J Parasit Dis (Jan-Mar 2014) 38(1):49–60
DOI 10.1007/s12639-012-0190-4

ORIGINAL ARTICLE

J P D

Two new and two already known species of genus *Thelohanellus* Kudo, 1933 (Myxozoa: Myxosporea: Bivalvulida) infecting Indian major carp fishes in Punjab wetlands (India)

Ranjeet Singh · Harpreet Kaur

Received: 10 August 2012 / Accepted: 8 October 2012 / Published online: 23 October 2012

Abstract A survey of parasites of freshwater fishes in Harike, Kanjali and Ropar wetland of Punjab (India) revealed the presence of two new and two already known myxosporean species belonging to the genus *Thelohanellus* Kudo, 1933 parasitizing fins and gills respectively. Spores of the first species, *T. kalavatae* n. sp. measure 11.5 × 4.9 μm, elongately oval in valvular view having rounded blunt anterior end and rounded posterior end with lateral walls almost parallel to each other. Polar capsule is globular in shape and measure 5.2 × 3.3 μm in size. Anterior end of the polar capsule terminate into a small distinct neck. Spores of the second species, *T. kalbensi* n. sp. measure 9.5 × 4.9 μm, egg shaped to ovoid in valvular view having narrower anterior end with a prominent pore and broad rounded posterior end. Polar capsule is globular in shape with a short distinct tubular neck, measure 4.8 × 3.16 μm and occupies almost two-third of the spore body cavity. Spores of third species, *T. avijiti* Basu and Haldar, 2003 measure 10.1 × 6.6 μm, egg shaped in valvular having tapering, bluntly pointed anterior end and broad rounded posterior end. Polar capsule is rounded to subspherical in shape, measure 3.3 × 3.0 μm and is situated anteriorly. Spores of fourth species, *T. gangeticus* Tripathi, 1952 measure 13.3 × 4.8 μm, elongately pyriform in valvular view having tapering anterior end and rounded posterior end. Polar capsule is also elongately pyriform in shape measure 6.6 × 3.1 μm with thin neck and occupy half of the spore body cavity.

R. Singh · H. Kaur (✉)
Department of Zoology and Environmental Sciences, Punjabi University, Patiala 147002, Punjab, India
e-mail: harpreet_bimbra@yahoo.com

R. Singh
e-mail: ranjitsrana@gmail.com

Keywords Gills · Harike wetland · Plasmodia · Punjab

Introduction

Wetlands are the ecotones or transitional zones between permanently aquatic and dry terrestrial ecosystems. Ramsar convention has defined wetlands as "areas of marsh, peat land or water, whether natural or artificial, temporary or permanent, with water that is static or flowing, fresh, brackish or salty including area of marine water, the depth of which at low tide does not exceed six meter". In Punjab, there are 12 natural, 10 man-made wetlands covering 15,500 Ha area and only 3 main wetlands are included in Ramsar list of International importance i.e., Harike, Kanjali and Ropar wetlands. State has 2 other wetlands of national importance and 5 of state importance (ENVIS Centre, PSCST, Punjab; The Tribune, Feb 04, 2008). These wetlands have extremely rich biodiversity as they support a variety of plant and animal life. Flora is comprised of variety of trees, bushes, shrubs, herbs, grasses and fauna consists of different types of fishes, amphibians, reptiles and birds. Harike wetland is the largest freshwater wetlands in northern India occupying 4,100 Ha of area harbour 16 species of freshwater fishes (Punjab State Council for Science and Technology Chandigarh, 2002). Kanjali wetland with an area of 185 Ha support diversity of resident and migratory birds, nurture large number of fish fauna with as many as 17 species of fishes. Ropar wetland is an important habitat of many species and has tremendous ecological value, spread over 1,365 Ha, this wetland support as many as 35 species of fishes. These fishes are vulnerable to various parasitic infections, out of which Myxozoa is emerging as the major group. They cause

production loss and deaths and some fish have to be discarded because they are unsightly and not considered to be fit for human consumption.

Up till now, Phylum Myxozoa include 4 malacosporean and 2,180 myxosporean species to a total of 62 genera (Lom and Dykova 2006). However, three more genera (*Soricimyxum, Gadimyxa, Thelohanelloid*) with type species *S. fegati* Prunescu et al. 2007 from liver of *Sorex araneus*; *G. atlantica* Koie et al. 2007 from urinary system of *Gadus morhua* and *T. bengalensis* Sarkar 2009 from gall bladder of *Arius sagor* have been described subsequently. Phylum Myxozoa has been studied by only limited number of workers in Indian subcontinent. Most of the work on this phylum has been done on fresh water as well as marine fishes of mainly two states, West Bengal and Andhra Pradesh.

In north India, Gupta and Khera (1987, 1988a, b, c, d, 1989a, b, 1990, 1991) recorded 25 species belonging to genera *Myxobolus*, *Henneguya*, *Myxidium*, *Thelohanellus* and *Unicauda* infecting freshwater fishes.

There is an addition in the existing number of myxosporean species particularly those belonging to *Myxobolus* since 2007 in India alone. Recently, Kaur and Singh (2008, 2009, 2010a, b, 2010/2011, 2011a, b, c, d, e, f, 2012a) have contributed 17 new species to the genus *Myxobolus* and 1 new species of the genus *Triangular* from freshwater fishes in wetlands of Punjab. Kaur and Singh (2012b) also compiled and published a synopsis of 131 nominal species of *Myxobolus* Butschli, 1882 (Myxozoa: Myxosporea: Myxobolidae) reported from India and a revised dichotomous key of 59 genera of the Phylum Myxozoa (class Myxosporea).

There are very few numbers of species of the genus *Thelohanellus* reported all over the world. In a monograph, Lom and Dykova (1992) enlisted 39 species of this genus. Basu and Haldar (1999) described a new species of *Thelohanellus* from gills of hybrid carps and gave a checklist of its different species described from Indian fishes. Basu et al. (2006) provided a synopsis of 32 indian species belonging to the genus *Thelohanellus* including one new species- *T. disporomorphus* infecting Indian major carp, *Cirrhina mrigala.* Kalavati and Nandi (2007) gave a compilation of 27 species of genus *Thelohanellus* infecting Indian fishes.

During the present study on the fishes of Harike, Kanjali and Ropar wetlands of Punjab (India), two new species, *T. kalavati* sp. nov., *T. kalbensi* sp. nov. and two already known species *T.*

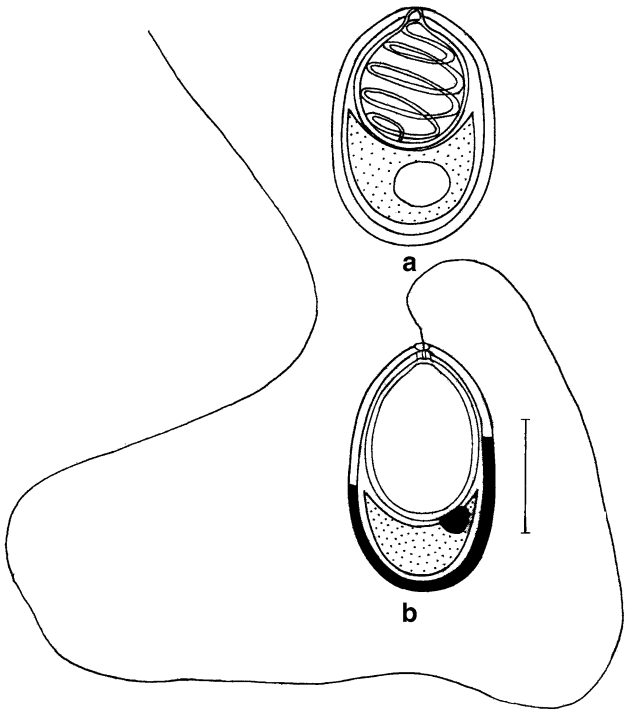

Fig. 1 *T. kalavatae* sp. nov. **a** spore stained in Ziehl-Neelsen (*valvular view*), **b** spore stained in Iron-haematoxylin (extruded polar filament) *Scale bar* = 0.005 mm

