Description of three new species of the genus *Myxobolus* infecting carp fishes of India

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Abstract *Myxobolus* Bütschli, 1882 (Myxozoa, Myxosporea, Bivalvulida, Myxobolidae) is an important parasitic protozoan of freshwater fishes reported from almost all over the world. The severity of infection may lead to mortality of the host fish. The present paper deals with the description of three new species of *Myxobolus* Bütschli, 1882, *Myxobolus sonarpurensis* sp. nov., *Myxobolus elongatum* sp. nov. and *Myxobolus petalum* sp. nov. from a freshwater minor carp *Labeo bata* (Hamilton, 1822) and major carp *Labeo rohita* (Hamilton, 1822) respectively from West Bengal, India. Spores of *Myxobolus sonarpurensis* sp. nov. measures $12.16\ \mu\text{m} \times 6.74\ \mu\text{m}$, with two elongated unequal sized polar capsules measuring, $8.84\ \mu\text{m} \times 3.019\ \mu\text{m}$ and $7.71\ \mu\text{m} \times 3.12\ \mu\text{m}$. Spores of *Myxobolus elongatum* sp. nov. are $16.23\ \mu\text{m} \times 7.9\ \mu\text{m}$ with two equal polar capsules $8.896\ \mu\text{m} \times 3.468\ \mu\text{m}$ and $6.51\ \mu\text{m} \times 3.46\ \mu\text{m}$. In comparison to aforementioned two new species, *Myxobolus petalum* sp. nov. have two equal polar capsules, $7.905\ \mu\text{m} \times 2.975\ \mu\text{m}$ ($2.9\ \mu\text{m}$) in each spore, $12.07\ \mu\text{m} \times 5.95\ \mu\text{m}$.

Keywords *Myxobolus sonarpurensis* sp. nov. · *Myxobolus elongatum* sp. nov. · *Myxobolus petalum* sp. nov. · *Labeo rohita* · *Labeo bata* · West Bengal · India

Introduction

Myxosporeans are an abundant and diverse group of parasites infecting fishes, amphibians and reptiles (they have also recently been reported from birds and mammals). According to Lom and Dykova (2006), the Phylum Myxozoa includes four malacosporean and 2180 myxosporean species in a total of 62 genera. Myxosporeans (Phylum: Myxozoa) are microscopic, multicellular, spore-forming parasites of aquatic animals characterized as host, organ and tissue specific organisms. *Myxobolus* Bütschli 1882 (Myxobolidae) remains by far the largest genus within the Myxosporea. In terms of freshwater fishes, the majority of studies both in freshwater and culture systems deal with fishes of the northern hemisphere (Eurasia and North America), while studies on myxosporeans of marine fishes have mostly been done worldwide on cage-cultured species. Data on myxosporean infections were also presented from different countries. Kalavati and Nandi (2007) reported the distribution of one hundred myxosporean species infecting fresh water as well as marine fish from India but the phylum Myxozoa has been studied by only a limited number of workers in the Indian subcontinent, most of the work on this Phylum has been carried out, on both freshwater and marine fishes, in two states, namely West Bengal and Andhra Pradesh. During the last decade, Basu and Haldar (1999, 2002a, b, 2003a, b, 2004), Bandyopadhyay et al. (2007), Acharya and Dutta (2007) and Basu et al. (2006, 2009) have contributed a significant number of new species from freshwater and marine fishes belonging to genera

Myxobolus, *Thelohanellus* *Myxidium* and *Henneguya*. Reports on myxosporean species from other parts of India are few, excepting from freshwater fishes of Manipur (Hemananda et al. 2009, 2010) and Kerala (Sheeja and

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Janardanan 2006). Since 2007, there are numerous myxosporean species, belonging to *Myxobolus*, described from India. During the survey on protozoan parasites of fresh water carp fishes of West Bengal three species of *Myxobolus* have so far been recorded during winter season i.e., October 2013–March 2014. In the present study, three new species collected from West Bengal, India, i.e., *Myxobolus sonarpurensis* sp. nov. and *Myxobolus elongatum* sp. nov. from *Labeo bata*, and *Myxobolus petalum* sp. nov. from *Labeo rohita* have been described.

