasitic ciliates.

These six species have not yet been reported earlier from goldfish in India. The survey of trichodinids ciliophorans in goldfish help to disseminate our knowledge on the diversity and distribution of the ciliophorans.

Materials and methods

Sampling. During the study (March 2014–October 2015), about thirty fish farms, of different districts of West Bengal, India, like Nadia(23.4710° N, 88.5565° E), Hooghly(22.8963° N, 88.2461° E), Howrah(22.5958° N, 88.2636° E), South 24-pargana (22.1352° N, 88.4016° E) and North 24-parganas (22.6168° N, 88.4029° E) have been surveyed for collection of goldfish *Carassius auratus* L. The specimens were brought alive to the laboratory and all fishes were kept in several aerated covered glass aquaria of 20 lit capacities at $26.6 \pm 2.3^\circ\text{C}$, pH 6.9 ± 0.1 with dissolved oxygen 6.0–7.8 mg/L in the Parasitology laboratory, University of Kalyani, Kalyani.

Parasitological examination. The length and weight (weight 4.38 ± 0.28 gm, length $3-9 \pm 0.89$ cm), of each fish were recorded. The symptoms and general health conditions have also been checked immediately after bringing it in the Parasitology laboratory. More than 500 fishes were examined for detection of ectoparasitic infection. Parasitological examination was carried out for the isolation and identification of the external parasites on the skin, gills and fins of the samples.

Isolation of pathogens. The infected fishes were isolated and examined in every month of the year. Gill, body, and tail fin smear were prepared on grease free clean slides with the help of a drop of 0.5% NaCl solution and air-dried. The smear were air dried and impregnated for 10 min in 2% aqueous AgNo₃ solution (Klein 1958), washed in distilled water, and exposed to ultraviolet light for 20–25 min to study the details of the adhesive disc. Examinations of prepared slides were made under an Olympus CX 41 model (100 X) magnification with an oil immersion lens and photographs were taken with an Olympus CX 41 model. Measurements based on 15–20 fresh specimen, with a calibrated ocular micrometer follow the uniform specific characteristics as proposed by Lom (1958), Arthur & Lom (1984). In each case, minimum and maximum values are given, followed in parentheses by arithmetic mean and standard deviation. The span of the denticle is measured from the tip of the blade to the tip of the ray. Body diameter is measured as the adhesive disc plus border membrane. The description of denticle elements follows the guidelines of Van & Basson (1989) was followed of denticle description, as shown in Fig 1.

Statistical analysis. The seasonal incidence of parasites was calculated according to the method of Saha and Bandyopadhyaya (2016).

Results and discussion

Trichodinosis is an ectoparasitic protozoan diseases caused by *Trichodina spp.* which is a uniformly saucer shaped ciliated protozoan parasites. During the present study huge infestation of trichodinid in *Carassius auratus auratus* (L.) have been observed throughout the year, but the prevalence, abundance and intensity of parasitic infestation are much higher in post-monsoon season in comparison to other season. (Fig 2). As the water quality parameters fluctuate very quickly during post-monsoon season, the fish becomes more affected by diseases in these seasons (Ahmed *et al.* 1991). During the calculation of statistical parameter, only the genus level for identification has been done in the present study. In our study *Trichodina reticulata* Hirschman and Partesh 1955, *Trichodina mutabilis*

Kazubski and Migala 1968, *Trichodina acuta* Lom 1961, *Trichodina ngoma* Van As & Basson 1992, *Trichodina nandusi* Mitra et al. 2013 and *Trichodina domergui* Wallengren 1897 have been collected and identified from the gills and skin of *Carassius auratus auratus* (L.). Descriptions of these have been provided below.

