A new myxosporean species *Myxobolus sclerii* sp. nov. and one known species *M. stomum* Ali et al. 2003 from two Indian major carp fishes

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Received: 5 February 2010 / Accepted: 20 May 2010 / Published online: 8 October 2010
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Abstract The present communication deals with description of one new species of *Myxobolus* (Myxozoa: Myxospora: Bivalvulida), *M. sclerii* sp. nov. infecting eye ball of *Catla catla* (Hamilton) and redescription of *M. stomum* infecting scales of *Labeo rohita* (Hamilton), two major carps of Kanjali and Ropar Wetlands respectively. Spores of *M. sclerii* sp. nov. measure $7.9\text{--}9.5(8.7 \pm 1.13) \times 4.3\text{--}5.7(5 \pm 0.98) \mu\text{m}$ in size. Parietal folds absent. Polar capsules two, equal and measuring $4\text{--}5.4(4.7 \pm 0.98) \times 1\text{--}2.6(1.8 \pm 1.31) \mu\text{m}$ in size. A rod-shaped medium-sized intercapsular process is present. Iodinophilous vacuole present measuring $2.19\text{--}4.13(3.16 \pm 1.37) \mu\text{m}$ in diameter. Spores of *M. stomum* Ali et al. 2003 measure $9.8\text{--}10.3(10.0 \pm 0.35) \times 7.9\text{--}8.7(8.3 \pm 0.56) \mu\text{m}$ in size, with rounded anterior and posterior end. Spore valves smooth, symmetrical, thick measuring $0.88 \mu\text{m}$ in thickness. Parietal folds absent. Two anteriorly situated polar capsules are equal, pear-shaped measuring $4.8\text{--}5.2(5.0 \pm 0.28) \times 1.5\text{--}2.3(1.9 \pm 0.56) \mu\text{m}$ in size, each with a neck leading to a fine duct opening independently. Both polar capsules converge slightly anteriorly but diverge apart posteriorly occupying more than half of spore body. Intercapsular appendix is absent. Earlier, the parasite was recorded in the buccal cavity, muscles and lips of *Plectorhynchus gaterinus* (Forsskal), Egypt. A new locality-Ropar Wetland, a new location-scales and a new host- *Labeo rohita* (Hamilton) are recorded for this parasite.

Keywords Freshwater fish · *Myxobolus* spp. · India · Wetland

Abbreviations

LS	Length of spore
WS	Width of spore
LPC	Length of polar capsule
WPC	Width of polar capsule
ICP	Intercapsular process
NC	Number of coils of polar filaments
SD	Standard deviation

Introduction

Fishes constitute a favourite biotope for the development of large number of parasites including myxozoans. India is a country with numerous rivers and lakes having the most diversified fauna of freshwater fishes. As essential fish parasites, myxozoans are important group of microscopic metazoan parasites causing production losses, death and leave fish unfit for human consumption. Landsberg and Lom (1991) gave a list of 444 *Myxobolus* species followed by Eiras et al. (2005) who listed approximately 744 species of *Myxobolus* from all over the world. In India, more than 104 species of *Myxobolus* spp. have been reported (Kalavati and Nandi 2007) infecting freshwater as well as marine fishes. During the present study, one new species of *Myxobolus* i.e. *M. sclerii* sp. nov. and one already known species found infecting eye ball and scales of *Catla catla* (Hamilton) and *Labeo rohita* (Hamilton) respectively have been described. Description of new species has been prepared in accordance with the guidelines by Lom and Arthur (1989).

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Materials and methods

Fishes collected from the Kanjali and Ropar Wetlands were brought to the laboratory and examined for myxozoan infection. Plasmodia when found were removed and teased on slides and covered with cover slips 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 (based on 15–20 fresh spores treated with Lugol's Iodine solution) of spores were done with the aid of a calibrated ocular micrometer. All measurements are presented in μm as range values followed by mean $\pm$ SD in parentheses.

Results

Myxobolus sclerii sp. nov. (Figs. 1, 2, 5, 6, 7)

Plasmodia

Very small, white in colour, microscopic, present on each eye-ball, measuring 1–2 mm in diameter respectively. 30–32 spores present per plasmodium.