Materials and methods

Fish samples and parasitological examination

Hosts examined in the present study namely, *L. rohita* and *L. bata* were collected during the period between October 2013 and March 2014, from ponds and markets of two districts of West Bengal, India, i.e., Sonarpur, and Garia of South 24 parganas and Chinsurah of Hoogly. The small-sized, young in age fishes were then brought alive to the parasitology laboratory of University of Kalyani, Kalyani for parasitological examinations. When whitish spots were found in gill lamellae, impression preparations of gills were made on clean glass slides with a drop of 0.9 % NaCl solution, covered with cover slips, and examined for the presence of myxospores. Some of the impression preparations were stained with Lugol's iodine solution to observe iodophilous vacuoles in myxospores, and others were treated with 8 % KOH for polar filament extrusion from myxospores. For permanent specimens, the impression preparations were fixed in absolute methanol for 2–8 min and then stained with Giemsa solution for about 25–30 min, then washed in tap water and dried. Permanent slides were prepared with DPX mountant. Sporogonic plasmodia, when found, were carefully removed with sterile needles, put on clean slides with drops of distilled water, covered with cover slips and sealed with DPX mountant for examination of fresh spores under an oil immersion lens of Olympus KH phase contrast microscope. Photomicrographs of fresh and stained spores were taken at 1000× magnification. Drawings were made from stained materials with the aid of camera lucida.

Measurements based on 20 fresh spores (stained with both Lugol's Iodine and Geimsa) were done with a calibrated ocular micrometer according to Lom and Arthur (1989) and Lom and Dykova (1992). All measurements are expressed in micrometer (µm) as mean ± standard deviation (SD) followed by the range in parentheses. The following abbreviations are used in the present study: LS, length of spore; LPC, length of polar capsule WS, width of spore; PF, polar filament and WPC, width of polar capsule.

Results

A total one hundred thirteen (n = 113) fishes, of which fifty-one number of *Labeo rohita* (n = 51) and sixty-two number of *Labeo bata* (n = 62) have been examined at the laboratory for myxozoan parasites. Three myxobolid species were observed in microscopic cysts attached to the mucous membrane of gill lamellae. Based on morphological parameters, all three myxobolid species, found in the gill of carps correspond to definition of the genus *Myxobolus* Bütschli, 1882, but none of them are known species.

Systematic position

Phylum: Myxozoa Grasse, 1970.

Class: Myxosporea Butschli, 1881.

Order: Bivalvulida Schulman, 1959

Sub-order: Platysporina Kudo, 1919

Family: Myxobolidae, Thelohan, 1892

Genus: *Myxobolus*, Butschli, 1892
Myxobolus sp. nov.

Description

Myxobolus sonarpurensis sp. nov. (Table 1; Fig. 1a–d)

Plasmodia

Rounded. Small in size (2–3 mm in diameter). Attached to the mucous membrane of gill lamellae. Creamy white in colour.

Spore (based on 20 spores from fully developed plasmodia: In, valvular view, spores water droplet shaped, measuring $12.16 \pm 0.95 \mu\text{m}$ (11.05–13.26 µm) × 5.9–6.1 µm (6.74) µm. The surface of shell valve is smooth. Two slender and elongated polar capsules unequal in shape (left one slight bigger than the right one) occupying the anterior portion of spore measuring (8.84 µm × 3.012 µm; 7.71 µm × 3.12 µm). Filamentous coils present in the capsules. Polar filament is visible measuring $22.10 \pm 0.048 \mu\text{m}$ (19–23) µm. Sporoplasm with round iodophilous vacuole.

Spore index

LS:WS = 1:0.554
LLPC:WLPC = 1:0.340
LSPC:WSPC = 1:0.404
LLPC:LSPC = 1:0.872
WLPC:WSPC = 1:1

Table 1 The measurements (in μm) and ratio of *Myxobolus sonarpurensis* sp. nov.