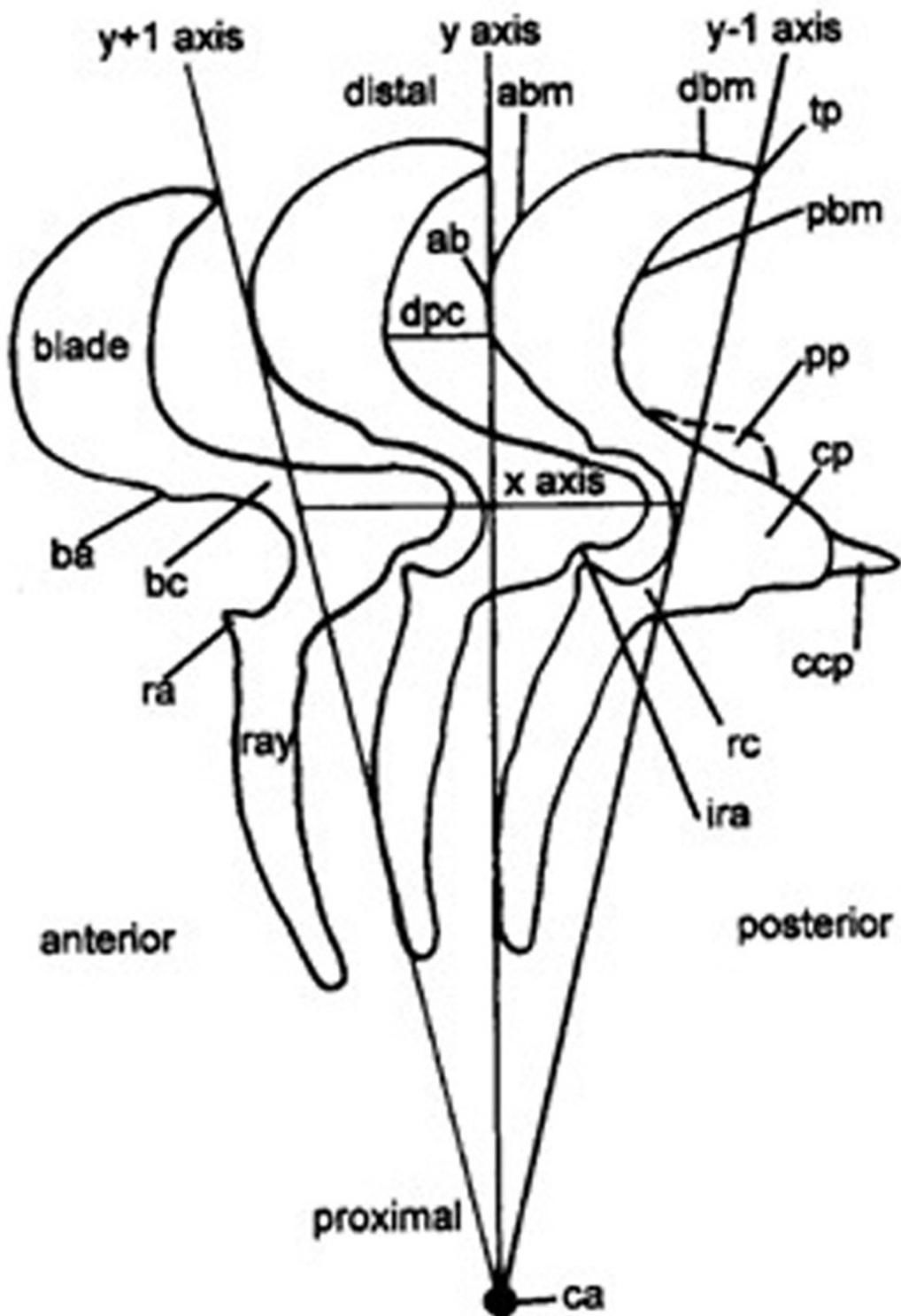


FIGURE 1. Schematic drawing of denticles of *Trichodina magna* Van As and Basson, 1989 to illustrate the sequence and method of the description of denticle elements, according to the method of Van As and Basson (1989). Abbreviations: ab—blade apex, abm—anterior blade margin (surface), ba—blade apophysis, bc—blade connection, ca—centre of adhesive disc, ccp—central conical part, cp—central part, dbm—distal blade margin (surface), dpc—deepest point of curve relative to apex, ira—indentation in lower central part, pbm—posterior blade margin (surface), pp—posterior projection, ra—ray apophysis, rc—ray connection, tp—tangent point.

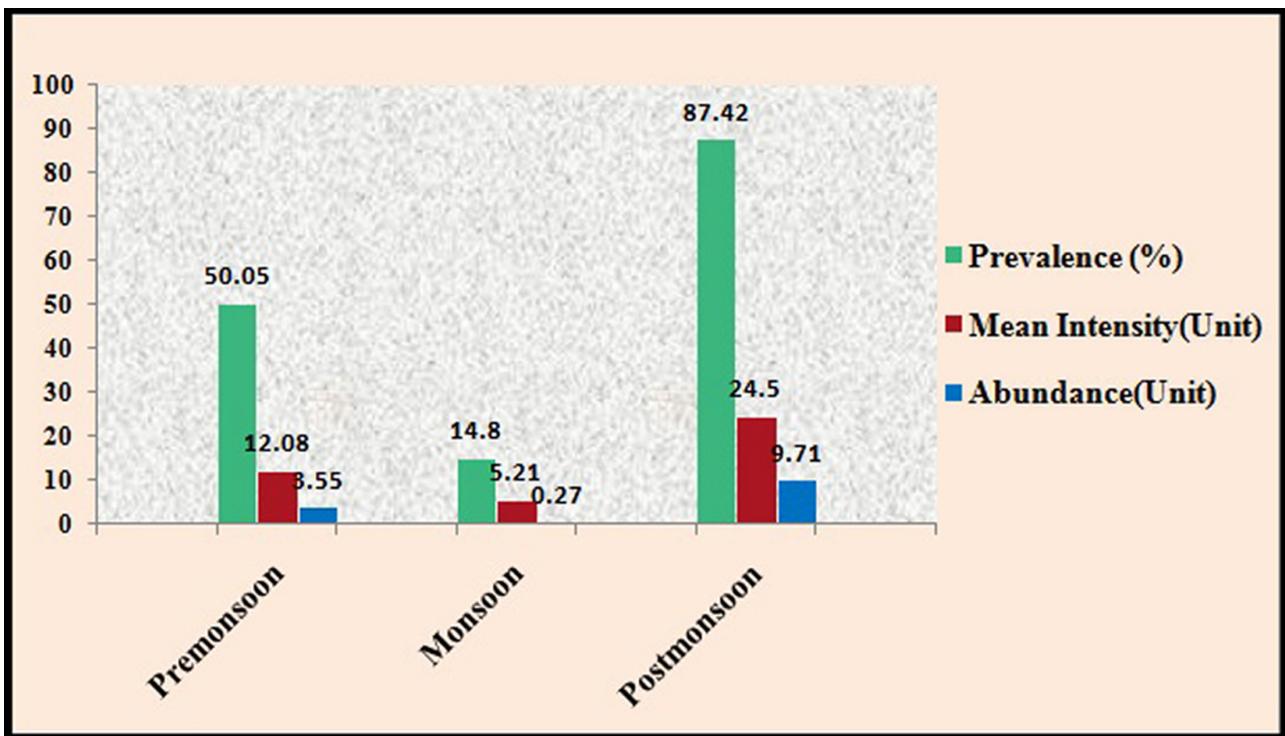


FIGURE 2. Season wise prevalence, mean intensity and abundance of Trichodinid parasites.

