ISSN 1996-3351

Asian Journal of Biological Sciences

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

OPEN ACCESS Asian Journal of Biological Sciences

ISSN 1996-3351
DOI: 10.3923/ajbs.2017.110.120

Research Article
Three New Species of *Myxobolus* (Myxosporea: Myxobolidae), Parasites of *Barbus callipterus* Boulenger, 1907 in Cameroon

Lekeufack Folefack Guy Benoît, Defoueng Nza Alex Sorel and Fomena Abraham

Laboratory of Parasitology and Ecology, Faculty of Science, University of Yaoundé I, P.O. Box 812, Yaounde, Cameroon

Abstract

Background and Objective: Fish are vulnerable to various parasitic infections, out of which Myxozoa is emerging as the major group. *Myxobolus* Bütschli, 1882 is the largest genus within the Myxozoan fish parasites. The aim of the present study was to study Myxosporidia parasites of *Barbus callipterus* Boulenger, 1907. **Materials and Methods:** Cyprinid *Barbus callipterus*, sampled in the Sessaba river at Lebamzip in Cameroon was examined in the present study. Classic fishing methods, fish autopsy and search for myxosporidia parasites were used. Identification of parasite species was based on morphometric characteristics of spores. The arithmetic mean (m) values and interval confidence (2 Sm) of spore parameters was calculated. **Results:** Results were expressed as follow: m±2 Sm (minimal value-maximal value). The study revealed the presence of three new species of the genus *Myxobolus*. *Myxobolus ngassami* sp. nov. was found in fin, operculum, skin, eye and kidneys of the host. Its spores were ovoid, an intercapsular appendix was present and its polar capsules were unequal. *Myxobolus sanagaensis* sp. nov. was found in the heart with ovoid spore and unequal polar capsules. The spores of *Myxobolus sessabai* sp. nov. were found in skin and kidneys of the host. They were ovoid, with an intercapsular appendix and equal polar capsules. **Conclusion:** The study revealed that Myxosporidia parasite of *Barbus callipterus* was made of three new species: *Myxobolus ngassami* sp. nov., *Myxobolus sanagaensis* sp. nov. and *Myxobolus sessabai* sp. nov. The predominance of the genus *Myxobolus* in the fauna of Myxosporidia parasites of fish was confirmed.

Key words: *Myxobolus ngassami* sp. nov, *Myxobolus sanagaensis* sp. nov, *Myxobolus sessabai* sp. nov, fish parasite

Received: February 26, 2017 Accepted: May 16, 2017 Published: June 15, 2017

Citation: Lekeufack Folefack Guy Benoît, Defoueng Nza Alex Sorel and Fomena Abraham, 2017. Three new species of *Myxobolus* (Myxosporea: Myxobolidae), parasites of *Barbus callipterus* Boulenger, 1907 in Cameroon. Asian J. Biol. Sci., 10: 110-120.

Corresponding Author: Lekeufack Folefack Guy Benoît, Laboratory of Parasitology and Ecology, Department of Animal Biology and Physiology, Faculty of Science, University of Yaoundé I, P.O. Box 812, Yaounde, Cameroon Tel: 00237677887294

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cameroon offers a full spectrum of tropical natural environments. Its dense and diversified hydrographic network covers an area of 294 040 km^2 [1]. Within this large freshwater ecosystem, Vivien[1] listed 603 fish species. In the context of such fish diversity, many species are economically very important in fisheries and some are involved in fish farming projects. However, these fish also constitute a favourable biotope for the development of a large number of parasites, including Myxosporidia[2-4].

Worldwide, the first bibliographical references in the study of Myxosporidia parasite of fish refer to the works of Jurine[5]. Numerous studies have shown that Myxosporidia constitute an important and very diverse fauna among freshwater fish parasites[6-13].

Based on the morphological and the metric characteristics of the spores, the worldwide Myxosporidia fauna is now estimated at 2200 species belonging to 64 genera and 17 families[14]. The African freshwater fish Myxosporidia fauna is estimated at about 270 species[3,4]. These Myxosporidia have been described in the following countries: Benin, Botswana, Burkina Faso, Cameroon, Egypt, Ghana, Morocco, Nigeria, Uganda, Senegal, Chad and Tunisia. They belong to the genera *Chloromyxum* Mingazzini, 1890; *Henneguya* Thelohan, 1892; *Hoferellus* Berg, 1898; *Kudoa* Meglisch, 1947; *Myxidium* Bütschli, 1882; *Myxobilatus* Davis, 1944; *Myxobolus* Bütschli, 1882; *Ortholinea* Schulman, 1962; *Sinusolinea* Davis, 1917; *Sphaerospora* Thelohan, 1892; *Thelohanellus* Kudo, 1933; *Triangula* Chen and Hsieh, 1984; *Zchokkella* Auerbach, 1910.