Parameters	Range (μm)	Mean (μm)	Standard deviation (SD)
Length of the spore (LS)	11.05–13.26	12.16	0.95
Width of the spore (WS)	5.9–6.1	6.74	0.078
Length of larger polar capsule (LLPC)	8.16–9.18	8.84	0.517
Width of larger polar capsule (WLPC)	2.9–3.06	3.019	0.051
Length of smaller polar capsule (LSPC)	7.14–8.16	7.71	0.485
Width of smaller polar capsule (WSPC)	3.06–3.162	3.12	0.054
Length of polar filament	19–23	22.1	0.048

Fig. 1 **a, b** Light microscopic photomicrographs of *Myxobolus sonarpurensis* sp. nov. (scale bar 10 μm); **c, d** camera lucida drawings of *Myxobolus sonarpurensis* sp. nov. (scale bar 10 μm)

Table 2 The comparative account of the *Myxobolus sonarpurensis* sp. nov. with morphologically similar species (measurements are in micrometer)

Name of the species	Host	Site of infection	Length of spore (μm)	Width of spore (μm)	Length of larger polar capsule (μm)	Width of larger polar capsule (μm)	Length of smaller capsule (μm)	Width of smaller polar capsule (μm)	Polar filament (μm)	Authors
<i>M. buccorooofus</i>	<i>Labeo bata</i> Ham.	Roof of buccal cavity	11.6–12.7 (12.1)	6.4–8.1 (7.1)	4.5–5.3 (4.9)	2.7–3 (2.9)	2–2.9 (2.5)	1.3–1.7 (1.5)	Absent	Basu and Halder (2004)
<i>M. esomi</i>	<i>Esomus</i> sp.	Caudal fin	11.2–12.4 (11.8)	6.8–7.2 (7.0)	4.8–5.2 (5.2)	3–3.2 (3.16)	1.6–2	1	Absent	Kalavati and Narasimhamurti (1984)
<i>M. indirae</i>	<i>Cirrhinia mirigala</i> Ham.	Scales of tail fin and Head cartilage	11–14 (12.6)	9–11 (9.6)	4–6 (4.7)	2–2.5 (2.2)	–	–	Absent	Landsberg and Lom (1991)
<i>M. mahendrar</i>	<i>Catla catla</i> Ham.	Gill arch epithelium	11.52–13.96 (12.7)	9.77–10.47 (9.2)	6.28–7.33 (6.98)	3.49–4.19 (3.73)	4.19–6.98 (5.44)	3.14–3.49 (3.42)	Absent	Kundu (1985)
<i>M. manoramae</i>	<i>Catla catla</i> Ham. × <i>Labeo rohita</i> (hybrid)	Tail fin	11.8 (10.7–13.1)	(4.8–6.3) 5.6	5.5–6.6 (6.2)	2.0–2.5 (2.2)	–	–	Absent	Gupta and Khera (1988)
<i>M. seshadri</i>	<i>Labeo fimbriatus</i> Bloch	Gills	11.4–12.9 (12.21)	8.6–10 (9.04)	5.7	2.9–4.3 (3.66)	4.3–5 (4.9)	2.5–3.6 (2.99)	Absent	Sarkar (1986)
<i>Myxobolus sonarpurensis</i> sp. nov.	<i>Labeo bata</i>	Gills	11.05–13.26 (12.16)	5.9–6.1 (6.74)	8.16–9.18 (8.84)	2.9–3.06 (3.019)	7.71 (7.14–8.16)	3.12 (3.06–3.162)	Present	Basu and Halder (2002b)
									22.1	Lalitha Kumari (1969)
									19–23	Present study

Taxonomic summary

Type host *Labeo bata* (Hamilton, 1822)

Type locality Sonarpur (22.4200°N, longitude: 88.4200°E), South 24 Parganas, West Bengal, India

Type specimens Slide No. MB/PA/KU/011-015 containing the holotype and four slides MB/PAKU/09-12 containing paratypes has been deposited in the collection of Parasitology Laboratory, Department of Zoology, University of Kalyani, West Bengal, India.