***Trichodina reticulata* Hirschman & Partesh 1955**

(Fig 3A, 4A; Table 1)

Description. (n=26) Body is big sized. In lateral view, it is disc shaped with a cell diameter of 50.0–74.5 (62.25 ± 7.32) μm . Central area of an adhesive disc arranged with twelve equal shaped and spherical granules containing border membrane measuring 4.0–5.1 (4.5 ± 0.7) μm in width with adhesive disc of 42.3–57.5 (49.9 ± 3.78) μm in diameter. It contains denticlular ring measuring 27.9–36.0 (31.95 ± 5.7) μm in diameter. The number of denticle is 25–31 (28 ± 4.2). Denticle spans measuring 12.5–15.9 (14.2 ± 2.4) μm . Length of denticle is 6.0–8.0 (7.0 ± 1.4) μm . Blade broad and club-shaped. It is 2.5–8.0 (5.25 ± 3.8) in length. Anterior blade surface straight and the lower part of anterior blade slightly curve in some specimens (Figure 3a and 3b). Central part consists of rounded overlapping area measures 2.0–3.0 (2.5 ± 0.7) μm in diameter in width. Apex of the blade is projected towards Y+1 axis. Length of ray measures 5.5–7.0 (6.25 ± 1.0) μm and number of radial pins per denticle is 8–10 (9 ± 1.4). Nuclear apparatus not conspicuous.

Taxonomic summary

Host: *Carassius auratus auratus* (L.)

Fish Family: Cyprinidae

Locality: Howrah, West Bengal, India ($22^{\circ}35'N$, $88^{\circ}19'E$)

Location: Gills

Reference material. Lectotype: In slide no. GF-TR-11/2014, deposited in the collection of the Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal, India.

Remarks. On analyzing the morphometric and quantitative data of the present specimen, it was readily identified as *Trichodina reticulata* Hirschman & Partesh (1955). The species was originally described by Hirschmann (1955). It has been reported from different part of the world (Lom 1960; Lom *et al.* 1976; Dove & Donoghue 2005; Tang & Zhao 2010; Hu 2012; Martin 2012). *Trichodina reticulata* is a highly distinctive species, clearly recognizable based on its denticles shape and granules present in the central area. *T. reticulata* has previously been recorded in India by Mishra and Das in 1993 from the gill of freshwater fish, *Catla catla* but it has been recorded for the first time as a pathogen of *Carassius* spp. in India and throws new light on the biodiversity and most importantly revealed a wide range of host preference, as it is the first record from *Carassius auratus auratus* (L.) which established as a new

host for *T. reticulata* in India. The dimensions of the present material are showing huge similarities to those recorded in Florianópolis, Santa Catarina State, Brazil by Martins *et al.* (2012). (Table 1)

TABLE 1. Morphometric comparison of *Trichodina reticulata* Hirschman and Partesh (1955) (n=26) obtained in the present study with those of Martins *et al.* (2012).

Species	<i>Trichodina reticulata</i>	<i>Trichodina reticulata</i>
Host	<i>Carassius auratus auratus</i>	<i>Carassius auratus</i>
Locality	Haringhata, West Bengal, India	Florianópolis, Brazil
Site of Infection	Gills	Skin
Reference	Present study	Martins <i>et al.</i> (2012)
Diameter of Body	50.0–74.5 (62.25±7.32)	44.2–68.6 (55.0±7.6)
Adhesive disc	42.3–57.5 (49.9±3.78)	36.3–55.2 (45.5±5.6)
Dimension of body		
Denticular ring	27.9–36.0 (31.95±5.7)	19.7–41.0 (28.7±5.2)
Central area	7.5–11.8 (9.65±3.0)	-
Width of broader membrane	4.0–5.1 (4.5±0.7)	-
Number of denticles	25–31 (28±4.2)	25–28 (26.3±1.1)
Number of radial pins/Denticle	8–10 (9±1.4)	9–10 (9.7±0.7)
Dimension of denticle		
Span	12.5–15.9 (14.2±2.4)	11.8–16.5 (13.3±1.3)
Length	6.0–8.0 (7.0±1.4)	3.9–7.8 (5.1±0.9)
Dimension of denticle components		
Length of ray	5.5–7.0 (6.25±1.0)	3.9–7.8 (5.2±0.8)
Length of blade	2.5–8.0 (5.25±3.8)	2.3–7.8 (5.5±0.8)
Width of central part	2.0–3.0 (2.5±0.7)	1.5–3.1 (2.2±0.3)

***Trichodina mutabilis* Kazubski & Migala 1968**

(Fig 3B, 4B; Table 2)

Description. (n=14) Medium to large sized parasite. Compressed body having a diameter of 75.3–80.5 (77.9±3.6) μm . Distal surface of the denticle is flattened and straight lined simultaneously running equally to border membrane about 3.3–4.5 (3.9±0.8) μm in width and adhesive disc 40.5–55.7 (48.1±7.7) μm in diameter. Denticular ring 24.5–37.0 (30.75±8.8) μm in diameter, having a 22–26 (24±2.8) number of denticles containing 9–10(11±0.7) radial pins in each denticle. The denticle spans are 12.0–19.0 μm (15.5±4.9) in width and 5.4–8.5 μm (6.95±2.1) in length. The blade almost thickened along with posterior borders (Figure 3b and Figure 4b). Denticle blade is oblong with rectangular distal end having a length of 5.0–9.0 μm (7.0±2.8). Apex projected towards the y+1 axis. Blade apophysis is very prominent and with narrow central part having a diameter of about 1.5–3.9 (2.7±1.6) μm , which extends almost halfway to y-1 axis. The denticles were arranged in a tight manner. Narrow ray with blunted tip of 5.2–9 (7.1±2.6) μm long and directed towards y+1 axis. The number of radial pins 11 (9–13) per denticle present. Nuclear apparatus not observed.