In Cameroon, the available data on Myxosporidia parasites of fish are those of Fomena[2,15], Fomena and Bouix[16-22], Fomena *et al.*[23-29], Folefack[3], Nchoutpouen[4]; Nchoutpouen and Fomena[30]. From the above works, it appears that in this country, the fauna of Myxosporidia parasites of fish is represented by 77 species belonging to the following genera: *Myxobolus*, *Henneguya*, *Hoferellus*, *Myxidium*, *Thelohanellus*, *Sphaerospora* and *Chloromyxum*. In this central African country, the study of Myxosporidia parasites of the Cyprinid fish has focused on the genus *Barbus* Cuvier and Cloquet, 1816; *Raiamas* Jordan, 1919; *Labeo* Cuvier, 1817 and *Labeobarbus* Rüppell, 1836[4,23,30]. It is important to record and report new parasites and new pathological conditions when they are discovered because such information may be useful in the future as baseline data for assessing ecosystem health in the face of threats from global warming.

This study provided the description of *Myxobolus ngassami* sp. nov., *Myxobolus sanagaensis* sp. nov. and *Myxobolus sessabai* sp. nov. parasites of *Barbus callipterus* Boulenger, 1907 (Cyprinidae).

MATERIAL AND METHODS

Data on host fish and study site: *Barbus callipterus* Boulenger, 1907 (Cyprinidae) is an endemic fish from Central and Western Africa. This gregarious and omnivorous fish has a maximum standard length of 65 mm[31]. Fifty specimens of *Barbus callipterus* with standard length varying between 42 and 65 mm were harvested from April, 2015 to June, 2016 in the Sessaba river (a sub tributary of the Sanaga river) at Lebamzip, a small village of the district of Sa'a (Department of Lékié, Central Region). This village is elevated at 605 m, between 4°15' 20" and 4°16' North latitude and 11°28' and 11°29' longitude East. The climate is the equatorial transition type in this locality, which is characterized by two rainy seasons (September to mid-November and mid-March to June) and two dry seasons (mid-November to mid-March and July to August) of unequal importance. The mean annual rainfall is 1645 mm[32]. The primitive vegetation is the rainforest or hemi-ombrophilous forest[33].

Fishing and fish conservation: Fish capture was carried out using the fishing rod. In the field, once the fish were caught, a buttonhole was made on the abdominal region of each host individual. The latter were immediately immersed in a 10% formalin solution that is contained in a plastic container. Systematic position of sampled fishes was taken from Stiassny *et al.*[31].

Fish dissection and parasites collection: In the laboratory, the fish were first examined with the naked eye (eyes, fins, operculum, scales and skin) and then with the Olympus BO61 stereoscopic microscope, to detect the presence of cysts. After dissection of the hosts, all organs (gills, heart, liver, kidneys, spleen, gallbladder, gonads, intestine and urethra) were also taken individually and examined. The content of these cysts were identified with the objective 100X of an YVYMEN optical microscope. The content of the gallbladder was examined between slide and cover glass under the microscope. The smears of the kidney, spleen, liver, gonads, heart and urethra were mounted on slides and examined at the 40X objective of the microscope.

Stainning, drawing, measurement and photography of parasites: Spore smears were fixed with methanol and then stained with May-Grünwald-Giemsa. Drawings of fresh spores were performed using a Wild M-20 microscope equipped with a camera Lucida. The measurements were carried out on at least 40 spores using an objective micrometer. The variables taken into account are those proposed by Lom and Arthur[34]. Microphotographies of spores were performed using an Olympus BH-2 microscope in the laboratory of parasitology and ecology of the University of Yaounde 1, Cameroon.

Statistical analysis: The arithmetic mean values of the various parameters measured (spore and its components) were calculated. Results were expressed as follow: m ± 2 Sm (X_{min}-X_{max}) with m = Mean values, 2 Sm = Confidence interval, X_{min} and X_{max} = Minimal and maximal values of the parameter considered.

Let a sample of n specimens (n≥40), the variable X denotes a series of measurements and m the mean. Following Folefack[3], the mean is calculated using the equation:

$$m = \frac{\sum_{i=1}^{n} x_i}{n}$$

The standard deviation (S) is the square root of the variance S^2 (estimate of variance), the later is expressed as:

$$S^2 = \frac{\sum (x - m)^2}{n - 1}$$

where, n-1 is the number of degrees of freedom.