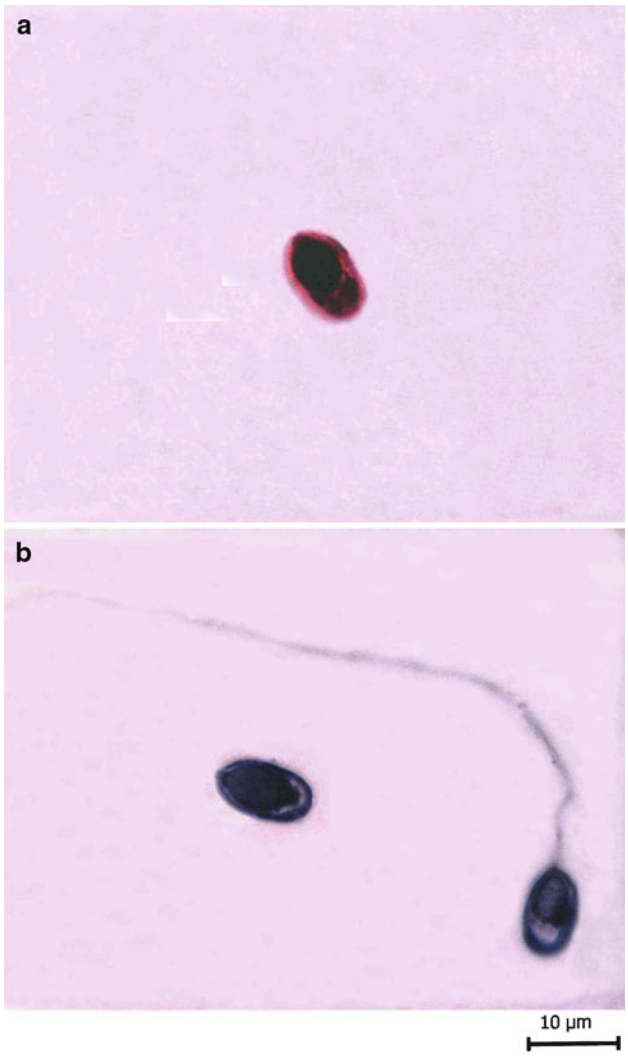

Fig. 2 *T. kalavatae* sp. nov. **a** spore stained in Ziehl-Neelsen, **b** spores stained in Iron-haematoxylin (extruded polar filament)

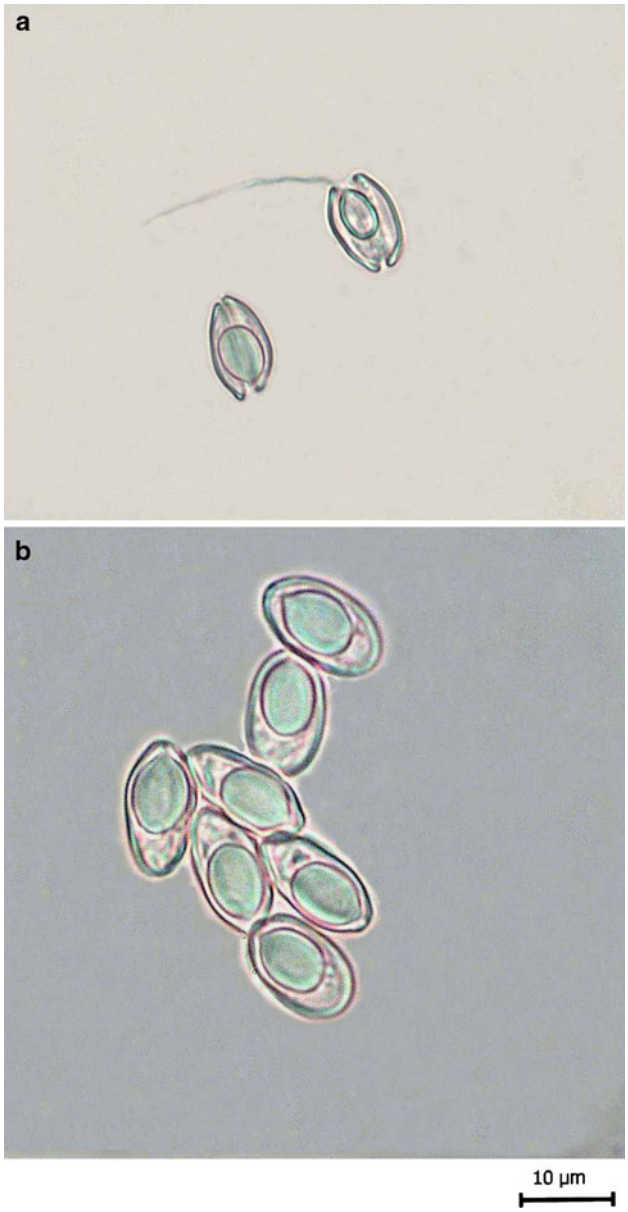

Fig. 3 **a**, **b** Fresh spores of *T. kalavatae* sp. nov. **a** spores in *side view* (polar filament everted), **b** spores in *valvular view*

Table 1 Measurements (µm) and ratio of *T. kalavatae* n. sp.

Characters	Range	Mean values	SD
LS	11.0–12.0	11.5	0.70
WS	4.3–5.5	4.9	0.84
LPC	4.7–5.7	5.2	0.70
WPC	2.9–3.7	3.3	0.56
Ratio: LS/WS		2.3	
NC		5–6	
Parietal folds		Absent	

avijiti Basu and Haldar 2003 and *T. gangeticus* Tripathi 1952 collected from fins and gills of *C. reba*, *L. bata* and *L. calbasu* respectively. The description has been prepared in accordance with the guidelines of Lom and Arthur (1989).

Materials and methods

Fishes collected from Harike, Kanjali and Ropar wetlands were brought to the laboratory and examined for myxozoan infections. Plasmodia when found were removed and teased on slide and covered with cover slip and examined under the oil immersion for the presence of myxospores. Fresh spores were treated with 8 % KOH solution for the extrusion of polar filaments. For permanent preparation, air-dried smears were stained with Ziehl-Neelsen and Iron-haematoxylin. Drawings were made from stained material with the aid of camera lucida. Measurements of spores were done with the aid of a calibrated ocular micrometer. All measurements are presented in µm as range values followed by mean ± SD in parentheses. The abbreviations used in the paper are as follows: LS, Length of spore; WS, Width of spore; LPC, Length of polar capsule; WPC, Width of polar capsule; NC, Number of coils of polar filaments; SD, Standard deviation.

Results and discussion

T. kalavatae n. sp. (Figs. 1a, b, 2a, b, 3a, b)

Plasmodia

White, spherical to rounded, present on the caudal fin, 3–4 in number and measure 0.6–0.8 mm in diameter. 7–8 spores are present per plasmodium.

Spore (Table 1) measurements based on 7–8 spores in frontal view

The spores are histozoic, measure 11.5 × 4.9 µm, elongately oval in valvular view having rounded blunt anterior end and rounded posterior end with lateral walls almost parallel to each other. Shell valves are thick, smooth, symmetrical and measure 0.65 µm in thickness. Shell valves at the posterior end of the spore appear thicker (which stain dark blue with Heidenhain's Iron-haematoxylin) than the rest on the spore body. Parietal folds are absent. Polar capsule is globular in shape and measure 5.2 × 3.3 µm in size. Anterior end of the polar capsule terminate into a small distinct neck. Polar filament form 5–6 coils arranged slightly oblique to the polar capsule axis and measure 53–54 µm in length after eversion. One capsulogenic nucleus is present beneath the polar capsule measuring 0.33 µm in diameter.

Sporoplasm is agranular, homogenous, half moon shaped and occupy whole of the extracapsular space behind the polar capsule. An iodinophilous vacuole is present and measure 3.1 μm in diameter.