Spores (Table 1)

Histozoic, pyriform in shape and slightly boat-shaped in lenticular view. The anterior end of spore bluntly pointed, narrow containing two distinct openings, posterior end broad and rounded. Spores measure 7.9–9.5 (8.7 ± 1.13) $\times$ 4.3–5.7 (5.0 ± 0.9) μm in size. Spore valves thick, symmetrical, and smooth without any parietal folds measuring 0.67 μm in thickness. Polar capsules two, equal in size, measuring 4–5.4 (4.7 ± 0.98) $\times$ 1–2.6 (1.8 ± 1.31) μm in size, pyriform in shape with blunt anterior end and rounded posterior end, converging closely towards the anterior end but placed at distance posteriorly. They occupy more than half of the spore cavity, containing 4–5 turns of polar filaments aligned perpendicular to the axis of polar capsule. Polar filaments thin, thread-like, measuring 29.1 μm in length. A medium-sized, rod-shaped intercapsular process present. Three capsulogenic nuclei, two of them present beneath polar capsule and one in between polar capsules measuring 0.50 and 0.25 μm in diameter respectively. Sporoplasm agranular, homogeneous, half-moon shaped contains one sporoplasmic nucleus measuring 0.50 μm in diameter. Iodinophilous vacuole present measuring 2.19–4.13 (3.16 ± 1.37) μm in diameter.

Figs. 1–2 Photomicrographs of the spore of *M. sclerii* sp. nov. stained with Ziehl-Neelsen (unextruded) and Iron-haematoxylin (extruded polar filaments)

Taxonomic summary

Type host: *Catla catla* (Hamilton)

Type locality: Kanjali 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, No. is C/I/ZN 10.05.2009 and C/I/IH 10.05.2009.

Site of infection: Eye-ball (sclera)

Prevalence of infection: 30%(3/10)

Etymology: The species epithet “*sclerii*” is given to highlight the type location i.e. sclera of eye

M. stomum Ali et al. 2003 (Figs. 3, 4, 8, 9)

Plasmodia

White, large, spherical to round, 2–5 in number, 20–22 spores present per plasmodium.

Figs. 3–4 Photomicrographs of the spores of *M. stomum* Ali et al. 2003 stained with Ziehl-Neelsen (unextruded) and Iron-haematoxylin (extruded polar filaments). Scale bar: 10 µm

Table 1 Measurements (in micrometer) and Ratios of *M. sclerii* sp. nov.

Measurements	Range	Mean values	SD
LS	7.9–9.5	8.7	1.13
WS	4.3–5.7	5.0	0.9
LPC	4–5.4	4.7	0.98
WPC	1–2.6	1.8	1.31
Ratio: LS/WS		1.74	
ICP		B (medium-sized) and rod-shaped	
NC		4–5	
Parietal folds		Absent	

Spores

Histozoic, circular to sub-spherical in shape measuring $9.8\text{--}10.3(10.0 \pm 0.35) \times 7.9\text{--}8.7(8.3 \pm 0.56)$ µm in size, with rounded anterior and posterior end. Spore valves

Figs. 5–7 Camera lucida drawings of the spore of *M. sclerii* sp. nov. **5** Mature spore stained in Ziehl-Neelsen (valvular view); **6** Spore in sutural view; **7** Spore with extruded polar filaments

smooth, symmetrical, thick measuring 0.88 µm in thickness. Parietal folds absent. Two anteriorly situated polar capsules are equal, pear-shaped measuring $4.8\text{--}5.2(5.0 \pm 0.28) \times 1.5\text{--}2.3(1.9 \pm 0.56)$ µm in size, each with a neck leading to a fine duct opening independently. Both polar capsules converge slightly anteriorly but diverge apart posteriorly occupying more than half of spore body. Inter-capsular appendix is absent. Polar filaments thin, thread-like measuring 27.5 µm in length when extruded, each forming 5–6 turns. Two capsulogenic nuclei are present beneath each

Figs. 8–9 Camera lucida drawings of the spores of *M. stomum* Ali et al. 2003. **8** Valvular view of spore stained in Ziehl-Neelsen; **9** Spore with extruded polar filaments. Scale bar: 0.005 mm

polar capsule measuring 1.3 μm in diameter. Sporoplasm occupy whole of the extracapsular space behind polar capsules. Sporoplasm contains two nuclei measuring 1.5 μm in diameter. Iodinophilous vacuole is absent.