Symbiotype The host specimen bearing no. CM/PARA/09-17 deposited in the museum of the Parasitology Laboratory, Department of Zoology, University of Kalyani, West Bengal, India.

Specific epithet The specific epithet “*sonarpurensis*” has been given after the name of the habitat from where the host has been captured.

Site of infection Gill lamellae

Prevalence of infection 28 out of 62 hosts examined (45.16 %).

Remarks (Table 2)

Myxobolus sonarpurensis sp. nov.

The present species can be distinguished from its closely related species by its shape, measurement of the spore, polar capsules and geographical location. In having unequal polar capsules, elongated spore body and polar filament with filamentous coil justifies its inclusion in the genus and can be segregated from the other myxozoans reported from the gills of *Labeo bata*, having two equal polar capsules and. The *Myxobolus* species described here is unique in measurement of spore body, polar capsule, host fish and habitat from its closely related species with unequal polar capsules.

While comparing the present form, with its closely related species it has been found that the length of the spore of the present form is smaller in comparison to spore of *M. seshadri*, *M. mahendrae*, and *M. indirae* but larger in case of *M. esomi* and *M. manoramae* and equal in case of *M.*

buccoroofus. The shape of the spore also varies. The width of the spore of the present form is much lesser than the described species expecting *M. manoramae* which is lesser than that of the present form. The species under description is in shape of water droplet and somewhat oval having one small and another slightly large cylindrical polar capsules. The study of the polar capsule shows that the posterior end of both the polar capsule is rounded with pointed anterior tip. The polar capsule occupies more than half of the spore and the larger polar capsule extends up to the neck of the spore leaving behind the smaller polar capsule that resides in the middle of the spore body. The two polar capsule remains distended from each other leaving behind a large intercapsular process. Further study reveals that the length and width of the polar capsule of present form is comparatively larger than the entire compared closely related species excepting *M. seshadri* and *M. manoramae* which have much wider polar capsule than the described one and rest of the species have much narrower polar capsule than the species under discussion. The polar filament is clearly visible in the species under discussion but filamentous coil which is situated perpendicular to the polar capsular axis have not been noticed. While comparing the present form with its closely related species absence of polar filament have been observed which is very much prominent in the present form, which makes it more unique from the other. In the present species sporoplasm occupies the extra-capsular space behind the polar capsule. The shape is much larger in the present form when compared to the other described forms.

In addition, the present form has been further compared with the other two proposed new species namely, *M. elongatum* sp. nov. and *M. petalum* sp. nov. In respect to the shape which is water droplet shaped in the present form while it is elongated and thinner in *M. elongatum* and petaloid shaped in *M. petalum* sp. nov. From the spore dimension we can conclude that *M. elongatum* sp. nov. is much bigger than present form in length of the spore while polar capsules of both the species are somewhat similar in measurement but slightly bigger in *M. elongatum* sp. nov. and occupies half of the spore body cavity. While comparing the former two with *M. petalum* sp. nov. the major difference lies in the spore index. The polar capsule is

Table 3 The measurements (in μm) and ratio of *Myxobolus elongatum* sp. nov

Parameters	Range (μm)	Mean (μm)	Standard deviation (SD)
Length of the spore (LS)	13–17.68	16.23	2.89
Width of the spore (WS)	7–9	7.9	0.87
Length of larger polar capsule (LLPC)	7–10	8.896	0.082
Width of larger polar capsule (WLPC)	3–4	3.468	0.242
Length of smaller polar capsule (LSPC)	6–7	6.513	0.261
Width of smaller polar capsule (WSPC)	3–4	3.468	0.242

Fig. 2 a, b Light microscopic photomicrographs of *Myxobolus elongatum* sp. nov. (scale bar 10 µm); c camera lucida drawings of *Myxobolus elongatum* sp. nov. (scale bar 10 µm)

equal in case of *M. petalum* sp. nov. and unequal in the previous two. The spore index of both the species are significantly different. The comparative study on filamentous coil shows that in present form, it is distinctly visible while in other two, it is invisible.