Taxonomic characters

Type host:	*Cirrhina reba* (Ham.) vern. chunni, mori, kursa
Type locality:	Harike wetland, Punjab, India
Type specimen:	Paratypes are spores stained in Ziehl-Neelsen and Iron-haematoxylin, deposited in the museum of department of Zoology, Punjabi University, Patiala, India. Slide no. TH/ZN/12.04.1010 and TH/IH 12.04/1010
Site of infection:	Caudal fin
Prevalence of infection:	25 % (3/12)
Etymology:	The specific epithet *kalavatae* has been given after the name of the Dr. C. Kalavati, an eminent worker of the department of Zoology, Andhra University, Waltair, India

Discussion

The present species of *Thelohanellus* was compared with *T. niloticus* Gurley 1893 from skin of head of *Labeo niloticus*; *T. seni* (Southwell and Prashad 1918) Chakravarty and Basu 1948 from branchiae of *Catla catla*; *T. mrigalae* Tripathi 1952 from skin on the head of *C. mrigala*; *T. nikolski* Akhmerov 1955 from fin of *Cyprinus carpio haematopterus*; *T. potaili* Lalitha Kumari 1969 from fin of *L. potail*; *T. sanjibi* Sarkar and Ghosh 1990 from kidney of *Mystus gulio*; *T. sudevi* Sarkar and Ghosh 1990 from kidney of *Amblypharyngodon mola*; *T. caudatus* Pagarkar and Das 1993 from between rays of caudal fin and anal fin of *L. rohita*; *T. orissae* Haldar et al. 1997 from gills of *C. mrigala* and *T. avijiti* Basu and Haldar 2003 from dorsal fin of *L. rohita*; *T. habibpuri* Acharya and Dutta 2007 from pectoral fin of *L. rohita* and *T.*

Table 2 Comparative description of *T. kalavatae* n. sp. with morphologically similar species (measurements are in micrometer)

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. kalavatae n. sp. (present study)	*Cirrhina reba*	Caudal fin	Harike wetland, Punjab (India)	11.5 × 4.9	5.2 × 3.3
T. niloticus Gurley 1893	*Labeo niloticus*	Skin of head	Nile (Egypt)	5.0 × 3.5	–
T. seni (Southwell and Prashad 1918) Chakravarty and Basu 1948	*Catla catla*	Branchiae	West Bengal (India)	12.48–14.94	8.56
T. mrigalae Tripathi 1952	*C. mrigala*	Skin on the head	West Bengal (India)	10.8–12.0 × 6.3–7.2	5.4–7.2 × 3.6–5.0
T. nikolski Akhmerov 1955	*Cyprinus carpio haematopterus*	Fin	Amur basin (Russia)	19.0–20.0 × 12.0	7.0 × 5.0–6.0
T. potaili Lalitha Kumari 1969	*L. potail*	Fin	Andhra Pradesh (India)	13.0 × 8.2	5.9 × 4.3
T. sanjibi Sarkar and Ghosh 1990	*Mystus gulio*	Kidney	West Bengal (India)	12.52 × 8.27	4.52 × 4.0
T. sudevi Sarkar and Ghosh 1990	*Amblypharyngodon mola*	Kidney	West Bengal (India)	14.05 × 5.87	5.17 × 2.65
T. caudatus Pagarkar and Das 1993	*L. rohita*	Between rays of caudal fin and anal fin	West Bengal (India)	13.8 × 9.0	7.02 × 5.07
T. orissae Haldar et al. 1997	*C. mrigala*	Gills	Orissa (India)	7.29 × 3.11	3.72 × 2.32
T. avijiti Basu and Haldar 2003	*L. rohita*	Dorsal fin	West Bengal (India)	14.0 × 9.7	6.0 × 4.0
T. habibpuri Acharya and Dutta 2007	*L. rohita*	Pectoral fin	West Bengal (India)	13.0–14.3 (13.9) × 8.0–9.0 (8.5)	6.0–6.5 (6.0) × 4.1–5.0 (4.9)
T. imphlaensis Hemananda et al. 2010/2011	*L. rohita*	Gills	Imphal, Manipur (India)	20.4–22.1 (21.33) × 8.5–10.2 (9.43)	10.2–11.05 (10.79) × 3.40–4.25 (3.78)

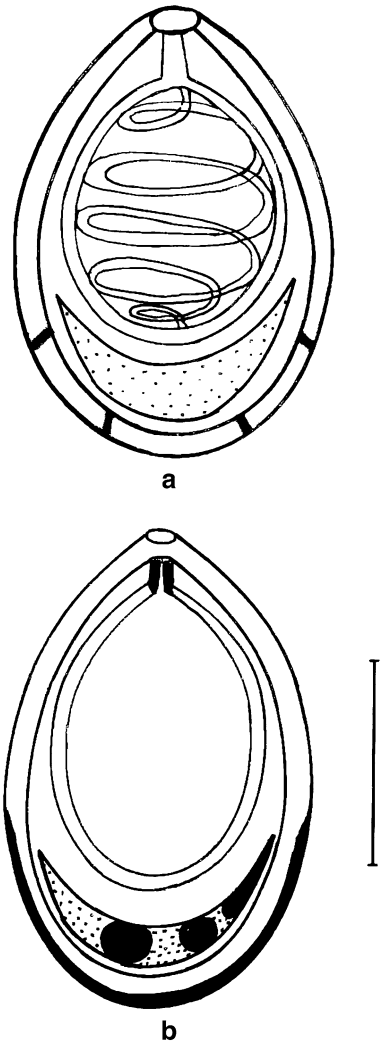

Fig. 4 *T. kalbensi* sp. nov. **a** spore stained in Ziehl-Neelsen (*valvular view*), **b** spore stained in Iron-haematoxylin *Scale bar* = 0.005 mm

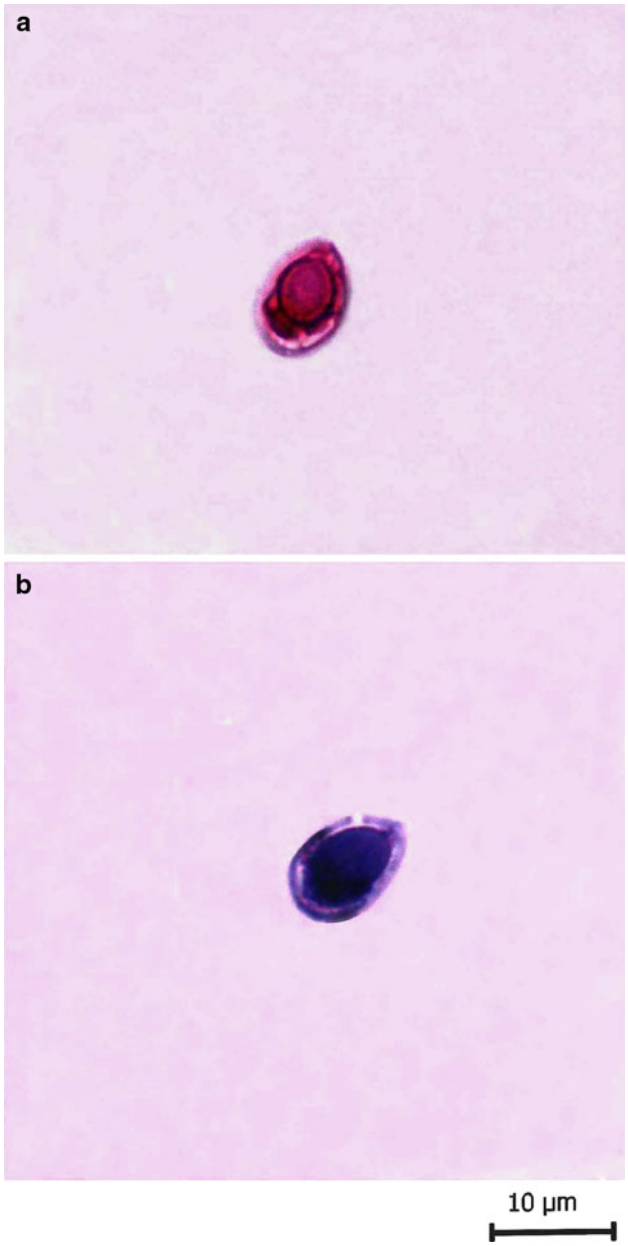

Fig. 5 *T. kalbensi* sp. nov. **a** spore stained in Ziehl-Neelsen, **b** spore stained in Iron-haematoxylin

imphlaensis Hemananda et al. 2010/2011 from gills of *L. rohita* but differ from all of the above species in morphological and morphometric characteristics (Table 2).

