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Thelohanellus (Myxozoa: Myxosporea: Bivalvulida) infections in major carp fish from Punjab wetlands (India)

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Summary

A survey of freshwater fish parasites in Harike and Kanjali wetlands of Punjab (India) revealed two new and two already known myxosporean species of the genus *Thelohanellus* Kudo, 1933 parasitizing various fish organs, such as caudal fin, skin of snout, and gill lamellae. Spores of the first species, *T. globulosa* sp. nov. (11.67 × 7.9 μm) are oval to spherical in valvular view, with blunt anterior ends and broad rounded posterior ends. A polar capsule, measuring 5.3 × 4.8 μm, is rounded, balloon-like and located eccentrically inside the spore body cavity. Shell valves are very thick (stained dark blue with Heidenhain's Iron-haematoxylin). Spores of the second species, *T. kanjalensis* sp. nov. (11.67 × 6.6 μm) are elongated. Their anterior end is acuminated and exhibits a distinct pore. The posterior end is rounded, with lateral sides nearly parallel to each other. The pyriform to oblong polar capsule (7.5 × 3.3 μm) occupies more than a half of the spore body cavity. The prominent neck leads to the fine duct opening. Shell valves stain dark-blue with Iron-haematoxylin in the middle part of the spore body cavity. Spores of the third species, *T. boggoti* Qadri, 1962 (10.1 ×5.0 μm) are egg-shaped to ovoid in valvular view, with bluntly pointed anterior ends and broad rounded posterior ends. The polar capsule (5.0 × 3.1 μm) is flask-shaped, with the distinct neck, and is located anteriorly. Spores of the fourth species, *T. caudatus* Pagarkar and Das, 1993 (15.0 × 7.0 μm) are pyriform in valvular view, with tapering and pointed anterior ends and broad rounded posterior ends. Their polar capsule (6.3 × 4.6 μm) is oval, with the blunt anterior end and rounded posterior end.

Key words: Bivalvulida, Myxozoa, *Thelohanellus*, gill lamellae, carp fish, plasmodia, polar capsule, Harike and Kanjali wetlands, India

Introduction

In Punjab (India), 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. These wetlands have extremely rich biodiversity supporting a variety of plant and animal life. Harike wetland, the largest freshwater wetlands in northern India, occupies 4100 Ha and harbors 16

species of freshwater fish (Punjab State Council for Science and Technology Chandigarh, 2002). Kanjali wetland with an area of 185 Ha supports diversity of resident and migratory birds, and nurtures as many as 17 fish species. These fish are vulnerable to various parasitic infections, out of which Myxozoa is emerging as the major group. Myxozoa cause production loss and deaths, and some fish have to be discarded because they are unsightly and not considered fit for human consumption.

According to the latest review (Lom and Dykova, 2006), the phylum Myxozoa includes 4 malacosporean and 2,180 myxosporean species of 62 genera. However, three more genera (*Soricimyxum, Gadimyxa, Thelohanelloid*) with a type species *S. fegati* (Prunescu et al., 2007) from the liver of *Sorex araneus, G. atlantica* (Koie et al., 2007) from the urinary system of *Gadus morhua*, and *T. bengalensis* (Sarkar, 2009) from the gall bladder of *Arius sagor* have been described subsequently. In India, Myxozoa have been studied insufficiently, predominantly in two states, West Bengal and Andhra Pradesh.

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

Recently, Kaur and Singh (2008, 2008-2009, 2009, 2010a, 2010b, 2010/2011, 2011a, 2011b, 2011c, 2011d, 2011e, 2011f, 2012a, 2012b) and Singh and Kaur (2012) have described 18 new species of the genus *Myxobolus* and one new species of the genus *Triangula* from freshwater fish in wetlands of Punjab. Furthermore, Kaur and Singh (2012a) also provided a synopsis of Indian myxobolids and revised the keys to the phylum Myxozoa.

There are very few species of the genus *Thelohanellus* reported all over the world. Lom and Dykova (1992) enlisted 39 species in this genus. Basu and Haldar (1999) described a new species of *Thelohanellus* from the gills of hybrid carps and published a checklist of *Thelohanellus* spp. parasitizing fish in India. Basu with co-authors (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*.