Myxobolus elongatum sp. nov. (Table 3; Fig. 2a–c)

Plasmodia

Small, macroscopic (1–2 mm), attached to the mucous membrane around gill lamellae. 5–10 spores present. Spore (based on 20 spores from fully developed plasmodia).

In valvular view, spores remarkably elongated, lancet-shaped, measuring $16.23 \pm 2.89 \mu\text{m}$ (13–17.68 µm) $\times$ (7–9 µm) (7.9 µm). The surfaces of shell valve smooth. Two slender and elongated polar capsules unequal in shape occupying the anterior portions of spores and measuring $7\text{--}10 \mu\text{m}$ (8.896 µm) $\times$ $3\text{--}4 \mu\text{m}$ (3.468 µm) and $6\text{--}7 \mu\text{m}$ (6.513 µm) $\times$ $3\text{--}4 \mu\text{m}$ (3.468 µm). Filamentous coils have not been observed in the capsules. Sporoplasm with round iodophilous vacuole.

Spore index

LS:WS = 1:0.486
 LLPC:WLPC = 1:0.389
 LSPC:WSPC = 1:0.532
 LLPC:LSPC = 1:0.732
 WLPC:WSPC = 1:1

Taxonomic summary

Type host *Labeo bata* (Hamilton, 1822)

Type locality Garia (Lon-88.3967486; Lat-22.46) South 24 parganas, West Bengal, India

Type specimens Slide No. MB/PA/KU/07-08 containing the holotype and four slides MB/PAKU/09-12 containing paratypes has been deposited in the collection of Parasitology Laboratory, Department of Zoology, University of Kalyani, West Bengal, India.

Symbiotype The host specimen bearing no. CM/PARA/01-07 deposited in the museum of the Parasitology Laboratory, Department of Zoology, University of Kalyani, West Bengal, India.

Site of infection Gill lamellae

Prevalence of infection 38 out of 62 hosts examined (61.29 %).

Specific epithet The specific epithet “*elongatum*” has been given after the name of the shape of the species described in the communication.

Remarks (Table 4)

Myxobolus elongatum sp. nov.

The present species can be distinguished from its closely related species by its shape, measurement of the spore, polar capsules and geographical location. In having unequal polar capsules, the myxozoan isolated from the gills of *Labeo rohita*, have been presented in this communication can be segregated from the earlier described species of the genus *Myxobolus* having equal polar capsules. The *Myxobolus* species described here is unique in measurement from its closely related species.

While comparing the present form with its closely related species it has been found that the length of the spore of the present form is smaller only in comparison to *M. channai* but larger in case of all the closely related species namely, *M. catlae*, *M. cylindricus*, *M. indiae*, *M. maruliensis*, *M. puntiusi*, *M. variformis* and *M. vedavatiensis*. The shape of the spore also varies. The width of the spore of the present form is much bigger than all the closely related species excepting *M. puntiusi* and *M. vedavatiensis* which have

Table 4 The comparative account of the *Myxobolus elongatum* sp. nov with morphologically similar species (measurements are in micrometer)