The present species have spores elongately oval in shape with rounded, blunt anterior end and rounded posterior end with lateral walls almost parallel to each other. Polar capsule is globular in shape. The anterior end of the polar capsule terminate into a distinct neck and the posterior end is rounded in outline. Morphologically, the present species is comparable with the spores of *T. sanjibi*, *T. sudevi* and *T. nikolski*. However, spores in *T. sanjibi* are egg to ovoidal in shape and more pointed anteriorly; elongately ellipsoidal spores with slightly acuminated anterior end in *T. sudevi* and egg to ovoidal shaped spore with variable shape and size in *T. nikolski* differentiate all of them from the present species.

Furthermore, the shell valves at the posterior end of the spore appear thicker (stain dark blue with Heidenhain's Iron-haematoxylin) than the rest on the spore body in the species under study.

In view of the above differences, the present species under study is proposed as new to the science and named as *T. kalavatae* n. sp. through this communication.

T. kalbensi n. sp. (Figs. 4a, b, 5a, b, 6)

Plasmodia

Minute, present in the gills, 6–8 spores are present per plasmodium.

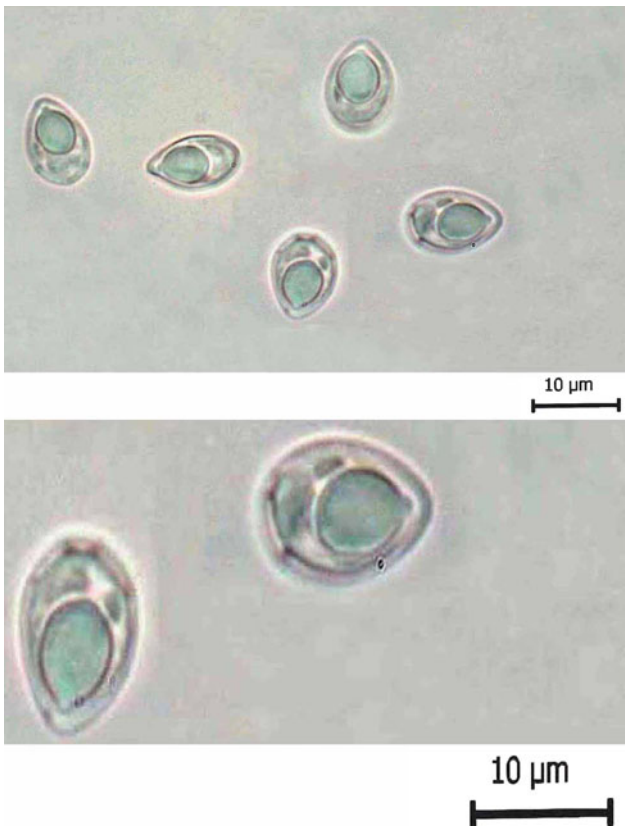

Fig. 6 Fresh spores of *T. kalbensi* sp. nov. **a** *Normal view*, **b** *enlarged view* showing parietal folds

Spore (Table 3) measurements based on 6–8 spores in frontal view

The spores are histozoic, measure 9.5 × 4.9 µm, egg shaped to ovoid in valvular view having narrower anterior end with a prominent pore and broad rounded posterior end. Shell valves are thick, smooth, symmetrical and measure 0.5 µm in thickness. Parietal folds are absent. Shell valves at the posterior end of the spore appear thicker (which stains dark blue with Heidenhains, Iron-haematoxylin) than the rest on the spore body. Polar capsule is globular in shape with a short distinct tubular neck, measure 4.8 × 3.16 µm and occupies almost two-third of the spore body cavity. Polar filament form 5–6 coils arranged perpendicular to the polar capsule axis. Sporoplasm is agranular, homogenous, half moon shaped and occupies whole of the extracapsular space behind the polar capsule. Sporoplasm contain three nuclei, larger one measuring 1.0 µm and other two 0.8–0.9 µm in diameter. An iodinophilous vacuole is absent.

Taxonomic characters

Type host: *Labeo calbasu* (Ham.) vern. kalbans

Table 3 Measurements (µm) and ratio of *T. kalbensi* n. sp.

Characters	Range	Mean values	SD
LS	9.0–10.0	9.5	0.70
WS	4.4–5.4	4.9	0.70
LPC	4.4–5.2	4.8	0.56
WPC	2.8–3.4	3.16	0.42
Ratio: LS/WS		1.9	
NC		5–6	
Parietal folds		Absent	

Type locality: Kanjali wetland, Punjab, India

Type specimen: Paratypes are spores stained in Ziehl-Neelsen and Iron-haema toxylin, deposited in the museum of department of Zoology, Punjabi University, Patiala, India. Slide no. LC/I/ZN 01.02.2010 and LC/I/IH 01.02.2010

Site of infection: Gills

Prevalence of infection: 20 % (2/10)

Etymology: The specific epithet *kalbensi* has been given after the vernacular name of the fish

Discussion

The present species under study was compared with *T. niloticus* Gurley 1893 from skin of head of *Labeo niloticus*; *T. rohitae* Southwell and Prashad 1918 from gills of *L. rohita*; *T. seni* Southwell and Prashad 1918 from gills, fin of *Catla catla*; *T. calbasui* Tripathi 1952 from scales of *L. calbasu*; *T. mrigalae* Tripathi 1952 from skin on the head of *C. mrigala*; *T. nikolski* Akhmerov 1955 from fin of *Cyprinus carpio haematopterus*; *T. caudatus* Pagarkar and Das 1993 from the rays, caudal and anal fin of *Labeo rohita*; *T. andhrae* Qadri, 1962 from gills of *L. fimbriatus; T. boggoti* Qadri 1962 from gills of *L. boggot*; *T. shortii* Qadri 1967 from fin of *L. fimbriatus*; *T. batae* Lalitha Kumari 1969 from gill filaments of *L. bata; T. potaili* Lalitha Kumari 1969 from fin of *L. potail; T. qadrii* Lalitha Kumari, 1969 from gill filaments of *L. potail; T. bengalensis* Sarkar and Raychaudhuri 1986 from gall bladder of *Catla catla*; *T. chilkensis* Kalavati and Vaidehi 1991 from gall bladder of *L. rohita*; *T. assambai* Fomena et al. 1994 of *Labeo* sp.; *T. costeae* Sakiti 1997 from gills of *L. senegalensis*; *T. ndjamenaensis* Kostoingue et al. 1999 from gills of *L. parvus*; *T. bicornei* Kabre et al. 2002 from intestine of *L. coubie*; *T. avijiti* Basu and Haldar 2003 from dorsal fin of *L. rohita*; *T.*

Table 4 Comparative description of *T. kalbensi* n. sp. with morphologically similar species (measurements are in micrometer)