Discussion

M. sclerii sp. nov.

After comparison with *Myxobolus* species described from major carps of India, the present species was found to be closest to *M. calbasui* Chakravarty 1939; *M. bengalensis* Chakravarty and Basu 1948; *M. seshadrii* Lalitha Kumari 1969; *M. cuttacki* Haldar et al. 1996; *M. hosadurgensis* Seenappa and Manohar 1981; *M. venkateshi* Seenappa and Manohar 1981; *M. indirae* (Kundu 1985) Gupta and Khera 1988; *M. multivaderis* Mukhopadhyay and Haldar 1998 and *M. orissae* Haldar et al. 1996 but differ from all of the above in morphometric characteristics (Table 2).

The present species is pyriform in shape with blunt anterior end and rounded posterior end. Two distinct openings are present at the anterior tip of the spores. In

contrast to this, spores in *M. cuttacki* are anteriorly elongated and pointed, oval to spherical in *M. indirae*, round to spherical with anterior end pointed or beak-like in *M. multivaderis* and presence of small protuberance at the anterior end of the spore in *M. venkateshi* demarcates all of them from spores of the present species. Intercapsular appendix is rod shaped and medium-sized in the present species in contrast to large sized in *M. venkateshi* and is absent in *M. cuttacki* and *M. bengalensis*. In the present species, polar capsules are equal in size and converging anteriorly but in *M. seshadrii*, *M. orissae*, *M. hosadurgensis*, *M. multivaderis* and *M. calbasui* polar capsules are unequal.

Furthermore, the present species was found to be morphologically closer to *M. macrocapsularis* Reuss 1906; *M. hemibarbi* Dogiel and Akhmerov in Akhmerov 1960; *M. cheisini* Shulman 1962; *M. orientalis* Shulman 1962; *M. elegans* Kashkovsky in Shulman 1966; *M. nokoueensis* Sakiti et al. 1991; *M. branchialis* (Markevitch 1932) Landsberg and Lom 1991; *M. karuni* Masoumian et al. 1994; *M. chinsurahensis* Basu and Haldar 2003; *M. branchiophilus* Abdel-Ghaffar et al. 2008 and *M. fomenai* Abdel-Ghaffar et al. 2008, however, differ from all of the above species in morphometric characteristics. Polar capsule exceed more than half of spore body in the present species but it occupy almost $\frac{3}{4}$ of the spore body in *M. cheisini*, *M. macrocapsularis*, *M. fomenai*, *M. orientalis*; less than $\frac{1}{2}$ in *M. hemibarbi*, *M. branchiophilus*, *M. elegans*, *M. branchialis*, *M. karuni* and $\frac{1}{3}$ rd in *M. nokoueensis*. Although polar capsules in *M. chinsurahensis* and *M. zillii* occupies $\frac{1}{2}$ of the spore body as in the present species but differ from the later in having tear shaped spore in *M. chinsurahensis* and anteriorly pointed in *M. zillii*. Comparing our species with other *Myxobolus* described from the sclera, it comes closer in morphometry to *M. karelicus* Petrushevski 1940; *M. spatulatus* Dogel and Bogolepova 1957; *M. chakravartyi* Haldar et al. 1983 and *M. ophthalmosculata* Basu and Haldar 2002 but differ from all of them morphologically i.e. spores are oval to spherical in shape in *M. karelicus*, *M. spatulatus*; elongated pyriform with a small depression in *M. ophthalmosculata* and ovoidal in shape with anterior end flat in *M. chakravartyi* in contrast to pyriform, narrow and anteriorly bluntly pointed with two distinct openings in the species under study.

All of these differences suggest that the present species is a new one and hence named *M. sclerii* sp. nov. through this communication.

M. stomum Ali et al. 2003

Remarks

Present observations on *M. stomum* Ali et al. (2003) are in conformity with the original description except for some

Table 2 Comparative description of the present *M. scleritii* sp. nov. with morphologically similar species (measurements in micrometer)