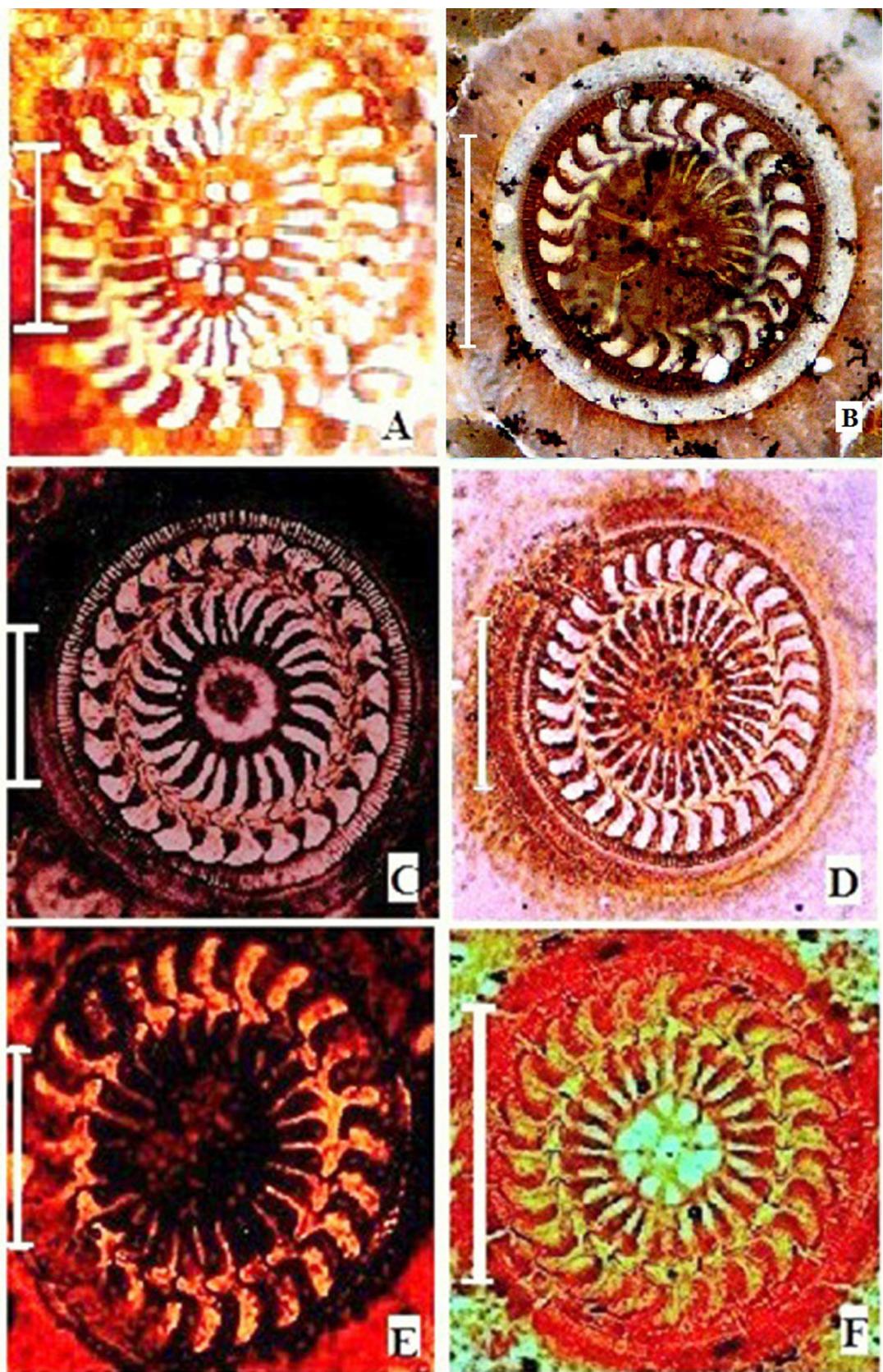


FIGURE 3. A–F Photomicrographs of silver nitrate impregnated adhesive discs of Trichodinid species. (A) *Trichodina reticulata* Hirschman & Partesh 1955 (B) *Trichodina mutabilis* Kazubski & Migala 1968 (C) *Trichodina acuta* Lom 1961 (D) *Trichodina ngoma* Van & Basson 1992 (E) *Trichodina nandusi* Mitra et al. 2013 (F) *Trichodina domergui* Wallengren 1897 identified from *Carassius auratus auratus* (L.). Scale Bar—20 μm .