The confidence interval of the mean is 2 Sm, Sm been the standard error of the average calculated by the equation:

$$S_m = \frac{S}{\sqrt{n - 1}}$$

For statistical analysis, the level of security retained is 95%.

RESULTS

Myxobolus ngassami sp. nov.

Vegetative form: Whitish plasmodia are observed implanted between the bony rays of the fins, on the operculum, on the skin and in the sclera of the eye. Ocular infestations are uni or bilateral. Plasmodia are ovoid or elongated, measured 315×205 µm on average and are polysporous. A host individual carries up to five cysts. Vegetative stages are not observed in the kidneys but isolated or grouped spores are found:

- **Spore:** Spores are ovoid in front view (Fig. 1a-d). The valves are thick. At the anterior end, there was an intercapsular appendix of 2.3±0.04 (2-2.8) µm long on average (Fig. 1a, c). Five to six valvular folds are visible at the posterior half of the spore (Fig. 1a, c). The polar capsules are ovoid and slightly dissymmetrical (Fig. 1b, c). The largest surpassing the mid-length of the spore and contains a filament with 7-10 coils. In the small polar capsule, there are 5-7 coils of the filament (Fig. 1c). The sporoplasm often contains an iodinophilous vacuole of varying shape and size (Fig. 1a, d)
- **Measurements:** Measurements are given in Table 1
- **Host:** *Barbus callipterus* Boulenger, 1907 (Cyprinidae)
- **Location:** Lébamzip (Center region)
- **Location in the host:** Fins, kidneys, eyes, operculum and skin
- **Prevalence:** 52% (26 parasitized fish out of 50 examined).
- **Type material:** Glass slides with stained spores (syntype) and cysts preserved in 10% buffered neutral formalin are deposited in the parasitological collection of the Laboratory of Parasitology and Ecology, Faculty of Science, University of Yaounde 1, Cameroon (No. Myxo/2017/LPE-001)
- **Etymology:** The species is dedicated to Professor NGASSAM Pierre of the University of Yaounde 1

Myxobolus sanagaensis sp. nov.

Vegetative form: In the host, the parasite forms whitish, polysporated, ovoid or subspherical cysts in the heart auricles. They vary in size and are 140-270 µm long and 65-195 µm wide. On a host individual, one can count 1-3 cysts:

- **Spore:** Medium in size, the spores are ovoid with both rounded ends (Fig. 2a-d). The valves have 5-6 folds at the posterior end of the spore (Fig. 2a, d). There is no intercapsular triangle. The polar capsules are piriform shape and slightly unequal (Fig. 2b, d). The filament has 8-10 coils in the larger polar capsule and 6-7 coils in the smaller polar capsule (Fig. 2d). The sporoplasm is granular and often contains an iodinophilous vacuole (Fig. 2a, d)
- **Measurements:** Measurements are given in Table 1
- **Host:** *Barbus callipterus* Boulenger, 1907 (Cyprinidae)
- **Location:** Lébamzip (Center region)

Table 1: List of different species of Myxosporidia of the genus *Myxobolus* described in the fishes of the genus *Barbus* (measurements in micrometers)