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. kalbensi n. sp. (present study)	*Labeo calbasu*	Gills	Harike wetland, Punjab (India)	9.5 × 4.9	4.8 × 3.16
T. niloticus Gurley 1893	*Labeo niloticus*	Skin of head	Nile (Egypt)	5.0 × 3.5	–
T. rohitae Southwell and Prashad 1918	*L. rohita*	Gills	West Bengal (India)	30.0–33.0 × 10.0–13.0	16.0–20.0 × 7.8–24.0
T. seni Southwell and Prashad 1918	*Catla catla*	Gills, fin	West Bengal (India)	12.48–14.94 × 8.56	6.42 × 4.52
T. calbasui Tripathi 1952	*L. calbasu*	Scales	West Bengal (India)	9.0–10.8 × 7.2	5.4 × 34
T. mrigalae Tripathi 1952	*Cirrhina mrigala*	Skin on the head	West Bengal (India)	10.8–12.0 (11.4)	5.4–7.2 × 3.6–5.0
T. nikolski Akhmerov 1955	*Cyprinus carpio haematopterus*	Fin	Amur basin (Russia)	19.0–20.0 × 12.0	7.0 × 5.0–6.0
T. caudatus Pagarkar and Das 1993	*L. rohita*	Rays, caudal, anal fin	West Bengal (India)	13.8 × 9.0	7.02 × 5.07
T. andhrae Qadri, 1962	*L. fimbriatus*	Gills	Andhra Pradesh (India)	11.2–14.5 × 4.5–5.5	6.0–8.0 × 2.0–2.5
T. boggoti Qadri 1962a	*L. boggot*	Gills	Andhra Pradesh (India)	11.5 × 6.75	6.2 × 3.8
T. andhrae Qadri 1962b	*L. fimbriatus*	Gills	Andhra Pradesh; Kerala (India)	11.2–14.5 × 4.5–5.5	6.0–8.0 × 2.0–2.5
T. shortii Qadri 1967	*L. fimbriatus*	Fin	Andhra Pradesh (India)	12.53 × 6.91	7.07 × 4.2
T. batae Lalitha Kumari 1969	*L. bata*	Gill filaments	Andhra Pradesh (India)	12.3 × 6.2	7.7 × 3.0
T. potaili Lalitha Kumari 1969	*L. potail*	Fin	Andhra Pradesh (India)	13.0 × 8.2	5.9 × 4.3
T. qadrii Lalitha Kumari 1969	*L. potail*	Gill filaments	Andhra Pradesh (India)	14.7 × 5.4	8.2 × 3.8
T. bengalensis Sarkar and Raychaudhuri 1986	*Catla catla*	Gall bladder	West Bengal (India)	10.95 × 6.59	5.42 × 3.47
T. chilkensis Kalavati and Vaidehi 1991	*L. rohita*	Gall bladder	Orissa (India)	26.7 × 8.7	17.54 × 7.01
T. assambai Fomena et al. 1994	*Labeo* sp.	–	Africa	10.5 × 6.0	7.5 × 2.7
T. costeae Sakiti 1997	*L. senegalensis*	Gill	Benin (Africa)	8.5–10.5 (9.4) × 5.0–6.5 (5.6)	4.0–5.5 (4.8) × 2.0–3.0 (2.6)
T. ndjamenaensis Kostoingue et al. 1999	*L. parvus*	Gill	Chad (Central Africa)	10.0–11.0 (10.0) × 7.0–8.0 (7.3)	4.0–5.0 (4.2) × 3.0–5.0 (3.2)
T. bicornei Kabre et al. 2002	*L. coubie*	Intestine	Burkina Faso (Africa)	13.0–14.0 (13.5) × 8.0–9.0 (8.4)	6.5–8.0 (7.2) × 3.5–4.0 (3.7)
T. avijiti Basu and Haldar 2003	*L. rohita*	Dorsal fin	West Bengal (India)	14.0 × 9.7	6.0 × 4.0
T. chandannagarensis Basu and Haldar 2003	*Catla catla*	Gill filaments	West Bengal (India)	12.5 × 6.7	5.1 × 3.1
T. endodermitus Mukhopadhyay and Haldar, 2004	*L. rohita*	Under scales	West Bengal (India)	13.66 × 5.35	7.14 × 3.0
T. habibpuri Acharya and Dutta 2007	*L. rohita*	Pectoral fin	West Bengal (India)	13.9 × 8.5	6.0 × 4.9
T. zahrahae Szekely et al. 2009	*Barbonymus gonionotus*	Gills	Malaysia	23.8 × 9.0	9.9 × 6.3
T. imphlaensis Hemananda et al. 2010/2011	*L. rohita*	Gills	Imphal (India)	20.4–22.1 (21.33) × 8.5–10.2 (9.43)	10.2–11.05 (10.79) × 3.40–4.25 (3.78)

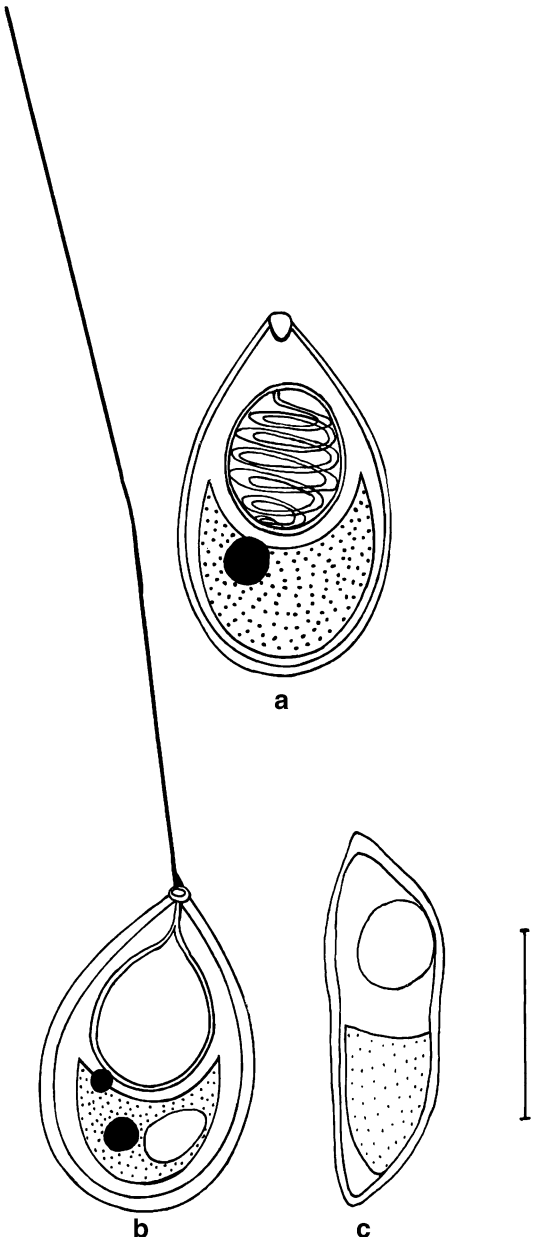

Fig. 7 *T. avijiti* Basu and Haldar 1981a. **a** spore stained in Ziehl-Neelsen (*valvular view*), **b** spore stained in Iron-haematoxylin (extruded polar filament), **c** spore in *side view*, *Scale bar* = 0.005 mm

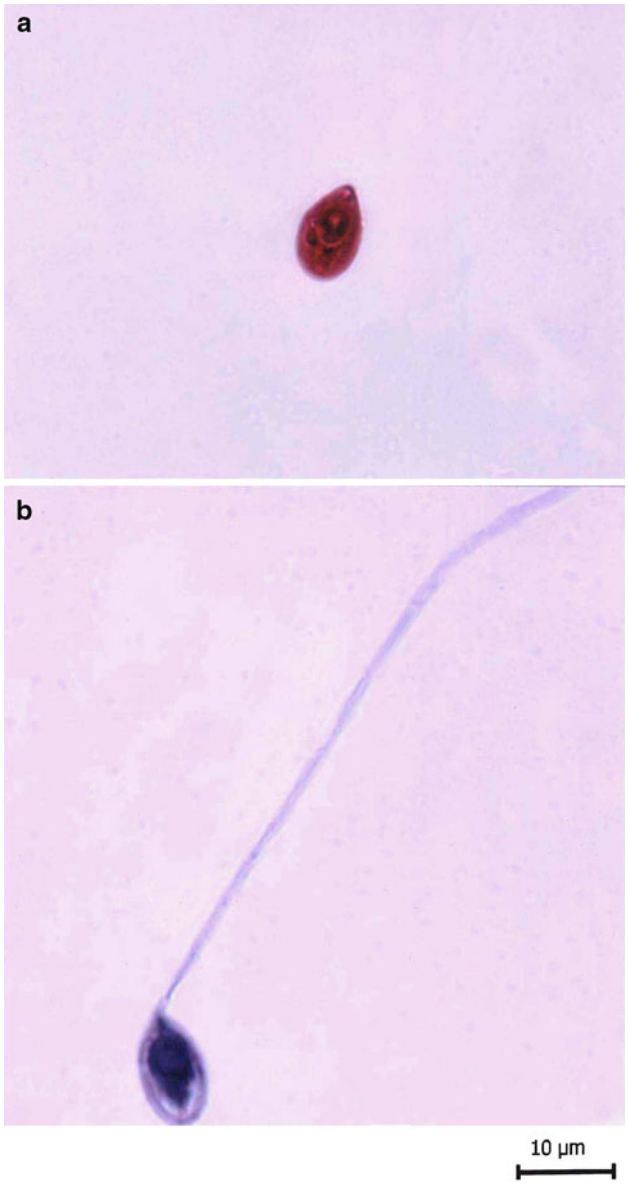

Fig. 8 *T. avijiti* Basu and Haldar 1981a. **a** spore stained in Ziehl-Neelsen, **b** spore stained in Iron-haematoxylin (extruded polar filament)

chandannagarensis Basu and Haldar 2003 from gill filament of *Catla catla*; *T. endodermitus* Mukhopadhyay and Haldar 2004 from under scales of *L. rohita* and *T. habibpuri* Acharya and Dutta 2007 from pectoral fin of *L. rohita*; *T. zahrahae* Szekely et al. 2009 from gills of *Barbonymus gonionotus* and *T. imphlaensis* Hemananda et al. 2010/2011 from gills of *L. rohita* but differ from all of the above species in morphological and morphometric characteristics (Table 4).