Name of the species	Host	Site of Infection	Length of spore (μm)	Width of spore (μm)	Length of larger polar capsule (μm)	Width of larger polar capsule (μm)	Length of smaller polar capsule (μm)	Width of smaller polar capsule (μm)	Polar filament (μm)	Authors
<i>M. catlae</i>	<i>Cirrhina mrigala</i> Ham., <i>Laboe bata</i> Ham.	Gills	14.5–16.5 (14.9)	6.18	10.3–12.36	2.06–3.01	–	–	Absent	Chakravarty (1943)
<i>M. channai</i>	<i>Channa punctatus</i> Bloch	Fins, body muscles, kidney, liver	14.5–18.0 (17.2)	6.0–6.5 (6.3)	9–10.8 (10.2)	2.8–3.2 (3.0)	7.2–8.8 (7.5)	2.8–3.2 (3.0)	Absent	Kalavati et al. (1981) Gupta and Khera (1988)
<i>M. cylindricus</i>	<i>Channa gachua</i> Ham.	Kidney	12.8–16.32 (14.37)	4.48–6.4 (4.91)	4–5.2 (4.4)	1.12–2.24 (1.68)	–	–	Absent	Sarkar et al. (1985) Gupta and Khera (1988)
<i>M. indiae</i>	<i>Barbus sarana</i> Ham.	Gill filaments	12.4–15 (13.7)	6.4–8.6 (7.3)	5.7–7.1 (5.9)	1.4–2.5 (2.1)	5–6.4 (5.2)	1.4–2.5 (2.1)	Absent	Lalitha Kumari (1969) Gupta and Khera (1988)
<i>M. maruliensis</i>	<i>Channa marulius</i> Ham.	Kidneys	12–17.5 (14.37)	2.5–5 (4.23)	7.5–13 (10.05)	1–2 (1.55)	–	–	Absent	Sarkar et al. (1985) Gupta and Khera (1988)
<i>M. puntiusi</i>	<i>Puntius ticto punctatus</i> Day	Heart wall	13.5–16.5 (15.0)	10.5–12 (11.02)	6.75–7.5 (7.08)	3–4.5 (3.67)	5.25–6.75 (5.7)	–	Absent	Sheeja and Janardanan (2006)
<i>M. variformis</i>	<i>Mystus gulio</i> Ham.	Body muscles, gills	13–17.9 (15.2)	4.9–8.1 (5.65)	8.1–11.4 (9.67)	1.6–4 (2.84)	6.5–11.4 (8.6)	1.6–3.2	Absent	Halder et al. (1996) Kalavati and Nandi (2007)
<i>M. vedavatiensis</i>	<i>Cirrhina mrigala</i> Ham.	Gills	13–15 (13.8)	8–10 (9.2)	6–7 (6.2)	3–4 (3.4)	3–5 (3.9)	2–3 (2.6)	Absent	Seenappa and Manohar (1981)
<i>Myxobolus elongatum</i> sp. nov	<i>Laboe bata</i>	Gills	13–17.68 (16.23)	7–9 (7.9)	7–10 (8.896)	3–4 (3.468)	6–7 (6.513)	3–4 (3.468)	Absent	Present study

Table 5 The comparative account of the *Myxobolus petalum* sp. nov

Parameters	Range	Mean	Standard deviation (SD)
Length of the spore (LS)	11–13	12.07	1.19
Width of the spore (WS)	5–7	5.95	0.53
Length of polar capsule (LPC)	7–8	7.905	0.52
Width of larger polar capsule (WPC)	2.5–3	2.975	0.28

Fig. 3 **a, b** Light microscopic photomicrographs of *Myxobolus petalum* sp. nov. (scale bar 10 μ m); **c, d** camera lucida drawings of *Myxobolus petalum* sp. nov. (scale bar 10 μ m)

much wider spore dimension, than that of the present form. The species under description is water droplet shaped and somewhat oval having one small and another slightly large cylindrical polar capsule. The study of the polar capsules shows that the posterior end of the larger polar capsule is

rounded lower tip and somewhat pointed anterior tip. The larger and smaller polar capsule occupies more than half of the spore. Further study shows that the polar capsule of present form is comparatively smaller than that of *M. indiae*, *M. cylindricus*, *M. puntiusi* and *M. vedavatiensis* while

larger than *M. channai*, *M. maruliensis* and *M. variformis*. The width of the polar capsule varies in each species but *M. cylindricus* and *M. maruliensis* are much narrower than the rest of the species and also with the present form. These differences in the length and width of each species with each other also reflect in the percentage of spore index and thus making them distinctively different from each other. Moreover while comparing the smaller polar capsules the same pattern can be observed. While comparing the present form with *M. puntiusi* and *M. indiae* in respect to the dimension of the smaller polar capsule it has been observed that both the above mentioned species have the lowest dimension whereas *M. variformis* and *M. channai* having the highest dimension.