Parasite species	Host species	Infestation site	Country	SL	SW	PC	LPC	WPC	PF	ICA	Reference
M. ampullaceus	*B. kolus*	Fins	India	9.8 (8.6-10.7)	7.1 (6.4-7.9)	0	5.8 (5.0-6.4)	2.8 (2.5-2.9)	5-6	A	Kumari[51]
M. azerbajdzanicus	*B. lacerta cyri*	Gills	Caucasus	18.4-20	13.8-15.7	0	6.1-7.3	5.2-5.9	/	P	Ibragimov[52]
M. barbi	*B. ticto*	Skin	India	12.6-13.5	9.0	0	3.6-4.5	2.7	/	A	Tripathi[53]
M. branchialis	*B. barbus borysthenicus*	Gills	Ukraine	6.8-8.4	5.8-6.4	0	2.5-3.2	1.6-2.0	/	A	Markevitsch[54]
M. branchilateralis	*B. barbus*	Gills	Hungary	9.9 (9.4-10.4)	8.4 (7.5-9.1)	0	3.0 (4.9-6.0)	3 (2.5-3.3)	6	A	Molnar *et al.*[55]
M. bulbocordis	*B. sharpeyi*	Heart	Iran	19 (17.3-19.6)	15.3 (13.8-15.5)	0	8.4 (8.1-9.2)	5.8 (5.2-6.3)	/	P	Masoumian *et al.*[46]
M. ngassami n. sp.	*B. callipterus*	Fins, kidneys, eye, opercules and integument	Cameroon	11.5 (10.7-12.8)	9.4 (8.3-10.5)	≠	5.0 (4-5.6)* 4.4 (3.5-5.1)**	2.8 (2.1-3.4)* 2.4 (1.7-3)**	7-10* 5-7**	P	Present study
M. caudatus	*B. bynni*	Caudal fin	Egypt	17.5 (16-19.2)	12.8 (11-13.6)	0	7.4 (6.4-9)	3.8 (3.2-4.5)	8-9	P	Ali *et al.*[56]
M. cutanei	*B. barbus bocagei*	Scales	Spain	11.5 (10.5-12.5)	8.9 (8.0-9.7)	0	5.2 (4.0-6.5)	2.7 (2.0-3.5)	8-10	P	Alvarez-Pellitero and Gonzalez-Lanza[57]
M. egypticus	*B. bynni*	Intestine	Egypt	12.5 (12.0-13.6)	8.8 (8.0-9.6)		7.7 (7.2-8.0)	3.3 (3.2-3.6)	5-6	P	Ali *et al.*[56]
M. etsatsaensis	*B. thamalanensis*	Gills	Botswana	13.0 (12.8- 15.0)	6.8 (6.2-8.0)	≠	7.5 (7.0-8.0)* /**	2.3 (1.2-2.5)* /**	7-8* /**	P	Reed *et al.*[58]
M. fahmii	*B. bynni*	Gills	Egypt	11.0 (10.8-12.0)	7.1 (6.4-8.0)	0	6.8 (6.4-7.2)	3.2 (2.8-3.8)	6-7	A	Ali *et al.*[56]
M. nyongana	*B. aspilus.* and *B. camptacanthus*	Gills	Cameroon	10.8 (7.3-13.0)	6.0 (5.0-7.0)	0	5.9 (5.0-7.0)	1.9 (1.4-2.5)	6-9	A	Fomena and Bouix[21]
M. hyderabadense	*B. pinnauratus*	Gills	India	10.1 (9.3-11.5)	5.9 (5.0-8.0)	0	5.8 (5.0-7.3)	2.2 (1.4-3.0)	8-9	A	Kumari[51], Landsberg and Lom[59]
M. impressus	*B. barbus*	Fins and gills	Ukraine	10.5-13.7	9.2-11		5.5-6.8	2.8-4	/	A	Miroshnichenko[60]
M. indiae	*B. sarana*	Gills	India	13.7 (12.4-15.0)	7.3 (6.4-8.6)	0	5.9 (5.7-7.1)	2.1 (1.4-2.5)	8-10	A	Kumari[51], Landsberg and Lom[59]
M. intestinealis	*B. bynni*	Intestine	Egypt	12.5 (12-13.6)	8.8 (8-9.6)	0	7.7 (7.2-8)	3.3 (3.2-3.6)	5-6	P	Ali *et al.*[56]
M. iranicus	*B. luteus*	Spleen	Iran	13.6 (13.2-14.0)	8.9 (7.5-9.2)	≠	7.3 (6.9-7.5)* 7.0 (6.6-7.2)**	3.3 (2.9-3.5)* /**	7* 6**	P	Molnar *et al.*[61]
M. irinae	*B. capito conocephalus*	Kidneys	Central Asia	9.4-10.6	7-7.7	0	4-5.9	2.4-3		P	Daniyarov[62]
M. karuni	*B. grypus.* and *B. luteus*	Gills	Iran	14.1 (13.0-14.9)	10.2 (9.7-10.4)	0	6.2 (6.5-7.5)	3.4 (3.2-3.9)	10-11	A	Masoumian *et al.*[63]
M. koli	*B. kolus*	Fins	India	8.4 (7.1-9.6)	6.0 (5.0-6.4)	≠	4.3 (3.9-4.6)* 2 (1.4-2.1)**	2.8 (2.1-3.1)* 1.2 (0.7-1.4)**	/	A	Kumari[51]
M. laterobranchialis	*B. barbus*	Gills	Hungary	9.9 (9.4-10.4)	8.4 (7.5-9.1)	0	3 (4.9-6)	3 (2.5-3.3)	6	A	Molnar *et al.*[55]
M. sanagaensis n. sp.	*B. callipterus*	Heart	Cameroon	9.9 (9.4 - 11)	6.8 (6.1 - 7.3)	≠	4.6 (4.1 - 5.1)* 2.3 (2 - 2.6)**	4 (3.2 - 4.3)* 2.1 (1.8 - 2.3)**	8-10* 6-7**	A	Present study