The present species (LS/WS: 1.9) under study have spores egg shaped to ovoid in outline. Anterior end of the spore is narrower ending into a wide, prominent pore and, posterior end is broad and rounded. In this respect, it is comparable with spores of *T. avijiti*, *T. boggoti*, *T. habibpuri* and *T. caudatus.* But the anterior end is slightly acuminated and the polar capsule occupy almost half of the spore body cavity in *T. avijiti* (LS/WS:1.4); polar capsule is flask-shaped in *T. boggoti* (LS/WS:1.70); larger spores in *T. habibpuri* (LS/WS: 1.6) containing polar capsule occupying less than half of the spore body cavity and anteriorly

Table 5 Measurements (μm) and ratio of *T. avijiti* Basu and Haldar 2003

Characters	Range	Mean values	SD
LS	9.9–10.3	10.1	0.28
WS	6.0–7.2	6.6	0.84
LPC	2.9–3.7	3.3	0.56
WPC	2.9–3.1	3.0	0.14
Ratio: LS/WS		1.5	
NC		6–7	
Parietal folds		Absent	

Table 6 Comparative description of *T. avijiti* Basu and Haldar 2003 with original species (measurements are in micrometer)

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. avijiti (present study)	*Labeo bata*	Pelvic fin	Ropar wetland, Punjab (India)	10.1 × 6.6	3.3 × 3.0
T. avijiti Basu and Haldar 2003	*L. rohita*	Dorsal fin	West Bengal (India)	14.0 × 9.7	6.0 × 4.0

pointed spores containing a pyriform polar capsule in *T. caudatus* (LS/WS: 1.5) differentiates all of them from the present species.

Furthermore, the polar capsule is globular in shape with a distinct tubular neck occupying almost two-third of the spore body cavity in the species under consideration. In addition, the presence of 4–5 parietal folds in present species separates it from all of the above species (see fresh spores). In this respect, the present species can be compared with *T. andhrae* Qadri, 1962 in which the spore as well the polar capsule are elongated pyriform with tapering anterior end in contrast to egg shaped to ovoid spores having globular polar capsule with a short distinct tubular neck. Shell valves at posterior end of the spore appear thicker (which stains dark blue with Heidenhains Iron-haematoxylin) than the rest on the spore body.

In view of the above differences, the present species is proposed as new to the science and named as *T. kalbensi* n. sp. through this communication.

T. avijiti Basu and Haldar 2003 (Figs. 7a–c, 8a, b)

Plasmodia

Small, white, rounded to spherical, present on the pelvic fin, 2–3 in numbers and measure 0.6–0.8 mm in diameter. 8–10 spores are present per plasmodium.

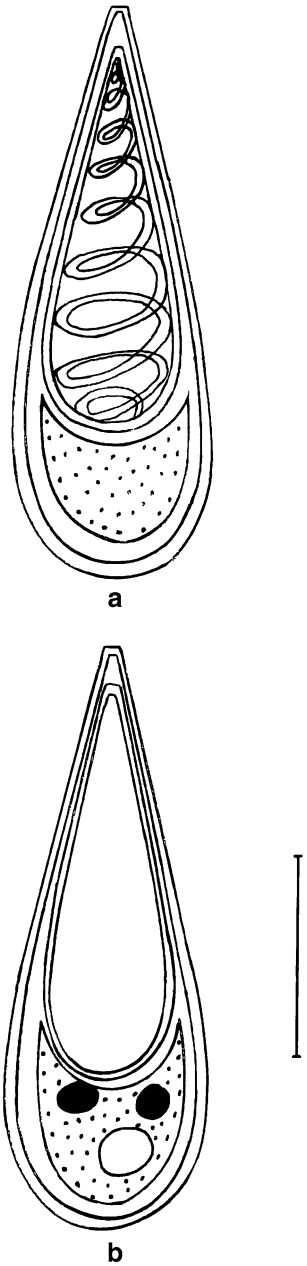

Fig. 9 *T. gangeticus* Tripathi 1952. **a** spore stained in Ziehl-Neelsen (*valvular view*), **b** spore stained in Iron-haematoxylin, *Scale bar* = 0.005 mm

Spore (Table 5) measurements based on 8–9 spores in frontal view

The spores are histozoic, measure 10.1 × 6.6 μm, egg shaped in valvular having tapering, bluntly pointed anterior end and broad rounded posterior end. Shell valves are thin, smooth, symmetrical and measuring 0.16 μm in thickness. Parietal folds are absent. Polar capsule is rounded to sub-spherical in shape, measure 3.3 × 3.0 μm and is situated anteriorly. It occupies almost half of the spore body cavity and contain 6–7 coils of polar filament arranged obliquely

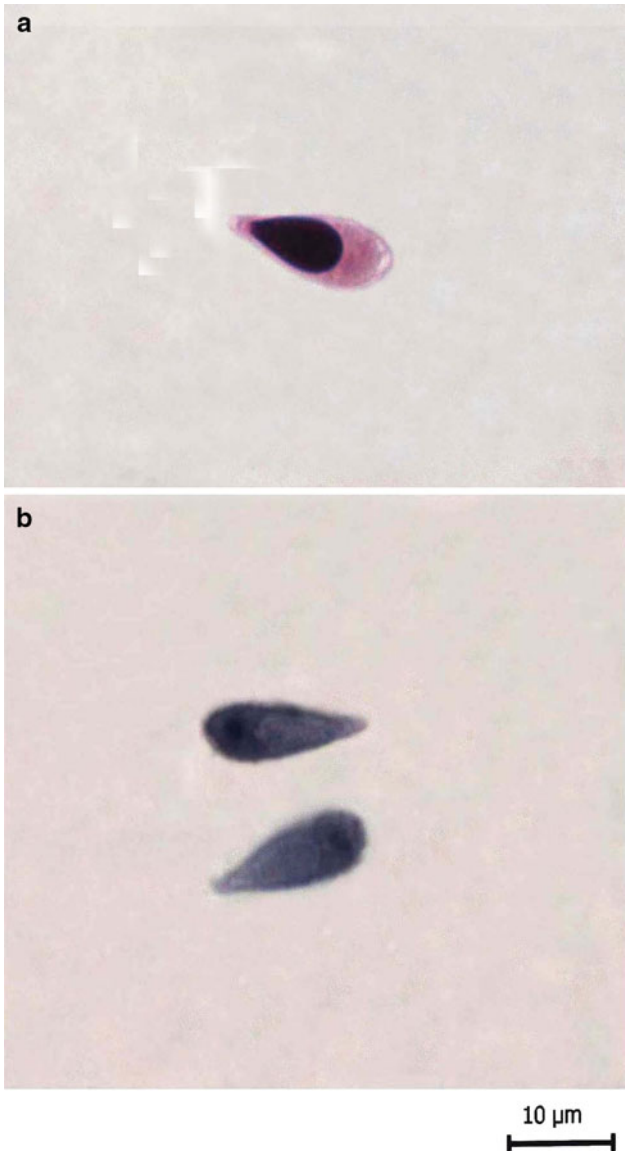

Fig. 10 *T. gangeticus* Tripathi 1952. **a** spore stained in Ziehl-Neelsen, **b** spore stained in Iron-haematoxylin

to the polar capsule axis. Polar filament is thick and thread-like measuring 70 µm in length, extrude through a prominent pore anteriorly. One capsulogenic nucleus is present beneath the polar capsule and measure 0.65 µm in diameter. Sporoplasm occupies whole of the extracapsular space behind the polar capsule and contain a nucleus measuring 0.95 µm. An iodinophilous vacuole measuring 2.8 µm in diameter is present.