Species	Host	Location	Locality	Spore	Polar capsule
<i>M. scleritii</i> sp. nov. (present study)	<i>Catla catla</i>	Eye-ball (sclera)	Kanjali Wetland, Punjab (India)	7.9–9.5 (8.7 ± 1.13) × 4.3–5.7 (5.0 ± 0.9)	4–5.4 (4.7 ± 0.98) × 1–2.6 (1.8 ± 1.31)
<i>M. macrocapularis</i> Reuss 1906	<i>Blicca bjoerkna</i>	Gills	Russia	9.0–14.5 × 6–9.9	5.0–8.6 × 2.4–3.6
<i>M. branchialis</i> (Markevitch 1932) Landsberg and Lom 1991	<i>Barbus barbus borysthenticus</i>	Gills	Ukraine	6.8–8.4 × 5.8–6.4	2.5–3.2 × 1.6–2.0
<i>M. hemibarbi</i> Dogiel and Akhmerov in Akhmerov 1960	<i>Hemibarbus labeo</i> , <i>H. maculatus</i>	Gills	Amur basin	12.5–14.5 × 10.5–11.5	6.5 × 3.6–4.5
<i>M. cheisini</i> Shulman 1962	<i>Channa maculata</i>	Gills	China	12.5–13.6 × 7.0–8.5	7–7.5 × 2.5–3
<i>M. orientalis</i> Shulman 1962	<i>Carassius auratus gibelio</i>	Gills	China	19.0–19.6 × 10.5–11	12.0–13.5 × 3.8–4.0
<i>M. elegans</i> Kashkovsky in Shulman 1966	<i>Rutilus rutilus</i> , <i>Leuciscus idus</i>	Gills, fins	Russia	13.5–17 × 7.4–10	6.8–8.0 × 2.5–3.5
<i>M. venkateshi</i> Seenappa and Manohar 1981	<i>Cirrhina mrigala</i>	Gills	India	9–10.0 (9.75) × 7.0–8.0 (7.15)	5.0–6.0 (5.25) × 2.0
<i>M. karuni</i> Masoumian et al. 1994	<i>Barbus grypus B. luteus</i>	Gills	Iran	14.1 × 10.2	6.2 × 3.4
<i>M. nokoueensis</i> Sakiti et al. 1991	<i>Sarotherodon melanotheron</i>	Gills	Benin	8.1–11.5 (10.0) × 5.0–7.0 (6.0)	2.5–4 (3.4) × 1.6–2.7 (2.0)
<i>M. zillii</i> Sakiti et al. 1991	<i>Tilapia zillii</i>	Gills	Benin	8–11(9.5) × 6–8 (7.5)	4–6 (5) × 2–3 (2.5)
<i>M. chinsurahensis</i> Basu and Haldar 2003	<i>Anabas testudineus</i>	Scales	India	8.4 × 5.4	4.4 × 2.1
<i>M. branchiophilus</i> Abdel-Ghaffar et al. 2008	<i>Oreochromis niloticus</i>	Gill filament	Egypt	10.78–11.55 (11.18) × 6.16–7.31 (6.56)	4.62–6.16 (5.49) × 1.93–2.31 (2.04)
<i>M. fomenai</i> Abdel-Ghaffar et al. 2008	<i>Oreochromis niloticus</i>	Muscles	Egypt	13.09–16.5 (15.02) × 6.16–9 (7.91)	8.47–10.13 (9.26) × 2.31–3.5 (2.77)
<i>M. seshadrii</i> Lalitha Kumari 1969	<i>Labeo fimbriatus</i>	Gills	India	12.21 × 9.04	Larger one is 5.7 × 3.66 and smaller one is 4.9 × 2.99
<i>M. orissae</i> Haldar et al. 1996	<i>Cirrhinus mrigala</i>	Gills	India	15.71 × 6.8	Larger one is 8.8 × 1.78 and smaller one is 7.58 × 2.57
<i>M. indira</i> (Kundu 1985) Gupta and Khara 1988	<i>Cirrhinus mrigala</i>	Scale of tail, cartilage of head	India	12.6 × 9.6	4.7 × 2.2
<i>M. hosadurgensis</i> Seenappa and Manohar 1981	<i>Cirrhinus mrigala</i>	Gills, muscle	India	10.5 × 6.25	Larger one is 5.37 × 2.3 and smaller one is 3.3 × 1.43
<i>M. calbasui</i> Chakravarty 1939	<i>Cirrhinus mrigala</i> , <i>Labeo calbasu</i> , <i>L. rohita</i>	Gall bladder	India	12.4–15.0 × 8.2–10.0	Larger one is 6.18 × 4.12 and smaller one is 4.12 × 3.09
<i>M. bengalensis</i> Chakravarty and Basu 1948	<i>Catla catla</i>	Gills	India	8.56–9.36 × 6.42–6.80	4.28–5.40 × 2.5–3.2
<i>M. cuttacki</i> Haldar et al. 1996	<i>Cyprinus carpio</i>	Branchial filaments	India	13.0–21.1 (17.04) × 4.9–8.1 (6.48)	6.5–13.0 (8.64) × 1.6–4.0 (2.8)
<i>M. karelicus</i> Petrushevski 1940	<i>Varicorhinus capoeta heratensis</i>	Gills, gut, eyes	Russia	7.0–13.0 × 6.0–10.0	4.0–6.3 × 2.0–4.0
<i>M. spatulatus</i> Dogiel, and Bogolepova 1957	<i>Paracottus knevi</i>	Eyes, gills	Baikal	9.0–12.0 × 6–7	5.0–6.0 × –