Genus *Thelohanellus* is characterized by pyriform or broadly ellipsoidal spores (valvular view), which look slimmer in sutural view. Spores always have smooth valves and single pyriform polar capsules, with a single coil of the polar filament, or subspherical polar capsules with two coils. Sporoplasms are binucleate, mostly with a spherical polysaccharide inclusion (Lom and Dykova, 2006). These parasites are histozoic and infect freshwater fish.

Two new species, *T. globulosa* sp. nov. and *T. kanjalensis* sp. nov., and two already known species, *T. boggoti* Qadri, 1962 and *T. caudatus* Pagakar and Das, 1993, collected from caudal fin, skin of snout, and gill lamellae of various species of carp fish have been discovered as a part of the study of fish parasitofauna of Harike and Kanjali wetlands. Spores have been identified following the keys of Kaur and Singh (2012a), and assigned to the genus *Thelohnaellus*. Description has been prepared in accordance with guidelines of Lom and Arhtur (1989).

Material and methods

Fish were collected in Harike and Kanjali wetlands. In the laboratory, plasmodia were removed, placed on microscopic slides, and examined in the light microscope under 100× oil objective (Magnus inclined Trinocular microscope MLX-Tr) for the presence of myxospores. Fresh spores were treated with 8% KOH solution to stimulate extrusion of polar filaments. For permanent preparations, air-dried smears were stained with Ziehl-Neelsen and Iron-haematoxylin. Drawings of stained material were made with the aid of camera lucida. Spores were measured with a calibrated ocular micrometer. All measurements are presented in μm as range values followed by mean ± standard deviation (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

Thelohanellus boggoti Qadri, 1962 (Figs 1–3)

Plasmodia. Minute, present around gill lamellae. Each plasmodium contains 7-8 spores.

Spores (Table 1, measurements based on 7-8 spores in frontal view). Spores were histozoic, measured 10.1 × 5.0 μm, egg-shaped to ovoidal in valvular view, with bluntly pointed anterior ends and broad rounded posterior ends. Shell valves were 0.65 μm thick, smooth and symmetrical. Parietal folds were absent. Polar capsules were flask-shaped with distinct neck, measured 5.0 × 3.1 μm and occupied half of the spore body cavity. A polar filament looked thin, formed 5 coils, and was arranged perpendicular to the polar capsule axis. When extruded at the anterior tip, the polar

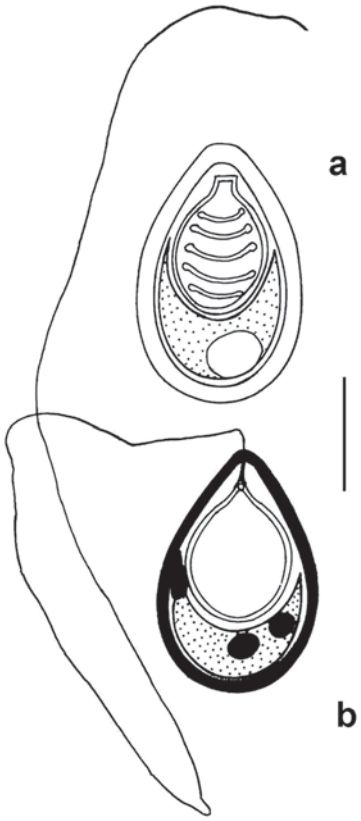


Fig. 1. Line drawing (Camera Lucida) of *T. boggoi* Qadri, 1962 spores. a – Spore stained with Ziehl-Neelsen (valvular view); b – spore stained with Iron-haematoxylin; the polar filament is extruded. Scale bar: 0.005 mm.

filament was thread-like, 45.4 µm long. One capsulogenic nucleus was present beneath the polar capsule measuring 1.6 µm in diameter. Sporoplasms were agranular, homogenous, moon-shaped, and occupied all extracapsular space behind the polar capsule. Sporoplasms contained two sporoplasmic nuclei, each 1.33 µm in diameter. An iodinophilous vacuole measured 1.4 µm in diameter.