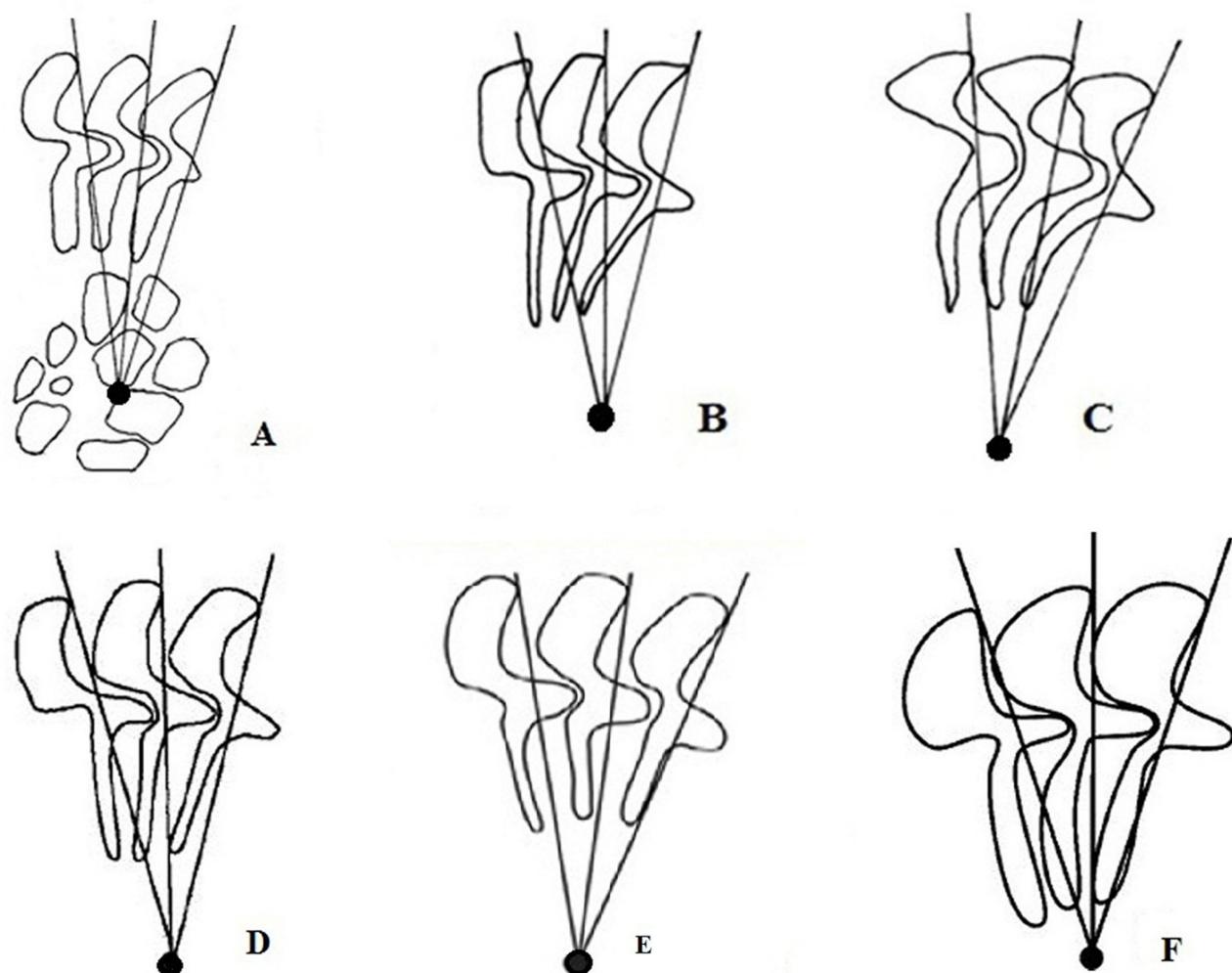


FIGURE 4. A–F Diagrammatic drawings of the denticles of Trichodinid species i.e. (A) *Trichodina reticulata* Hirschman and Partesh 1955 (B) *Trichodina mutabilis* Kazubski & Migala 1968 (C) *Trichodina acuta* Lom 1961 (D) *Trichodina ngoma* Van & Basson 1992 (E) *Trichodina nandusi* Mitra et al. 2013 (F) *Trichodina domergui* Wallengren 1897 obtain in the present study.

Taxonomic summary

Host: *Carassius auratus auratus* (L.)

Locality: Haringhata, Nadia, West Bengal, India (22°53'N–24°11'N/88°09'E–88°48'E)

Location: Skin and Gills

Reference material. Lectotype: In slide no. GF-TM-10/2014, deposited in the collection of the Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal, India.

Remarks. After careful consideration of the morphological characters and quantitative data, the specimen being described here has been clearly identified as *Trichodina mutabilis* Kazubski and Migala 1968. *T. mutabilis* was firstly described by Kazubski & Migala from Poland in 1968. Since then, it has been reported from various parts of the world, including India (Lom 1970; Basson & Van 1994; Mitra & Bandyopadhyay 2005; Dove & Donoghue 2005; Hu 2012). This is an important findings since indicated *T. mutabilis* also prefers ornamental fish as its host and also established as a new host for the parasite and it is the first record of this species from *Carassius* spp. in India. The population obtained from *Carassius auratus auratus* (L.) show significant resemblance in denticle structure with those of specimens reported by Lom (1970) found isolated *Cyprinus carpio* (Table 2).

TABLE 2. Morphometric comparison of *Trichodina mutabilis* Kazubski and Migala (1968) (n=14) obtained in the present study with those of Lom (1970).

Species	<i>Trichodina mutabilis</i>	<i>Trichodina mutabilis</i>
Host	<i>Carassius auratus auratus</i>	<i>C. carpio</i>
Locality	Haringhata, West Bengal, India	Czechoslovakia
Site of Infection	Skin and Gills	Skin
Reference	Present study	Lom (1970)
Diameter of Body	75.3–80.5 (77.9±3.6)	69–97 (78)
Adhesive disc	40.5–55.7 (48.1±7.7)	49–61 (57)
Dimension of body		
Denticular ring	24.5–37.0 (30.75±8.8)	32–41 (38)
Central area	5.5–6.5 (6.0±0.7)	-
Width of broader membrane	3.3–4.5 (3.9±0.8)	6–7
Number of denticles	22–26 (24±2.8)	26–30 (28)
Number of radial pins/Denticle	9–13 (11±0.7)	9–10
Dimension of denticle		
Span	12.0–19.0 (15.5±4.9)	-
Length	5.4–8.5 (6.95±2.1)	9.0
Dimension of denticle components		
Length of ray	5.2–9 (7.1±2.6)	8.0
Length of blade	5.0–9.0 (7.0±2.8)	7.0
Width of central part	1.5–3.9 (2.7±1.6)	2.5

Trichodina acuta Lom, 1961

(Fig 3C, 4C; Table 3)

Description. (n=17) Large to medium sized trichodinid, with compressed disc-shaped body having 55.6–71.4 (63.5±5.1) μm in diameter, featured by a central circular space of about 8.0–11.5 (9.75±2.4) μm in diameter, which remains free from silver. The specimen with an adhesive disc of 41.5–60.9 (51.2±3.7) μm in diameter containing denticular ring measuring 25.6–37.5 (31.55±8.4) μm in diameter. It consist of 18–25 (21.5±4.9) number of denticles which is surrounded by a wide broader membrane of about 4.4–5.1 (4.75±0.4) μm diameter in width. The denticle blades are sickle-shaped having a length of 6.5–11.0 (8.75±3.1) μm and with denticle span of about 11.7–18.9 (15.3±5.0) μm wide. Central part of the blade is triangular in shape and 8–12 (10±2.8) radial pins are found in each denticle of every specimen. The apophysis of the blade is pronounclly pointed with sharp ending having a blade length of 4.3–6.5 (5.4±1.5) since it is extended to the posterior portion of the central part. Ray mostly flattened and evenly from central part to pointed tip measuring 5.5–8.9 (7.2±2.4) long and forming a 2.1–3.5 (2.8±0.9) wide central part. Nuclear apparatus not observed.