Table 1: Continue

Parasite species	Host species	Infestation site	Country	SL	SW	PC	LPC	WPC	PF	ICA	Reference
M. mesopotamiae	*B. grypus*	Fins	Iran	9.2 (8.9-9.4)	8.1 (7.8-8.5)	0	3.8 (3.6-4.2)	2.5 (2.4-2.7)	7	A	Molnar *et al.*[61]
M. njinei	*B. camptacanthus*, *B. guirali* and *B. martorelli*	Gil arch connective tissue	Cameroon	16.17 (14-20)	13.46 (11.6-18.5)	0	7.81 (6.5-9)	4.59 (3.5-5.4)	7-8	P	Fomena *et al.*[23]
M. nkolyaensis	*B. jae*	Caudal muscles	Cameroon	9.0 (8.0-11.0)	8.3 (7.2-11.5)	0	4.4 (3.5-5.5)	3.0 (2.2-3.5)	/	A	Fomena and Bouix[18]
M. nodulointestinalis	*B. sharpeyi.* and *B. luteus*	Smooth muscles layer of intestine wall	Iran	12.6 (11.7-13)	8.1 (7.8-9.1)	0	3.6 (2.6-3.9)	2.4 (2.2-2.6)	4-5	P	Masoumian *et al.*[46]
M. oloi	*B. aspilus*, *B. camptacanthus*, *B. camptacanthus*, *B. guirali* and *B. martorelli*	Gill arch epithelium, gullet and kidneys	Cameroon	9.3 (6.3-11.5)	7.2 (5.1-9.4)	≠	5.7 (4.0-7.0)* 3.9 (2.2 - 5)**	3.1 (1.8-4.0)* 2 (1.5 -2.5)**	4-5* 3**	A	Fomena and Bouix[18]
M. osmaniae	*B. punjaubensis*	Liver and intestine	India	13.5 (12.0-15.0)	8.6 (7.1-10.0)	≠	5.6 (5.0-7.1)* 2.6 (2.1-3.6)**	3.2 (2.9-3.9)* 2.5 (1.4-2.9)**	5-6* /**	A	Kumari[51]
M. ovoidalis	*B.* sp.	Subcutaneous tissue	South Africa	19-26	8-15	≠	11-14* 8-11.5* *	3-4* 2-3* *	/	A	Fantham[64]
M. paludinosus	*B. paludinosus*	Gills	Botswana	12.0 (11.2-13.7)	8.6 (7.5-10.0)	0	5.7 (5.0-6.8)	2.4 (2.0-2.5)	6-7		Reed *et al.*[58]
M. persicus	*B. grypus*, *B. sharpeyi* and *B. luteus*	Gills	Iran	100 (9.1-10.4)	73 (65-78)	≠	5.1 (4.5-5.8)* 48 (45-51)**	27 (26-32)	6-7* 7-8**	P	Masoumian *et al.*[63]
M. pfei eri	*B. barbus*	Muscles gills, Kidneys and spleen	/	10-13	9-12.2	0	5-5.7	/	/	P	Thelohan[65]
M. pinnaurati	*B. pinnauratus*	Gills	India	9.6 (8.0-11.4)	7.0 (6.5-7.9)	≠	4.4 (3.6-6.4)* 3.1 (2.9-5)**	1.9 (1.1-2.1)* 1.6 (1.1 -2.1) **	/	A	Kumari[51]
M. saranai	*B. sarana*	Gills	India	6.4-7	4.5-5	≠	3.5* 1.5**	1.5* 1**	/	A	Tripathi[53], Landsberg and Lom[59]
M. sessabai n. sp.	*B. callipterus*	Skin and kidneys	Cameroon	13.4 (12.6-14)	10.8 (9.9-11.5)	0	5.9 (5-6.3)	3.4 (2.5-3.8)	8-10	P	Present study
M. shadgani	*B. rajanorum*	Gills	Iran	13.9 (13.3-14.1)	13.7 (13.3-14.1)	≠	8.2 (7.9-8.3)* 7.9 (7.6-8.1)**	5.3 (4.9-5.5)* 5.2 (4.6-5.4)**	8* 7**	P	Molnar *et al.*[61]
M. sharpeyi	*B. sharpeyi*	Gill cartillage	Iran	9.6 (9.2-9.8)	8.1 (8.6-7.5)	0	3.6 (3.3-4.0)	2.8 (2.2-2.4)	5	P	Molnar *et al.*[61]
M. tisae	*B. barbus*	Kidneys	Hungary	9-10	8	≠	5.5-6.5* 4.5-5.5**	3-3.5* 3-3.5**	7-8* 6-7**	P	Lom[66]
M. valdogeli	*B. brachicephalus*	Gills	Central Asia	7.5-9.5	6-6.5	0	4-4.5			P	Dogel[67], Landsberg and Lom[59]