The polar filament was not visible during the time of description, but filamentous coil have been noticed which is situated perpendicular to the polar capsular axis. Sporoplasm occupies the extra-capsular space behind it. The shape is much larger in the present form when compared with the other described forms.

In addition, the present form have been further compared with the other two proposed new species namely, *M. sonarpurensis* and *M. petalum*. The appearance of the present form is elongated, lancet-shaped while in *M. sonarpurensis* it is water droplet shaped and *M. petalum* petaloid shaped. The study of spore shows, it is much bigger than the present form in comparison to *M. sonarpurensis* and *M. petalum*. Polar capsule of the present form and *M. sonarpurensis* are somewhat similar in measurement but slightly bigger in the present form and occupies half of the spore body cavity. But while comparing the former two with *M. petalum* the major difference lies not only in their appearance and spore index but also the polar capsule which is equal in case of *M. petalum* and unequal in the previous two. The spore index of both the species are significantly different.

Myxobolus petalum sp. nov. (Table 5; Fig. 3a–d)

Plasmodia

Rounded. Small in size (2–3 mm in diameter). Attached to the mucous membrane of gill lamellae. Creamy white in colour.

Spore (based on 10 spores from fully developed plasmodia).

In valvular view spores small and oval measuring $12.07 \pm 1.19 \mu\text{m}$ (11–13 μm) $\times$ 5–7 μm (5.95 μm). The surfaces of shell valve smooth. Two slender and elongated polar capsules equal in shape occupying the anterior portions of spores and measures 7–8 μm (7.905 μm) $\times$ 2.5–3 μm (2.975 μm). Filamentous coils have not be observed in the capsules. Sporoplasm with round iodophilous vacuole.

Spore index

LS:WS = 1:0.492

LPC:WPC = 1:0.376

Taxonomic summary

Type host *Labeo rohita* (Hamilton, 1822)

Type locality Hooghly (22.8956°N, 88.4025°E) West Bengal, India.

Type specimens Slide no. MB/PA/KU/07-08 containing the holotype and four slides MB/PAKU/09-12 containing paratypes has been deposited in the collection of Parasitology Laboratory, Department of Zoology, University of Kalyani, West Bengal, India.

Symbiotype The host specimen bearing no. CM/PARA/01-07 deposited in the museum of the Parasitology Laboratory, Department of Zoology, University of Kalyani, West Bengal, India.

Site of infection Gill lamellae

Prevalence of infection 18 out of 51 hosts examined (35.29 %).

Specific epithet The specific epithet “*petalum*” has been given after the name of the shape of the species described in the communication.

Remarks (Table 6)

Myxobolus petalum sp. nov.

The present species can be distinguished from its closely related species by its shape, measurement of the spore, polar capsules and geographical location. The organism possesses two equal polar capsules and so can be placed in the group of species with equal polar capsules (Tripathi, 1952).

The shape of the spore of the present species is tear shaped, smaller in size and pointed anteriorly which resembles closely with *M. aligarhensis*, *M. anili*, *M. bankimi*, *M. clarii*, *M. edellae*, *M. manoramae* and *M. narasii*, but the spores of *M. aligarhensis*, *M. clarii* and *M. manoramae* are much wider than that of the present form. Moreover, in *M. aligarhensis* the polar capsules are also not equal whereas, in the described species it is equal. While comparing the present form with its closely related species in respect to shape and measurement of spores it has been found that, the spore is smaller than that of *M. anili*, *M. edellae*, *M. bankimi* but wider in respect to *M. edellae* and *M. bankimi*. *M. narasi* have almost similar spore length than that of the species under discussion but shows differences in having much wider spore surface.