Table 2 continued

Species	Host	Location	Locality	Spore	Polar capsule
<i>M. multivaderis</i> Mukhopadhyay and Haldar 1998	<i>Catla catla</i>	Gills, palate, intestine, brain tissue	India	On palate: 8.47–10.28 (8.98) × 6.05–7.26 (6.77); In intestine: 6.65–9.68 (8.35) × 4.23–6.05 (5.049)	On palate: larger one 3.66–5.44 (4.837) × 2.42–4.23 and smaller one is 1.21–3.63 (2.448) × 1.21–2.42 (1.752); In intestine: larger one is 1.81–2.42 (4.902) × 0.6–1.81 (1.269) and smaller one is 0.6–1.81 (1.147) × 0.36–1.21 (1.17)
<i>M. chakravartyi</i> Haldar et al. 1983	<i>Catla catla</i>	Internal eye musculature	India	12.1–14.3 (12.3) × 7.7–10.5	Larger one is 5.5–6.6 × 3.3–5.0 and smaller one is 4.4–5.0 × 2.2–4.4
<i>M. ophthalmusculata</i> Basu and Haldar 2002	<i>Cirrhina mrigala</i>	Eye muscles	India	12.4–13.97 (13.13) × 7.45–9.18 (8.04)	Larger one is 4.9–6.12 (5.47) × 2.65–3.37 (3.06) and smaller one is 2.35–3.37 (3.03) × 1.84–2.14 (1.99)

minor variations in size of spore and polar capsules i.e. spores are wider (WS: 8.3) and contain polar capsules longer in length but less in width (LPC: 5.5; WPC: 1.9) in comparison to original specimens (LS: 8.5; WS: 6.5; LPC: 4.4; WPC: 2.4). Parietal folds and intercapsular process are absent in the present material as in the original specimens. Two distinct openings are conspicuous at the anterior end of the species under study. Earlier, the parasite was recorded in the buccal cavity, muscles and lips of *Plectorhynchus gaterinus* (Forsskal), Egypt. A new locality-Ropar Wetland, a new location-scales and a new host- *Labeo rohita* (Hamilton) are recorded for this parasite.