Remarks. The present observations (LS/WS: 2.1) on *T. boggoti* Qadri, 1962 are in conformity with the original description (LS/WS: 1.7), except for some variations in sizes of the spore and polar capsule. Earlier, this parasite was recorded from gills of *Labeo boggot*. A new host, *Catla catla*, and a new locality, Harike wetland, are recorded for this parasite (Table 2).

THELOHANELLUS CAUDATUS PAGARKAR AND DAS, 1993 (FIGS 4–6)

Plasmodia. Small, white, spherical to round, 0.5-0.8 mm in diameter; 2-4 plasmodia were observed

Figs 2, 3. Micrographs of *T. boggoi* Qadri, 1962 spores. 2a – Spore stained with Ziehl-Neelsen; 2b – spores stained with Iron-haematoxylin; the polar filament is extruded; 3 – fresh spore. Scale bars: 10 µm.

per one caudal fin; each plasmodium contained 12-13 spores.

Spores (Table 3, measurements based on 7-9 spores in frontal view). Spores were histozoic, measured 15.0 × 7.0 µm, pyriform in valvular view, with tapering and pointed anterior ends and broad rounded posterior ends. The sutural ridge was distinct and straight. Shell valves were 0.4 µm thin, smooth and symmetrical. Parietal folds were absent. Polar capsules were oval, measured 6.3 × 4.6 µm, with blunt anterior ends and rounded posterior ends. The polar filament formed 5-6 coils and was arranged

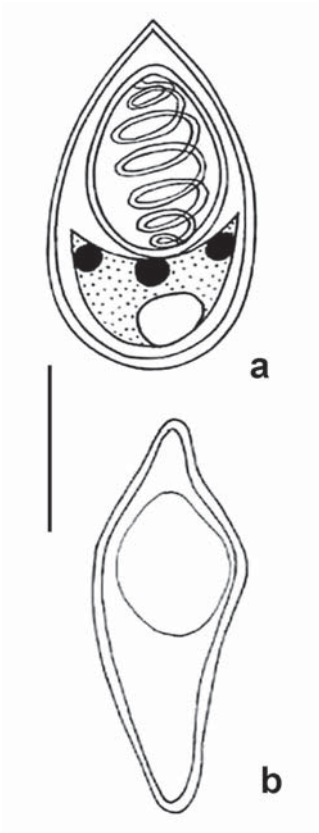
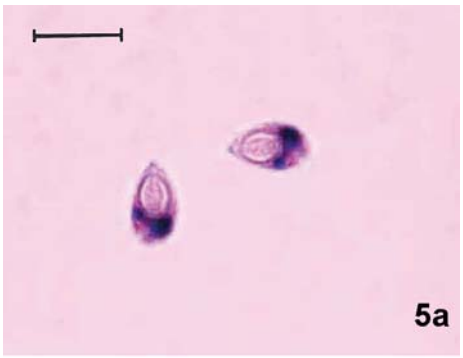
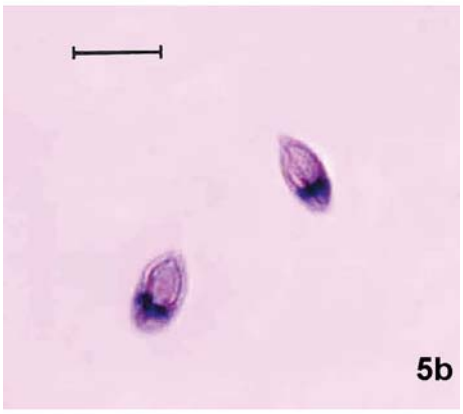


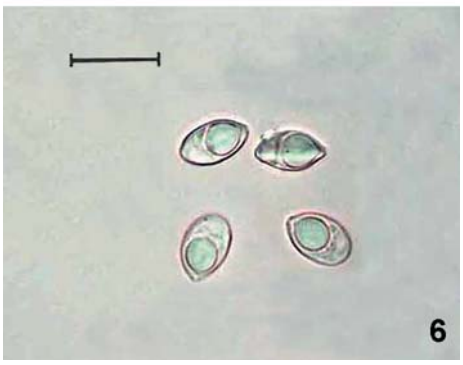
Fig. 4. Line drawing (Camera Lucida) of *T. caudatus* Pagarkar and Das, 1933. a – Spore stained with Ziehl-Neelsen (valvular view); b – spore in the side view. Scale bar: 0.005 mm.