Taxonomic characters

Host:	*Labeo bata* (Ham.) vern. bata
Locality:	Ropar wetland, Punjab, India
Site of infection:	Pelvic fin

Table 7 Measurements (µm) and ratio of *T. gangeticus* Tripathi, 1952

Characters	Range	Mean values	SD
LS	13.0–13.6	13.3	0.42
WS	4.6–5.0	4.8	0.28
LPC	6.2–7.0	6.6	0.56
WPC	2.9–3.3	3.1	0.28
Ratio: LS/WS		2.7	
NC		9–10	
Parietal folds		Absent	

Prevalence of infection: 20 % (3/15)

Remarks

The present observations (LS/WS: 1.5) on *T. avijiti* Basu and Haldar 2003 are in conformity with original description (LS/WS: 1.4), however, spore and polar capsule are smaller in size in the present species. In addition, a prominent pore is present at the anterior end of the spore of the present species. Earlier, this parasite was recorded from dorsal fin of *Labeo rohita.* A new location- pelvic fin and a new locality- Ropar wetland are recorded for this parasite (Table 6).

T. gangeticus Tripathi 1952 (Figs. 9a, b, 10a, b)

Minute, present in the gills, 4–5 spores are present per plasmodium.

Spore (Table 7) measurements based on 8–10 spores in frontal view

The spores are histozoic, measure 13.3 × 4.8 µm, elongately pyriform in valvular view having tapering anterior end and rounded posterior end. Shell valves are thin, smooth, symmetrical and measure 0.41 µm in thickness. Parietal folds are absent. Polar capsule is also elongately pyriform in shape measure 6.6 × 3.1 µm with thin neck and occupy half of the spore body cavity. Polar filament form 9–10 coils arranged obliquely to the polar capsule axis. Sporoplasm occupies whole of the extracapsular space behind the polar capsule and contain two sporoplasmic nuclei measuring 1.2–1.3 µm in diameter. An iodinophilous vacuole is present measuring 1.6 µm in diameter.

Taxonomic characters

Host:	*Labeo calbasu* (Ham.) vern. kalbans
Locality:	Kanjali wetland, Punjab, India

Table 8 Comparative description of *T. gangeticus* Tripathi 1952 with original species (measurements are in micrometer)

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. gangeticus (present study)	*Labeo calbasu*	Gills	Kanjali wetland, Punjab (India)	13.3 × 4.8	6.6 × 3.1
T. gangeticus Tripathi 1952	*Chela bacaila*	Muscles	West Bengal (India)	16.2–17.5 × 5.4	7.2 × 2.5

Site of infection: Gills
Prevalence of infection: 20 % (2/10)
Plasmodia

Remarks

The present observations (LS/WS: 2.7) on *T. gangeticus* Tripathi, 1952 are in conformity with the original description (LS/WS: 3.1) except some variations in the size of spore and polar capsule. Earlier, this parasite was recorded from muscles of *Chela bacaila*. A new host-*Labeo calbasu*, a new location- gills and a new locality-Kanjali wetland are recorded for this parasite (Table 8).

Acknowledgments The authors express thanks to University Grants Commission (UGC) for the financial support.

References

Acharya S, Dutta T (2007) *Thelohanellus habibpuri* sp. n. (Myxozoa: Bivalvulida) from the tropical freshwater fish rohu, *Labeo rohita* (Hamilton-Buchann, 1882) in West Bengal, India: Light and electron microscope observations. Anim Biol 57(3):293–300

Akhmerov AK (1955) Ways of the origin of myxosporidian species of the genus *Thelohanellus* Kudo from Amur wild carp. Doklad kad Nauk SSSR 105:1129–1132

Basu S, Haldar DP (1999) *Thelohanellus bifurcata* n. sp. a new species of the genus *Thelohanellus* from hybrid carps and checklist of the species of the genus described from Indian fishes. Proc Zool Soc Calcutta 52(1):115–124

Basu S, Haldar DP (2003) Observations on two new thelohanelloid species (Myxozoa: Bivalvulida) from Indian major carps of West Bengal. India J Parasitol Appl Anim Biol 12(1&2):15–24

Basu S, Modak BK, Haldar DP (2006) Synopsis of the Indian species of the genus *Thelohanellus* Kudo, 1933 along with description of *Thelohanellus disporomorphus* sp. n. J Parasitol Appl Anim Biol 15(1–2):81–94

Chakravarty M, Basu MS (1948) Observations on some myxosporidians parasitic in fishes, with an account of nuclear cycles in one of them. Proc Zool Soc Bengal 1:23–33

Fomena A, Marques A, Bouix G, Njine T (1994) *Myxobolus bilongi* n. sp., *Thelohanellus assambai* n. sp., *T. sanagaensis* n. sp., Myxosporidies parasites de *Labeo* sp. (Teleosteen, Cyprinidae) du Bassin de la Sanaga au Cameroun (Afrique Centrale). Annales de la Faculte des Sciences de Yaounde 131–142

Gupta S, Khera S (1987) On the genera *Henneguya* Thelohan, 1892 and *Unicauda* Davis, 1944. Res Bull (Sci) Panj Univ 38:153–163

Gupta S, Khera S (1988a) Review of the genus *Myxobolus* Bütschli, 1882. Res Bull (Sci) Panj Univ 39(I–II):45–48

Gupta S, Khera S (1988b) On a new myxozoan parasite (Myxozoa) *Lomosporus indicus* gen. sp. n. from fresh water fishes, *Labeo calbasu* (Ham.). Acta Protozool 27:171–175

Gupta S, Khera S (1988c) On a new species, *Myxidium labeonis* from freshwater fishes of Punjab, India. Arch Protistenkd 136:393–396

Gupta S, Khera S (1988d) On one new and one already known species of the genus *Myxobolus* from freshwater fishes of India. Res Bull (Sci) Panj Univ 39(III-IV):173–179

Gupta S, Khera S (1989a) Observations on *Myxobolus haldari* sp. nov. (Myxozoa: Myxosporea) from freshwater fishes of North India. Res Bull (Sci) Panj Univ 40:281–291

Gupta S, Khera S (1989b) Observations on *Myxobolus punjabensis* sp. nov. (Myxozoa: Myxobolidae), parasitic on gills and fins of *Labeo dyocheilus*. Riv Parasitol 50(1–2):131–138

Gupta S, Khera S (1990) On three species of the genus *Myxobolus* Bütschli, 1882 (Myxozoa: Myxosporea) from freshwater fishes of Northern India. Indian J Parasitol 14:1–8

Gupta S, Khera S (1991) On some species of the genus *Myxobolus* (Myxozoa: Myxosporea) from freshwater fishes of India. Indian J Parasitol 15(1):35–47

Gurley RS (1893) On the classification of the Myxospora group of protozoan parasites infesting fishes. Bull US Fish Comm 11:407–431

Haldar DP, Das MK, Sharma BK (1983) Studies on Protozoan Parasites from Fishes. Four New Species of the Genera *Henneguya* Thelohan, 1892. *Thelohanellus* Kudo, 1933 and *Myxobolus* Butschli, 1892. Arch Protistenkd 127:283–296

Haldar DP, Samal KK, Mukhopadhyay D (1997) Studies in the protozoan parasites of fishes in Orissa: five new species of the genera *Henneguya, Thelohanellus* and *Unicauda* (Myxozoa: Bivalvulida). J Bengal Nat Hist Soc 16(2):50–63

Hemananda T, Mohilal N, Bandyopadhyay PK, Mitra AK (2010/2011) *Thelohanellus imphalensis* sp. nov. (Myxozoa) infecting gills of a major carp *Labeo rohita* Hamilton 1822 from Thoubal, Manipur, India. Protistology 6 (4):280–283

Kabre GB, Sakiti NG, Marques A, Sawadogo I (2002) *Thelohanellus bicornei* sp. n., (Myxosporea, Bivalvulida) a gill parasite of *Labeo coubie* Ruppel, 1832 (Osteichthyes, Cyprinidae) from Burkina Faso, West Africa. Parasite 9:219–223