The arithmetic means of the measured variables are followed in brackets by the minimum and maximum values, SL: Spore length, SW: Spore width, PC: Relative length of the polar capsules (= : Equal, ≠: Unequal), LPC: Length of polar capsules, WPC: Width of polar capsules, PF: No. of coils of polar filament, ICA: Intercapsular appendice, (A: Absent, P: Present), *Relative to the large polar capsule, ** Relative to the small polar capsule, / : No data available

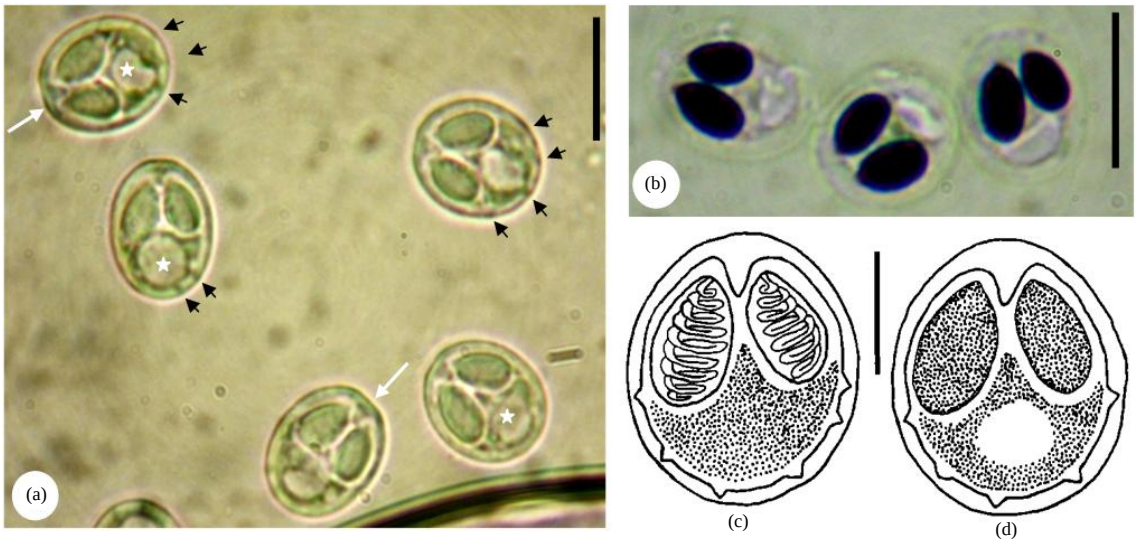

Fig. 1(a-d): Photomicrographs and line drawings of spores of *Myxobolus ngassami* sp. nov., (a) Fresh spores (Scale bars: 10 µm), (b) Stained spores with May-Grünwald-Giemsa (Scale bars: 10 µm) and (b-d) Line drawings of spores (Scale bars: 5 µm)