Table 1. Measurements (μm) of *T. boggoti* Qadri, 1962.

Character	Range	Mean value	SD
LS	9.8-10.4	10.1	0.42
WS	4.5-5.5	5.0	0.70
LPC	4.8-5.2	5.0	0.28
WPC	2.9-3.3	3.1	0.28
Ratio: LS/WS		2.1	
NC		5	
Parietal Folds		absent	







Figs 5, 6. Micrographs of *T. caudats* Pagarkar and Das, 1933 spores. 5a, b – Spores stained with Ziehl-Neelsen; 6 – fresh spores. Scale bars: 10 μm.

obliquely to the polar capsule axis. Sporoplasms occupied all extracapsular space behind polar capsules, and contained three sporoplasmic nuclei measuring 0.4-0.6 μm in diameter. An iodinophilous vacuole was 3.16 μm in diameter.

Remarks. The present observations (LS/WS: 2.1) on *T. caudatus* Pagarkar and Das, 1993 are in conformity with the original description (LS/WS: 1.5), except for some minor variations in the size of spors and polar capsules. Earlier, this parasite

Table 2. Comparison of the original description of *T. boggoti* Qadri, 1962 with the specimens from the new geographic isolate (measurements are in micrometer).

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. boggoti (present study)	*Catla catla*	gill lamellae	Harike wetland, Punjab (India)	10.1×5.0	5.0×3.1
T. boggoti Qadri, 1962	*Labeo boggot*	gills	Andhra Pradesh (India)	11.0-12.0× 6.0-7.5	5.5-7.0× 3.6-4.0

Table 3. Measurements (μm) of *T. caudatus* Pagarkar and Das, 1993.

Character	Range	Mean value	SD
LS	14.8-15.2	15.0	0.28
WS	6.8-7.2	7.0	0.28
LPC	6.0-6.6	6.3	0.42
WPC	2.9-3.3	3.1	0.28
Ratio: LS/WS		2.1	
NC		5-6	
Parietal Folds		absent	

was recorded from rays of caudal fin and anal fin. A new locality, Kanjali wetland, is recorded for this parasite (Table 4).

THELOHANELLUS GLOBULOSA SP. NOV. (FIGS 7–9)

Plasmodia. Small, white to pale yellow, round, 0.7-0.8 mm in diameter; 2-5 plasmodia were observed per one caudal fin; each plasmodium contained 7-8 spores.

Spores (Table 5, measurements based on 6-9 spores in frontal view). Spores were histozoic, measured 11.67 × 7.9 μm, oval to spherical in valvular view with blunt anterior and broad rounded posterior ends. Shell valves were 0.6 μm thick, smooth, symmetrical. Shell valves looked thick and stained dark blue with Heidenhain's Iron-haematoxylin. Parietal folds were absent. Polar capsules were rounded, balloon-like, measured 5.3 × 4.8 μm and positioned eccentrically inside the spore body cavity. Polar filament was ribbon-like, formed 4-5 coils, and was arranged perpendicular to the polar capsule axis. When extruded, the polar filament was thread–like, 49.5 μm long. Sporoplasms were scanty and not clearly seen.