Taxonomic summary

Host: *Carassius auratus auratus* (L.)

Locality: Haringhata, Nadia, West Bengal, India (22°53'N–24°11'N/88°09'E–88°48'E)

Location: Skin and Gills

Reference material: Lectotype: In slide no. GF- TA-15/2014, deposited in the collection of the Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal, India

Remarks. Considering the morphological characters and quantitative data, the specimen seems to be identified as *Trichodina acuta* Lom (1961). The sp. was first described by Lom in 1961 from various types of freshwater fish of Bohemia. Since the specimen showed a wide range of geographical distribution and biodiversity of hosts from various places of the world (Kazubski & Migala 1968; Lom 1970; Dove & Donoghue 2005; Basson *et al.* 1983; Van & Basson 1989; Gaze & Wooten 1998). *T. acuta* has previously been recorded in India by Asmat (2000b) and Mitra (2013) from freshwater fish, but it is recorded for the first time as a pathogen of *Carassius* spp. from India. *Trichodina acuta* obtained in the present study apparently shows considerable morphological variability with Lom (1961). (Table 3)

TABLE 3. Morphometric comparison of *Trichodina acuta* Lom (1961) (n=17) obtained in the present study with those of Lom (1961).

Species	<i>Trichodina acuta</i>	<i>Trichodina acuta</i>
Host	<i>Carassius auratus auratus</i>	Various
Locality	Haringhata, West Bengal, India	Bohemia
Site of Infection	Skin and Gills	Skin and gills
Reference	Present study	Lom (1961)
Diameter of Body	55.6–71.4 (63.5±5.1)	—
Adhesive disc	41.5–60.9 (51.2±3.7)	42–53
Dimension of body		
Denticular ring	25.6–37.5 (31.55±8.4)	23–32
Central area	8.0–11.5 (9.75±2.4)	—
Width of broader membrane	4.4–5.1 (4.75±0.4)	3.5–5
Number of denticles	18–25 (21.5±4.9)	18–21
Number of radial pins/Denticle	8–12 (10±2.8)	8
Dimension of denticle		
Span	11.7–18.9 (15.3±5.0)	—
Length	6.5–11.0 (8.75±3.1)	10–11
Dimension of denticle components		
Length of ray	5.5–8.9 (7.2±2.4)	4–7
Length of blade	4.3–6.5 (5.4±1.5)	4.5–6
Width of central part	2.1–3.5 (2.8±0.9)	3–4

***Trichodina ngoma* Van & Basson, 1992**

(Fig 3D, 4D; Table 4)

Description. (n=8) Large trichodinid with flattened body having a diameter of 52.5–59.6 μm (56.05 ± 5.0) and surrounded by a wide border membrane 3.8–6.0 μm (4.9 ± 1.5) in width. The adhesive disc is 44.1–48.3 (46.2 ± 2.9) μm in diameter with a clear granule at the free center. The denticulate ring measures 27.5–33.5 μm (30.5 ± 4.2) having a number of denticles about 25–31 (28 ± 4.24). Number of radial pins per denticle is 8–10 (9 ± 1.4). The blade of denticle is rectangular having 5.0–7.0 μm (6.0 ± 1.4) in length, covering almost half area of the entire spaces

between y+1 axis (Figure 6a and Figure 6b). Span of denticle is 14.2–16.5 (15.35 ± 1.6) μm and having a length of 5.1–7.2 (6.15 ± 1.4) μm . The apical ejection is well developed and never impregnated. The blade connection contains well developed smooth surface which mostly parallel to the anterior blade surface. The central part fits tightly into the preceding denticle with rounded point that extends almost halfway to y-1 axis, Width of the central part is 2.5–3.1 (2.8 ± 0.4) μm . Ray relatively narrow and measures 5.8–8.0 (6.9 ± 1.5) μm .

Taxonomic summary

Host: *Carassius auratus auratus* (L.)

Locality: Haringhata, Nadia, West Bengal, India ($22^{\circ}53'N$ – $24^{\circ}11'N$ / $88^{\circ}09'E$ – $88^{\circ}48'E$)

Location: Gills

Reference material. Lectotype: In slide no. GF-TN-11/2014, deposited in the collection of the Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal, India.

Remarks. After considering the morphological features and quantitative data of the present material it was very clearly identified as *Trichodina ngoma* Van & Basson (1992). It was firstly reported from *Hemigrammocharax multifasciatus* of Lake Lisikili, belonging to the Zambesi River System, which locates in Eastern Caprivi, South Africa by Van & Basson in 1992. After that it was reported from China by Tang & Zhao (2010). Till date it has not been reported again from India. The study will throw light on biodiversity and host preference of the species and also regarding new distribution in Asian subcontinent. The dimensions of the present specimen are showing close similarities to those reported in China by Tang & Zhao (2010) (Table 4).

TABLE 4. Morphometric comparison of *Trichodina ngoma* Van & Basson (1992) (n=8) obtained in the present study with those of Tang and Zhao (2010).