Kalavati C, Nandi NC (2007) Handbook of Myxosporidean parasites of Indian fishes. ZSI, Kolkata, p 293

Kalavati C, Vaidehi J (1991) A new myxosporidian, *Thelohanellus chilkensis* n. sp. from the gills of the common carp, *Labeo rohita* in Chilka lake, Orissa, India. Uttar Pradesh J Zool 11(1):73–78

Kaur H, Singh R (2008) Observations on one new species, of Genus *Myxobolus- M. naini* and rediscription of *M. magauddi* recorded from freshwater fishes of Kanjali Wetland of Punjab, India. In: Proceedings 20th National Congress Parasitol, NEHU, Shillong, pp 75–79

Kaur H, Singh R (2009) A new myxosporean species, *Myxobolus eirasi* sp nov, a known species *M. venkateshi* Seenappa, Manohar (1981) from the Indian major carp fish *Cirrhina mrigala* (Ham). Protistology 6(2):126–130

Kaur H, Singh R (2010/2011) Two new species of *Myxobolus* (Myxosporea, Bivalvulida) from the Indian major carp *Labeo rohita* Hamilton, 1822. Protistology 6(4):264–270

Kaur H, Singh R (2010b) One new myxosporidian species, *Myxobolus slendrii* sp. nov., one known species, *M. punjabensis* Gupta,

Khera (1989) infecting freshwater fishes in wetlands of Punjab, India. India Parasitol Res 106(5):1043–1047

Kaur H, Singh R (2011a) Two new species of *Myxobolus* (Myxozoa: Myxosporea: Bivalvulida) from freshwater fishes of Punjab Wetlands (India). J Parasit Dis 35(1):33–41

Kaur H, Singh R (2011b) Two new species of *Myxobolus* (Myxozoa: Myxosporea: Bivalvulida) infecting an Indian major carp in Ropar and Kanjali wetlands (Punjab). J Parasit Dis 35(1):23–32

Kaur H, Singh R (2011c) *Myxobolus harikensis* sp. nov. (Myxozoa: Myxobolidae) infecting fins of *Cirrhina mrigala* (Ham.)—an Indian major carp in Harike Wetland, Punjab (India). Parasitol Res 109(6):1699–1705

Kaur H, Singh R (2011d) Two new and one already known species of *Myxobolus* (Myxozoa: Myxosporea: Bivalvulida) infecting gill lamellae of Indian major carp fishes in Ropar and Harike wetlands (Punjab). In: Proceeding 22nd National Congress of parasitology, University of West Bengal, Kalyani, pp 81–90

Kaur H, Singh R (2011e) Two new species of *Myxobolus* (Myxozoa: Myxosporea: Bivalvulida) infecting Indian freshwater fishes in Punjab Wetlands (India). Parasitol Res 108(5):1075–1082

Kaur H, Singh R (2011f) Two new species of *Myxobolus* (Myxozoa: Myxosporea: Bivalvulida) infecting an Indian major carp and a cat fish in wetlands of Punjab, India. J Parasit Dis 35(2):169–176

Kaur H, Singh R (2012a) One new myxosporean species, *Triangula cirrhini* sp. nov., and one known species, *T. ludhianae* (Syn. *M. ludhianae* Gupta and Khera, 1991) comb. n. (Myxozoa: Myxosporea), infecting Indian major carp in Harike wetland of Punjab. Anim Biol 62:129–139

Kaur H, Singh R (2012b) A synopsis of the species of *Myxobolus* Bütschli, 1882 (Myxozoa: Bivalvulida) parasitizing Indian fishes and a revised dichotomous key to myxosporean genera. Syst Parasitol 81:17–37

Kaur H, Singh R et al (2010) A new myxosporean species *Myxobolus sclerii* sp. nov. and one known species *M. stomum* Ali et al. (2003) from two Indian major carp fishes. J Parasit Dis 34(1):33–39

Koie M, Karlsbakk E, Nylund A (2007) A new genus *Gadimyxa* with three new species (Myxozoa, Parvicapsulidae) parasitic in marine fish (Gadidae) and the two-host life cycle of *Gadimyxa atlantica* n. sp. J Parasitol 93(6):1459–1467

Kostoingue B, Fall M, Faye N, Toguebaye BS (1999) Three new myxosporidian (Myxozoa: Myxosporea) parasites of freshwater fishes from Chad (Central Africa). Acta Protozool 38:323–326

Kudo R (1933) A taxonomic consideration of Myxosporidia. Trans Am Microsc Soc 52:195–216

Lalitha Kumari PS (1969) Studies on parasitic protozoa (Myxosporidia) of fresh water fishes of Andhra Pradesh, India. Riv Parasitol 30:153–226

Lom J, Arthur JR (1989) A guideline for the preparation of species descriptions in Myxosporea. J Fish Dis 12:151–156

Lom J, Dykova I (1992) Myxosporidia (Phylum Myxozoa). In: Lom J, Dykova I (eds) Protozoan parasites of fishes. Developments in aquaculture and fisheries. Elsevier, Amsterdam, pp 159–235

Lom J, Dykova I (2006) Myxozoan genera: Definition and notes on taxonomy, life- cycle terminology and pathogenic species. Folia Parasitol 53:1–36

Mukhopadhyay D, Haldar DP (2004) *Thelohanellus endodermitus* sp. n. A new Myxozoan (Myxozoa: Bivalvulida) from the major carp, *Labeo rohita* (Hamilton-Buchanon) in a sewage farm in West Bengal, India. Environ Ecol 22(1):139–142

Pagarkar AU, Das M (1993) Two new species of myxozoa, *Thelohanellus caudatus* n. sp. and *Myxobolus serrata* n. sp. from cultural carps. J Inland Fish Soc India 25(1):30–35

Prunescu CC, Prunescu P, Pucek Z, Lom J (2007) The first finding of myxosporean development from plasmodia to spores in terrestrial mammals: *Soricimyxum fegati* gen. et sp. n. (Myxozoa) from *Sorex araneus* (Soricomorpha). Folia Parasitol 54:159–164

Qadri SS (1962a) A new Myxosporidian *Thelohanellus boggoti* n. sp. from an Indian fresh water fish *Labeo boggot*. Arch Protistenkd 106:218–222

Qadri SS (1962b) New Myxosporidia frm freshwater fish, *Labeo fimbriatus* II *Thelohanellus andhrae* sp. n. Arch Protistenkd 21:517–520

Qadri SS (1967) On a new Myxosporidian, *Thelohanellus shortti* n. sp. from a fresh water fish, *Labeo fimbricatus* of Andhra Pradesh, India. Protozoology 2:207–218

Sakiti GN (1997) Myxosporidies et Myxosporidies des poisons du Benin: faunistique, ultrastructure, biologie. These de doctorat d'E tat, Universite National du Benin, pp 296

Sarkar NK (2009) *Thelohanelloid bengalensis* gen. and sp. nov. (Myxosporea: Thelohanellidae) from the gall bladder of marine catfish of the Bay of Bengal, India. Uttar Pradesh J Zool 29(2): 251–254

Sarkar NK, Ghosh S (1990) Two new myxozoan parasite of the genus *Thelohanellus* Kudo, 1933 (Myxosporea: Myxobolidae) from freshwater fishes of West Bengal, India. New Agriculturist 1(1): 35–38

Sarkar NK, Raychaudhuri S (1986) *Thelohanellus bengalensis* sp. n. and *Myxidium mystuium* sp. n. (Myxozoa): Two new Myxosporidia from Indian freshwater teleost. Acta Protozool 25(3):359–362

Southwell T, Prashad B (1918) On some Mxosporidia. Parasites of Indian fishes with a note on the carcinoma in the climbing perch. II. Rec Indian Mus 15:341–355

Szekely C, Shaharom-Harrison F, Cech G, Mohamed K, Molnar K (2009) Myxozoan pathogens of Malaysian fishes cultured in ponds and net-cages. Dis Aquat Organ 83:49–57

Tripathi YR (1952) Studies on the parasites of Indian fishes. I. Protozoa. Myxosporidia together with a Checklist of parasitic protozoa described from Indian fishes. Rec Indian Mus 50:63–88