Differential diagnosis. The studied species was compared to 13 representatives of the genus *Thelohanellus* infecting fish (Table 6). It differs from all of them by morphometric characters. The novel species possess oval to spherical body outline, like *T. parastromataei* and *T. seni*. However, the narrow anterior end with 2-3 parietal folds at the anteriolateral region in *T. parastromataei*, spores with two polar capsules, and a short tail-like process in *T. seni*, differentiate both of them

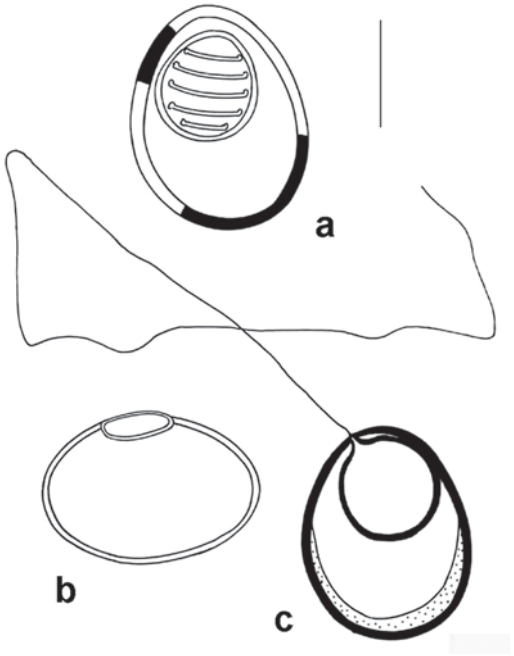


Fig. 7. Line drawing (Camera Lucida) of *T. globulosa sp. nov.* a, b – Spores stained with Ziehl-Neelsen (valvular view); c – spore stained with Iron-haematoxylin; the polar filament is extruded. Scale bar: 0.005 mm.

from the present species. Furthermore, eccentric polar capsules, scanty sporoplasms and thicker shell valves, especially at the anterior and posterior parts, stained dark blue with Heidenhain's Iron-haematoxylin, differentiate the present species from *T. parastromataei* and *T. seni*.

In view of these differences, we assign a myxozoan parasite of *Cirrhina reba* from Harike wetland to a new species of the genus *Thelohanellus*.

Taxonomic summary of *T. globulosa* sp. nov.

Plasmodia: small, white to pale yellow, round, 0.7-0.8 mm in diameter.

Spores: spores measure 11.67 × 7.9 μm, oval to spherical in valvular view with blunt anterior end and broad rounded posterior end. Polar capsules rounded balloon-like, measure 5.3 × 4.8 μm, and position eccentrically inside the spore body cavity.

Table 4. Comparison of the original description of *T. caudatus* Pagarkar and Das, 1993 with the specimens from the new geographic isolate (measurements are in micrometer).

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. caudatus (present study)	*Labeo calbasu*	caudal fin	Kanjali wetland, Punjab (India)	15.0×7.0	6.3×4.6
T. caudatus Pagarkar and Das, 1993	*L. rohita*	caudal fin; anal fin	West Bengal (India)	13.0-14.0× 8.5-9.5	7.0-7.5×5.0-5.5

Table 5. Measurements (μm) of *T. globulosa* sp. nov.

Character	Range	Mean value	SD
LS	11.07-12.27	11.67	0.8
WS	7.6-8.2	7.9	0.42
LPC	4.8-5.8	5.3	0.72
WPC	4.3-5.3	4.8	0.70
Ratio: LS/WS		1.4	
NC		4-5	
Parietal Folds		absent	

Type host: *Cirrhina reba* (Hamilton, 1822) vern. chunni, mori, kursa.

Type locality: Harike wetland, Punjab, India.

Type specimen: paratypes are spores stained by Ziehl-Neelsen and Iron-haematoxylin, deposited in the museum of Department of Zoology, Punjabi University, Patiala, India- Slide No. TF/ZN/04.04.2010 and TF/IH/04.04.2010.

Site of infection: Caudal fin.

Prevalence of infection: 46% (7/15).

Pathogenicity: non-pathogenic.

Etymology: the specific epithet globulosa highlights the globular-like shape of the parasite.