References

- Abdel-Ghaffar F, El-Toukhy A, Al-Quarishy S, Al-Rashid K, Abdel-Baki AS, Hegazy A, Bashtar AR (2008) Five new myxosporean species (Myxozoa: Myxosporea) infecting the Nile tilapia *Oreochromis niloticus* in Bahr Shebin, Nile Tributary, Nile Delta, Egypt. Parasitol Res 103:1197–1205
- Akhmerov AK (1960) Myxosporidia of fishes of the Amur River Basin. Rybnoe Khozyaistvo Vnutrikh Vodoemov Lat SSR 5: 239–308
- Ali MA, Abdel-Baki AS, Sakran T, Entzeroth R, Abdel-Ghaffar F (2003) Light, electron microscopic studies of *Myxobolus stomum* n. sp. (Myxosporea: Myxobolidae) infecting the black-spotted grunt *Plectorhynchus gaterinus* (Forsskal, 1775) in the Red Sea, Egypt. Parasitol Res 9:390–397
- Basu S, Haldar DP (2002) *Myxobolus ophthalmusculata*, a new species of histozoic myxozoan (Myxozoa: Bivalvulida) from *Cirrhina mrigala* (Hamilton). Proc Zool Soc Calcutta 55(2):43–48
- Basu S, Haldar DP (2003) Three new species of *Myxobolus* Butschli, 1882 from different food fishes of West-Bengal, India. Acta Protozool 42:245–251
- Chakravarty M (1939) Studies on Myxosporidia from the fishes of Bengal, with a note on the myxosporidia infection in aquarium fishes. Arch Protistenknd 92:169–178
- 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
- Dogel VA, Bogolepova II (1957) Parasitic fauna of Lake Baikal fishes. Trudy Baikalskoi Limnologicheskoi Stantsii, Akademiya Nauk SSR Vostochno-Sibirski Filial 15:427–464
- Eiras JC, Molnar K, Lu YS (2005) Synopsis of the species of *Myxobolus* Butschli, 1882 (Myxozoa: Myxosporea: Myxobolidae). Syst Parasitol 61:1–46
- Gupta S, Khera S (1988) Review of the genus *Myxobolus* Butschli, 1882. Res Bull (Science) Punjab University 39(I–II):45–48
- Haldar DP, Das MK, Sharma BK (1983) Studies on Protozoan Parasites from Fishes. Four New Species of the Genera *Henneguya* Thelohan, *Thelohanellos* Kudo, 1933 and *Myxobolus* Butschli, 1892. Arch Protistenk 127:283–296
- Haldar DP, Samal KK, Mukhopadhyaya D (1996) Studies on protozoan parasites of fishes in Orissa: Eight species of *Myxobolus* Butschli (Myxozoa: Bivalvulida). J Bengal Nat Hist Soc 16:3–24
- Kalavati C, Nandi NC (2007) Handbook of Myxosporidian parasites of Indian fishes. ZSI, India, Kolkata
- Kundu TK (1985) *Myxosoma indirae* spn. (Myxozoa: Myxosomatidae) from the head cartilage, scale and tail fin of *Cirrhina mrigala*. Acta Protozool 24:333–337

- Lalitha Kumari PS (1969) Studies on parasitic protozoa (Myxosporidia) of fresh water fishes of Andhra Pradesh, India. Riv Parasitol 30: 153–226
- Landsberg JH, Lom J (1991) Taxonomy of the genera of the *Myxobolus/Myxosoma* group (Myxobolidae:Myxosporea), current listing of species and revision of synonyms. Syst Parasitol 18:155–186
- Lom J, Arthur JR (1989) A guideline for the preparation of species descriptions in Myxosporea. J Fish Dis 12:151–156
- Markevitch AP (1932) Zur Kenntnis der Myxosporidien von Süßwasserfischen der Ukraine. Zoologischer Anzeiger 99:297–303
- Masoumian M, Baska F, Molnar K (1994) Description of *Myxobolus karuni* sp. n. and *Myxobolus persicus* sp. n. (Myxosporea, Myxozoa) from *Barbus grypus* of the River Karun, Iran. Parasitol Hungarica 27:21–26
- Mukhopadhyay D, Haldar DP (1998) Spore variations in a piscine myxozoan parasite (Myxozoa: Myxosporea) from the juvenile major carp, *Catla catla*. Trans Zool Soc India 2(1):46–52
- Petrushevski GK (1940) Data on fish parasitology in Karelia. Part II. Fish parasites in Lake Onega. Uchenyye Zapiski Leningradskogo Gosudarstvennogo Pedagogicheskogo Instituta Gercena 30: 133–184
- Reuss H (1906) Neue Myxosporidien von Süßwasserfischen. Bull scient Acad Sci St Petersburg 25:199–205
- Sakiti N, Blanc E, Marques A, Bouix G (1991) Myxosporidies (Myxozoa: Myxosporea) du genre *Myxobolus* Butschli, 1882 parasites de poissons cichlidae du lac Nokoue au Bénin (Afrique de l' Ouest). J Afr Zool 105:173–186
- Seenappa D, Manohar L (1981) Five new species of *Myxobolus* (Myxosporea:Protozoa), parasitic in *Cirrhina mrigala* (Hamilton) and *Labeo rohita* (Hamilton), with a note on a new host record for *M. curmucae* Seenappa and Manohar, 1980. J Protozool 28:358–360
- Shulman SS (1962) Phylum Protozoa. In: Bykhovskaya- Pavlovskaya, I.E. et al.(eds) Key to parasites of freshwater fishes of the USSR. (Keys to fauna of the USSR, No. 80). Leningrad, Nauka, pp 7–151
- Shulman SS (1966) The myxosporidian fauna of the USSR. Moscow-Leningrad, Nauka, p 504