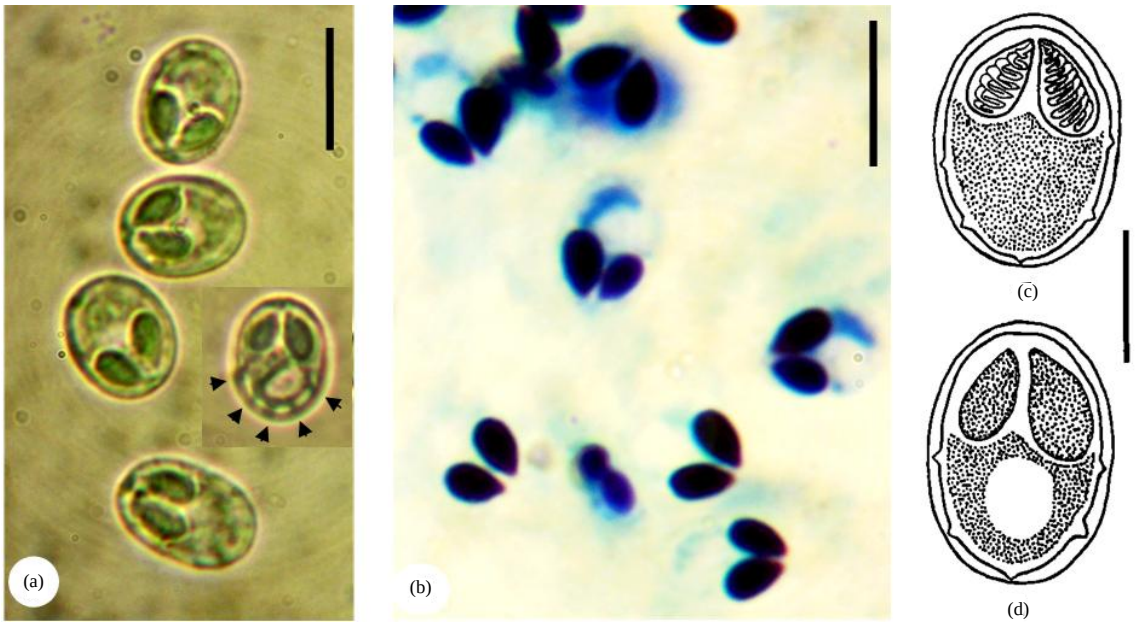

Fig. 2(a-d): Photomicrographs and line drawings of spores of *Myxobolus sanagaensis* sp. nov., (a) Fresh spores (Scale bars: 10 µm), (b) Stained spores with May-Grünwald-Giemsa (Scale bars: 10 µm) and (c, d) Line drawings of spores (Scale bars: 5 µm)

- **Location in the host:** Heart
- **Prevalence:** 18% (9 parasitized fish out of 50 examined)
- **Type material:** Glass slides with stained spores (syntype) and cysts preserved in 10% buffered neutral formalin are deposited in the parasitological collection of the Laboratory of Parasitology and Ecology, Faculty of Science, University of Yaounde 1, Cameroon (No. Myxo/2017/LPE-002)
- **Etymology:** The species is related to the Sanaga basin in which the host fish were caught

***Myxobolus sessabai* sp. nov.**

Vegetative form: Whitish and spherical cysts are implanted under the skin. They are polysporated and measured 350×345 µm on average. On a host individual, one can count 1-6 cysts. In the kidneys, the spores are isolated or grouped:

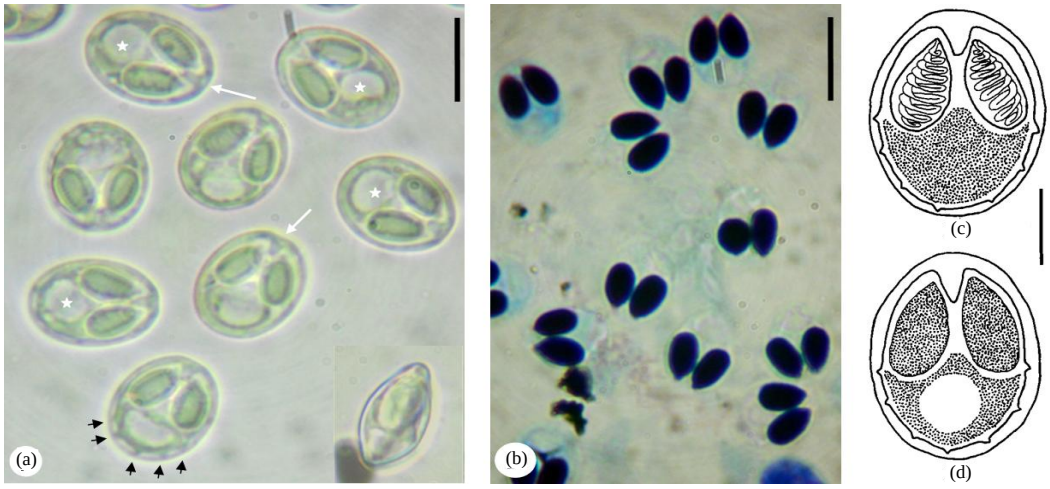

Fig. 3(a-d): Photomicrographs and line drawings of spores of *Myxobolus sessabai* sp. nov., (a) Fresh spores (Scale bars: 10 µm), (b) Stained spores with May-Grünwald-Giemsa (Scale bars: 10 µm) and (c, d) Line drawings of spores (Scale bars: 5 µm)

- **Spore:** Medium in size, they are ovoid with two rounded ends (Fig. 3a-d). There are 6-7 valvular folds at the posterior end of the spore (Fig. 3a, c). At the anterior end, there is a well-developed intercapsular process mesuring 2.6±0.08 (2.1-3.2) µm long (Fig. 3a, c). Polar capsules are piriform and symmetrical (Fig. 3b). In each of them, 8-10 coils of the filament are counted (Fig. 3c). The sporoplasm contains a large iodinophilous vacuole (Fig. 3a, d)
- **Measurements:** Measurements are given in Table 1
- **Host:** *Barbus callipterus* Boulenger, 1907 (Cyprinidae)
- **Location:** Lébamzip (Center region)
- **Localization in the host:** Skin, kidneys
- **Prevalence:** 22% (11 fish parasitized out of 50 examined)
- **Type material:** Glass slides with stained spores (syntype) and cysts preserved in 10% buffered neutral formalin are deposited in the parasitological collection of the Laboratory of Parasitology and Ecology, Faculty of Science, University of Yaounde 1, Cameroon (No. Myxo/2017/LPE-003)
- **Etymology:** The species is related to the Sessaba river in which the host fish were captured

DISCUSSION

According to Eiras *et al.*[11,13], there are many Myxosporidia of the genus *Myxobolus* having an intercapsular appendix and unequal polar capsules described in freshwater fishes.