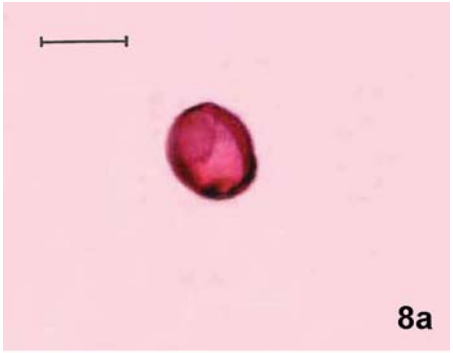
THELOHANELLUS KANJALENSIS SP. NOV. (FIGS 10–12)

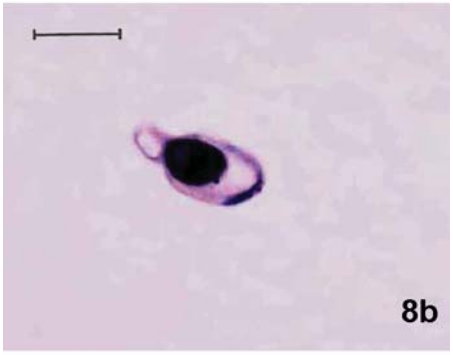
Plasmodia. Small, white, round, 0.4-0.5 mm in diameter, located on the skin of snout; each plasmodium contained 7-9 spores.

Spores (Table 7, measurements based on 9-11 spores in frontal view). Spores were histozoic, measured 11.67 × 6.6 μm, elongate to oval, with the acuminated anterior end exhibiting a distinct pore, and rounded posterior end with lateral sides nearly parallel to each other. Shell valves were 0.41 μm thin, smooth and symmetrical. Parietal folds were absent. Shell valves stained dark-blue (with Iron-haematoxylin) in the middle part of the spore body. Polar capsules were pyriform to oblong oval in shape, measured 7.5 × 3.3 μm and occupied more than half of the spore body cavity. The prominent neck led to the fine duct opening outside the spore. The polar filament was thick, ribbon-like, formed 4-6 coils, and was arranged perpendicular to the polar capsule axis. When extruded, the polar filament was 94.1 μm long. A capsulogenic nucleus was present just beneath the polar capsule and measured 0.4-0.6μm in diameter. Sporoplasms were agranular,

Table 6. *Thelohanellus globulosa* sp. nov. and morphologically similar species (measurements are in micrometer).

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. globulosa sp. nov. (present study)	*Cirrhina reba*	caudal fin	Harike wetland, Punjab (India)	11.67×7.9	5.3×4.8
T. niloticus Gurley, 1893	*Labeo niloticus*	skin of head	Nile (Egypt)	5.0×3.5	—
T. seni (Southwell et Prashad, 1918) Chakravarty et 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. parastromataei Narasimhamurti et al., 1990	*Parastromataeus niger*	gall bladder	Orissa coast (India)	11.18×9.46	8.6×6.88
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 et 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 et Haldar, 2003	*L. rohita*	dorsal fin	West Bengal (India)	14.0×9.7	6.0×4.0
T. habibpuri Acharya et 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)×3.4.0-4.25 (3.78)





Figs 8, 9. Micrographs of *T. globulosa* sp. nov. spores. 8a – Spore stained with Ziehl-Neelsen; 8b – spores stained with Iron-haematoxylin; the polar filament is extruded; 9 – fresh spore. Scale bars: 10 μm.

homogenous and occupied all extracapsular space behind polar capsules with sporoplasmic nuclei, 0.8-0.9 μm in diameter. An iodinophilous vacuole was absent.

Differential diagnosis. The studied species was compared to 21 *Thelohanellus* spp. infecting fish (Table 8). It differs from all these species by morphometric characters. Spores of the novel species are elongate to oval, with acuminated anterior ends, similar to *T. mrigalae, T. sanjibi* and *T. sudevi.* However, oval shaped spores with a slight knob-like projection at the anterior end in *T.*

Table 7. Measurements (μm) of *T. kanjalensis* sp. nov.

Character	Range	Mean value	SD
LS	11.4-11.8	11.67	0.28
WS	6.4-6.8	6.6	0.28
LPC	7.4-7.6	7.5	0.14
WPC	3.1-3.5	3.3	0.28
Ratio: LS/WS		1.7	
NC		4-6	
Parietal Folds		absent	

mrigalae, oval to spherical spores in *T. sanjibi* and *T. sudevi* differentiate them from the new species. The polar capsule of the described species was pyriform to oblong oval, with the prominent neck leading to the fine duct, which opened outside at the anterior end of the spore. The polar capsule occupied more than a half of the spore body cavity. In contrary to this, in *T. mrigalae* the polar capsule is oval, in *T. sanjibi* - broadly ovoid to almost spherical, and in *T. sudevi* it is pyriform and occupies nearly half of the spore body cavity. Furthermore, this new species can be distinguished from congeners by shell valves darkly stained mediolaterally.