Species	<i>Trichodina ngoma</i>	<i>Trichodina ngoma</i>
Host	<i>Carassius auratus auratus</i>	<i>Carassius auratus</i>
Locality	Haringhata, West Bengal, India	Chongqing, China
Site of Infection	Gills	Gills
Reference	Present study	Tang and Zhao (2010)
Diameter of Body	52.5-59.6 (56.05 ± 5.0)	56.0-62.0 (59.6 ± 2.3)
Adhesive disc	44.1-48.3 (46.2 ± 2.9)	44.0-50.0 (47.8 ± 2.1)
Dimension of body		
Denticular ring	27.5-33.5 (30.5 ± 4.2)	27.0-32.0 (30.3 ± 2.4)
Central area	7.2-12.1 (9.65 ± 3.4)	-
Width of broader membrane	3.8-6.0 (4.9 ± 1.5)	4.0-6.0 (5.2 ± 0.5)
Number of denticles	25-31(28 ± 4.24)	26-29
Number of radial pins/Denticle	8-10 (9 ± 1.4)	8-10
Dimension of denticle		
Span	14.2-16.5 (15.35 ± 1.6)	14.0-17.0 (15.8 ± 2.4)
Length	5.1-7.2 (6.15 ± 1.4)	5.0-7.0 (6.2 ± 0.9)
Dimension of denticle components		
Length of ray	5.8-8.0 (6.9 ± 1.5)	6.0-8.0 (7.9 ± 0.7)
Length of blade	5.0-7.0 (6.0 ± 1.4)	5.0-7.0 (6.1 ± 0.7)
Width of central part	2.5-3.1 (2.8 ± 0.4)	2.0-3.0 (2.1 ± 0.5)

***Trichodina nandusi* Mitra 2013**

(Fig 3E, 4E; Table 5)

Description. (n=15) A medium to small sized trichodinid having a body diameter of 40.5–52.3 μm (46.4 ± 8.3). The adhesive disc is 33.0–45.0 μm (39.0 ± 8.4) in diameter, surrounded by a wide border membrane of 4.5–6.5 μm (5.5 ± 1.4). The central area is 4.4–12.5 μm (8.45 ± 5.7) in diameter, which is surrounded by a denticulate ring, having a diameter of 22.6–29.0 μm (25.8 ± 4.5) consisting of 20–24 (22 ± 2.8) numbers of denticles. Tips of the rays are evenly touches with a margin of central area. The blades are elongated, having a length of about 4.6–7.5 (6.05 ± 2.0) and 10.5–13.0 (11.75 ± 1.7) in width which become softly curved with a viewable thickening of the posterior border. Anterior border is angular which forming a conical apex that extends almost all areas towards the y+1 axis (Figure 7a and Figure 7b). The central part usually triangular in shape. The tip of central part extends an almost half portion towards y-1 axis. The denticle rays are usually longer in comparison to the blades measuring about 4.5–7.5 μm (6.0 ± 2.1) in length. Ray is tapered to a rounded tip with a central part having a diameter of 1.5–2.3 μm (1.9 ± 0.5).

TABLE 5. Morphometric comparison of *Trichodina nandusi* Mitra *et al.* 2013 (n=15) obtained in the present study with those of Mitra *et al.* (2013).

Species	<i>Trichodina nandusi</i>	<i>Trichodina nandusi</i>
Host	<i>Carassius auratus auratus</i>	<i>Nandus nandus</i>
Locality	Hoogly, West Bengal, India	India
Site of Infection	Gills	Gills
Reference	Present study	Mitra <i>et al.</i> (2013)
Diameter of Body	40.5–52.3 (46.4 ± 8.3)	42.1–53.0 (47.1 ± 3.4)
Adhesive disc	33.0–45.0 (39.0 ± 8.4)	33.6–44.8 (39.0 ± 1.6)
Dimension of body		
Denticular ring	22.6–29.0 (25.8 ± 4.5)	20.1–28.8 (24.4 ± 1.0)
Central area	4.4–12.5 (8.45 ± 5.7)	4.4–12.2 (8.8 ± 1.5)
Width of broader membrane	4.5–6.5 (5.5 ± 1.4)	4.2–6.7 (4.8 ± 1.6)
Number of denticles	20–24 (22 ± 2.8)	20–24 (22 ± 3.3)
Number of radial pins/Denticle	5–9 (7.0 ± 2.8)	5–9 (7.0 ± 0.4)
Dimension of denticle		
Span	10.5–13.0 (11.75 ± 1.7)	10.9–13.4 (12.8 ± 0.6)
Length	4.6–7.5 (6.05 ± 2.0)	4.6–7.4 (5.7 ± 0.3)
Dimension of denticle components		
Length of ray	4.5–7.5 (6.0 ± 2.1)	4.6–7.4 (5.7 ± 0.8)
Length of blade	4.5–6.7 (5.6 ± 1.5)	4.5–6.7 (5.6 ± 0.5)
Width of central part	1.5–2.3 (1.9 ± 0.5)	1.3–2.2 (1.8 ± 0.3)

Taxonomic summary**Host:** *Carassius auratus auratus* (L.)**Locality:** Hoogly, West Bengal, India (230 01'20"N– 220 39'32"N / 880 30'15"E–870 39'32" E)**Location:** Gills

Reference material: Lectotype: In slide no. GF-TND-10/2014, deposited in the collection of the Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal, India

Remarks. On analyzing the photomicrographs of specimens, and morphometric and meristic data from all the populations are illustrated the specimen was readily identified as *Trichodina nandusi* Mitra *et al* (2013). *T. nandusi* was firstly reported from the gill of *N. nandus* of in the freshwater fishes of the river Rupnarayan in the Howrah district of West Bengal, India by Mitra *et al.* (2013) but in this study, this species recorded for the first time as a pathogen of *Carassius auratus auratus* (L.) in India. *Trichodina nandusi* obtained in the present study is morphometrically compared with an earlier one (Table 5).