While comparing the polar capsule of the present form with its closely related species it has been found that, the

Table 6 The comparative account of the *Myxobolus petalum* sp. nov with morphologically similar species (measurements are in micrometer)

Name of the species	Host	Site of Infection	Length of spore (μm)	Width of Spore (μm)	Length of Capsule (μm)	Width of Capsule (μm)	Polar filament (μm)	Authors
<i>M. aligarhensis</i>	<i>Ophiocephalus punctatus</i> Bloch	Accessory respiratory membrane	12–14	6–7.5	6.5–8	2–2.5	Absent	Bhatt and Siddiqui (1964)
<i>M. anili</i>	<i>Rhinomugil corsula</i> Ham., <i>Liza macrolepis</i> Smith	Duodenal mesentery, intestinal villi	9.8–11.06 (10.74)	7.92–9.84 (8.69)	4.74–5.05 (4.82)	2.48–3.16 (3.05)	Absent	Sarkar (1989)
<i>M. bankimi</i>	<i>Sicamugil cascasia</i> Ham.	Inner wall of gall bladder	10–11 (10.6)	8–9 (8.7)	3.5–4.5 (3.97)	2.5–3 (2.72)	Absent	Sarkar (1999)
<i>M. clarii</i>	<i>Clarias batrachus</i>	Gall bladder liver, testes, ovary	11.3–12.4	10.3	6.8	3.09	Absent	Chakravarty (1943)
<i>M. edellae</i>	<i>Ctenopharyngodon edella</i> Ham.	Kidneys	10.5–11.5 (10.7)	9–10 (9.4)	5.5–6.5 (6.14)	2.5–3.5 (3.12)	Absent	Sarkar (1999)
<i>M. manoramae</i>	<i>Catla catla</i> Ham. <i>Labeorohita</i> Ham. (hybrid)	Tail fin	11.8 (10.7–13.1)	5.6 (4.8–6.3)	5.5–6.6 (6.2)	2.0–2.5 (2.2)	Absent	Basu and Haldar (2002b)
<i>M. narasii</i>	<i>Mugil waigensis</i> Quoy & Gaimard	Intestine	12.5–13.5 (12.8)	8.6–9.5 (9.0)	2.9–3.6 (3.2)	1.6–1.8 (1.7)	Absent	Narasimhamurti (1970)
<i>Myxobolus petalum</i> sp. nov	<i>Labeo bata</i>	Gills	11–13 12.07	5–7 5.95	7–8 7.905	2.5–3 2.975	Absent	Landsberg and Lom (1991) Present study

polar capsules of the present species have short neck, less extended spore body with pointed anterior and rounded posterior end and situated anteriorly just behind the apex of the spore, running parallel to each other whereas in *M. aligarhensis* the polar capsules are unequal and thus leave a marked intercapsular process in between. Comparative study on inter-capsular process shows that the species under discussion occupies less than half of the spore body and they are placed anteriorly, distanced from each other leaving a vacuolar space in the lower part of the spore whereas among the closely related species the intercapsular process is less extended.

The species under discussion has also been compared with two proposed new species namely, *M. elongatum* and *M. sonarpurensis* for morphological variations. The spore and polar capsules of *M. elongatum* are much larger than that of the species under discussion. Moreover, the spore is elongated and wider in *M. elongatum* but it is petaloid and thinner in present form. Besides, the spore index of LS:WS of both the species differs marginally.

While comparing with *M. sonarpurensis* sp. nov., the present species show its differences having equal sized spore but different sized polar capsules of *M. sonarpurensis* sp. nov. Thus both the species shows variation in the spore index. In view of the above differences, the present species under discussion is considered to be new to science.

Conclusion

The paper deals with three noble species belonging to the phylum Myxozoa Grasse, 1970 of the genus *Myxobolus* Bütschli, 1881. These species have been isolated from the fresh water food fishes of West Bengal, India. After thorough comparison with its closely related species and with each other presented here, it may confirmly inferred that the species are new to science and very much different from each other in respect of morphometry and geographic locations. Thus after extensive survey and maintaining all aspects of taxonomy, dealing with the morphological and geographical descriptions of species concern, these three species being described here as new to science.

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