In view of these differences, we assign a myxozoan parasite of *Catla catla* from Kanjali wetland to a new species of the genus *Thelohanellus.*

Taxonomic summary of *T. kanjalensis* sp. nov.

Plasmodia: small, white, round, 0.4-0.5 mm in diameter.

Spores: spores measure 11.67 × 6.6 μm, elongate to oval, with acuminated anterior end having a distinct pore, and rounded posterior end with lateral sides nearly parallel to each other. Shell valves stain dark-blue with Iron-haematoxylin in the middle part of the spore body. Polar capsules pyriform to oblong oval in shape measure 7.5 × 3.3 μm and occupy more than a half of the spore body cavity.

Type host: *Catla catla* (Hamilton, 1822) vern. thail.

Type locality: Kanjali wetland, Punjab, India.

Type specimen: paratypes are spores stained by Ziehl-Neelsen and Iron-haematoxylin, deposited in the museum of Department of Zoology, Punjabi University, Patiala, India- Slide No. C/I/ZN 10.05.2009 and C/I/IH 10.O5.2009.

Site of infection: skin of snout.

Prevalence of infection: 30% (3/10).

Pathogenicity: non-pathogenic

Etymology: the specific epithet kanjalensis highlights the name of the type locality.

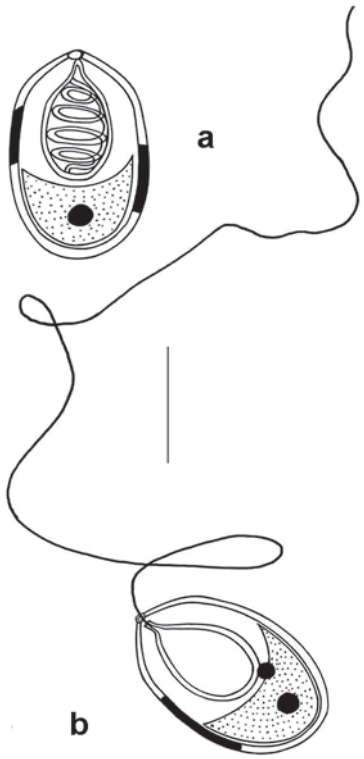
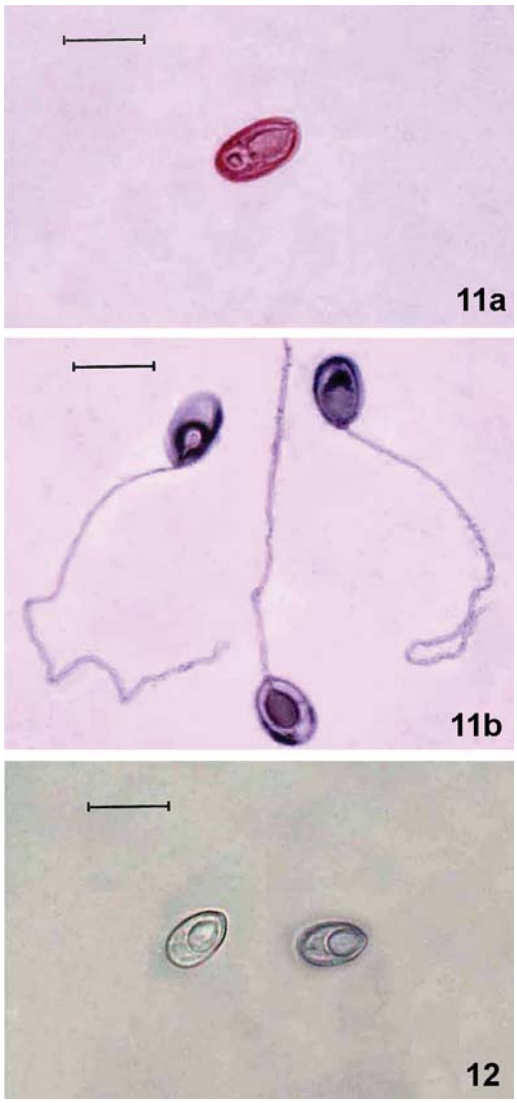