Trichodina domergui (Wallengren 1897)

(Fig 3F, 4F; Table 6)

Description. (n=9) Medium disc-shaped body having a diameter of 57.5–74.2 (65.85±5.8) µm. The adhesive disc measures 50.5–66.2 (58.35±3.10) µm in diameter, surrounded by a wide border membrane of 3.0–4.0 µm (3.5±0.7) in width. Adhesive disc having a diameter of 5.2–11.4 µm (8.3±4.3) and center of this packed with dotted granules. Diameter of denticular ring is 32.2–45.3 (38.75±9.2) µm consisting of 25–27(26±1.4) numbers of denticles having an 8–10 (9±1) number of radial pins per denticle. Rounded denticle blades relatively small with a well identified ray apophysis. A span of denticle is 12.6–16.0 (14.3±2.4) µm in width and length of denticle is 8.1–10.5 (9.3±1.6) µm. Denticle rays are often wider at their distal ends having a diameter of 2.5–3.5 µm (3.0±0.7). Central part finely developed and well notched into the preceding denticles that extending almost full area of y-1 axis. Length of blade is 5.0–6.5 µm (5.75±1.0). Ray softly curved, with a length of 4.5–6.8 (5.65±1.6) µm.

TABLE 6. Morphometric comparison of *Trichodina domergui* Wallengren (1897) (n=9) obtained in the present study with those of Mitra (2002).

Species	<i>Trichodina domergui</i>	<i>Trichodina domergui</i>
Host	<i>Carassius auratus auratus</i>	<i>Mytilus gallo</i>
Locality	24-Pargana(N), West Bengal, India	Canning, West Bengal, India
Site of Infection	Skin	Gills
Reference	Present study	Mitra (2002)
Diameter of Body	57.5–74.2 (65.85±5.8)	27.5–41.8 (34.81±3.17)
Adhesive disc	50.5–66.2 (58.35±3.10)	21.4–33.6 (27.21±3.05)
Dimension of body		
Denticular ring	32.2–45.3 (38.75±9.2)	13.7–23.4 (17.77±1.05)
Central area	5.2–11.4 (8.3±4.3)	4.0–11.2 (6.66±0.96)
Width of broader membrane	3.0–4.0 (3.5±0.7)	3.3–9.1 (6.29±0.57)
Number of denticles	25–27(26±1.4)	18–22 (19.83±0.86)
Number of radial pins/Denticle	8–10 (9±1.4)	5–9 (6.84±0.65)
Dimension of denticle		
Span	12.6–16.0 (14.3±2.4)	7.7–10.7 (9.25±0.79)
Length	8.1–10.5 (9.3±1.6)	2.3–6.1 (4.06±0.36)
Dimension of denticle components		
Length of ray	4.5–6.8 (5.65±1.6)	3.0–4.0 (3.45±0.31)
Length of blade	5.0–6.5 (5.75±1.0)	3.2–4.5 (3.71±0.38)
Width of central part	2.5–3.5 (3.0±0.7)	1.1–2.0 (1.53±0.30)

Taxonomic summary

Host: *Carassius auratus auratus* (L.)

Locality: Howrah, West Bengal, India (22°35'N, 88°19'E)

Location: Gills

Reference material: Lectotype: In slide no. GF-TD-8/2014, deposited in the collection of the Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal, India.

Remarks. After considering the photomicrographs of specimens and meristic data from all the populations are illustrated the specimen was simply identified as *Trichodina domergui* Wallengren (1897). The species *T. domerguei* has gone through a very complicated history. However, considering the ultimate established data *T. domerguei* was firstly reported by Wallengren (1897) from the skin of *Pungitius pungitius* and *Gasterosteus aculeatus*. After that it was reported by different authors, namely, Lom & Stein (1966), Stein (1976), Gaze & Wootten (1998), Xu *et al.* (1999), Mitra (2002). It has not been reported again up to now in India. Our study puts emphasis on the biodiversity and new host preference of the species. It may be mentioned that, though the dimension of our material is much larger in comparison to others, considering all the morphological characters the specimen described here has been clearly identified as *Trichodina domerguei*. *T. domerguei* Wallengren (1897) obtained in the present study is morphometrically compared with Mitra (2002) shown in Table 6.

Conclusion

Up to date more than 240 species of the genus *Trichodina* have so far been reported from various corners of the world. In India, the emphasis has always given to describing new species, and as a result twelve new species belonging to the genus *Trichodina* have so far been described (Asmat 2000a, 2002a; Mitra *et al.* 2013). Ultimately, the reports on the occurrence of known trichodinid species in India are much less numerous than expected. Only few previously known trichodinids have so far been reported from freshwater fishes by many workers (Mukherjee & Haldar 1982; Saha *et al.* 1995; Bandyopadhyay & Dash 2001; Asmat 2002a; Mishra & Das 1993; Asmat 2000b; Mitra *et al* 2013). A list of only Six known species of the trichodinid ciliophorans i.e. In our study *Trichodina reticulata*, *Trichodina mutabilis*, *Trichodina acuta*, *Trichodina ngoma*, *Trichodina nandusi* and *Trichodina domergui* have been recovered from the gills and skin of *Carassius auratus auratus* (L.) for the first time from a biodiversity hot spot country like India is obviously far from complete. The present investigation extends this area to include the *Carassius auratus auratus* (L.) is added to the list of hosts. This communication deals to extend our knowledge on the biodiversity and distribution of these ciliophorans and moreover, to reveal the first record of this genus from *Carassius auratus auratus* L. collected from some ornamental fish farms of West Bengal, India. Further investigations to be carried out in India to revealed the biodiversity status of trichodinid species and carry the identification process through molecular sequencing.

Acknowledgement

One of the authors (MS) is thankful to the University Grants Commissions, New Delhi for financial support under Special Assistance Programme No.F-3-11/2012(SAP-II).

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