Fig. 10. Line drawing (Camera Lucida) of *T. kanjalensis* sp. nov. a, – Spores stained with Ziehl-Neelsen (valvular view); b – spore stained with Iron-haematoxylin; the polar filament is extruded. Scale bar: 0.005 mm.



Figs 11, 12. Micrographs of *T. kanjalensis* sp. nov. spores. 11a – Spore stained with Ziehl-Neelsen; 11b – spores stained with Iron-haematoxylin, with extruded polar filaments; 10 – fresh spores. Scale bars: 10 μm.

Acknowledgements

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Table 8. *Thelohanellus kanjalensis* sp. nov. and morphologically similar species (measurements are in micrometer).

Species	Host	Site of infection	Locality	Spore	Polar capsule
T. kanjalensis sp. nov. (present study)	*Catla catla*	skin of snout	Kanjali wetland, Punjab (India)	11.67×6.6	7.5x3.3
T. niloticus Gurley, 1893	*Labeo niloticus*	skin of head	Nile (Egypt)	5.0×3.5	—
T. mrigalae Tripathi, 1952	*Cirrhina mrigala*	skin on the head	West Bengal (India)	10.8-12.0(11.4)	5.4-7.2x3.6-5.0
T. gangeticus Tripathi, 1952	*Chela bacaila*	muscles	West Bengal (India)	16.2-17.5x5.4	7.2×2.5
T. nikolski Akhmerov, 1955	*Cyprinus carpio haematopterus*	fin	Amur basin (Russia)	19.0-20.0×12.0	7.0×5.0-6.0
T. chrysopomati Lalitha Kumari, 1969	*Barbus chrysopoma*	gill contents	Andhra Pradesh (India)	12.4×5.4	6.5×2.7
T. potaili Lalitha Kumari, 1969	*L. potail*	fin	Andhra Pradesh (India)	13.0×8.2	5.9×4.3
T. coeli Sarkar et Mazumdar, 1983	*Tachysurus tenuispinis*	gall bladder	West Bengal (India)	12.75×7.12	7.13×3.2
T. wallagoi Sarkar, 1985	*Wallago attu*	gall bladder	West Bengal (India)	9.25×4.85	5.47×2.71
T. bengalensis Sarkar et Raychaudhury, 1986	*Catla catla*	gall bladder	West Bengal (India)	10.0-12.0 (10.95)× 5.5-7.5(6.59)	3.75-7.0 (5.42)× 3.0-4.5(3.47)
T. valeti Fomena et Boui×, 1987	*Barbus jae, B. aspilus*	intestine, muscles	Africa	11.0-13.0×4.0-5.0; 13.5-19.5×4.0-7.0	5.5-7.0×2.0-3.0; 6.0-9.0×2.0-3.5
T. sanjibi Sarkar et Ghosh, 1990	*Mystus gulio*	kidney	West Bengal (India)	12.0-13.0(12.52)× 8.0-8.5(8.27)	4.0-5.0(4.52)× 3.5-4.5(4.0)
T. sudevi Sarkar et Ghosh, 1990	*Amblypharyn-godon mola*	kidney	West Bengal (India)	13.0-15.0 (14.0)× 5.0-6.5(5.87)	4.75-6.0(5.17)× 2.0-3.0(2.65)
T. assambai Fomea 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 Kostoıngue et al., 1999	*L. parvus*	gills	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. endodermitus Mukhopadhyay et Haldar, 2004	*L. rohita*	undersurface of scales	West Bengal (India)	13.66×5.35	7.14×3.0
T. habibpuri Acharya et 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. 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, Manipur (India)	20.4–22.1 (21.33)× 8.5–10.2 (9.43)	10.2–11.05 (10.79)× 3.4.0 – 4.25 (3.78)

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