Myxobolus dossoui[35], parasite of cartilaginous tissue of the gill arches of *Tilapia zillii*, *Hemichromis fasciatus* and *Tilapia* hybrid in Benin, forms spores with unequal polar capsules and an intercapsular appendage. However, these spores are sub-spherical and less developed (9.9×9.2 µm on average).

While having an intercapsular triangle and asymmetric polar capsules, *Myxobolus bilongi*[25], parasite of *Labeo* sp. in Cameroon, forms larger and spherical spores (15.3×12.2 µm on average), with the anterior end slightly flattened.

With the general form and the components of the spore, the parasite in description approaches *Myxobolus analfinus*[36] *M. debsantus*[36] and *M. tripurensis*[37]. *Myxobolus analfinus* foud in the fins of *Heteropneustes fossilis* in India, forms spores with a narrowed anterior end and a suture line free of folds. *Myxobolus debsantus* described on the fins of hybrid carp, Catla-Rohu (*Catla catla*× *Labeo rohita*) differs from the species in description by its less developed spores (9.0×8.4 µm on average), strong dissymmetry between polar capsules. *Myxobolus tripurensis* was described in the gills of *Labeo calbasu* in India. Spores of this Myxosporidia are less developed (8.1-9.4×6.5-7.0 µm), with 9 shell valve folds in the posterior quarter, less developed polar capsules (4.2×2.3 µm on average for the larger and 2.7×1.7 µm for the smaller). The intercapsular appendage is crescent-shaped.

Myxobolus burkinei[38], a parasite of *Labeo coubie* in Burkina-Faso, forms spores with an intercapsular triangle and unequal polar capsules. This species differs from the parasite being described by its clearly dissymmetrical polar capsules (6.19 and 4 µm on average respectively for the larger and the smaller) and the lack of folds on shell valves.

Seenappa and Manohar[39] described *Myxobolus vedavatiensis* in the gills of *Cirrhina mrigala* (Cyprinidae) in

India. Although the general shape of spores, the presence of unequal polar capsules, the presence of an intercapsular triangle approximates this parasite to the species in description but *M. vedavatiensis* forms longer spores (13-15 µm), similarly. The suture line does not show fold. The larger polar capsule is more developed (6-7×3-4 µm).

Spores of *Myxobolus haldari*[40], parasites of numerous Cyprinid fishes (*Cirrhina mrigala*, *Labeo dyocheilus*, *L. rohita* and *L. bata*) in India are less developed (9.31×7.95 µm on average) with shorter polar capsules (4.31 and 2.95 µm on average respectively for the larger and smaller), compared to 5.0 and 4.4 µm obtained for our species.

Myxobolus buckei[41], parasite of Cyprinid fish (*Leuciscus cephalus*, *Abramis brama* and *Rutilus rutilus*) in the United Kingdom, forms ovoid spores with an intercapsular appendix and shell valve folds at the posterior end. Spores of this Myxosporidia are however longer (14 µm on average) with equal polar capsules.

These differences lead to the creation of a new species for the parasite of *B. callipterus* and we propose the name *Myxobolus ngassami* sp. nov., as a sign of honour to Professor NGASSAM Pierre, a lecturer at the University of Yaounde 1.

Several species of Myxosporidia have been described in the heart of freshwater fish throughout the world.

Myxobolus hearti[42] is a parasite the heart of *Carassius auratus auratus* in China. Its polar capsules are unequal and there is no intercapsular appendage. Spores of this species are ovoid but larger (14.8×11.2 µm on average) compared to those of the species in description.

Myxobolus dogieli[43], *M. cordis*[44] and *M. heteromorpha*[45] parasites of the heart in their hosts, form spherical spores and are devoid of intercapsular triangle. Spores of these parasites are more developed (9-16×8-15 µm, 12×10 µm and 10.9×9.5 µm, respectively) and their polar capsules are unequal.

Myxobolus bulbocordis[46] was found in the heart of *Barbus sharpeyi* in Iran. The spores of this Myxosporidia, although ovoid with shell valve folds are quite distinguished from those of the species in description by the following characteristics: Relatively large size (19×15.3 µm on average), presence of an intercapsular triangle, equal polar capsules.

Myxobolus oloi[18] parasites the heart, gills, esophagus and kidneys of *Barbus aspilus*, *B. camptacanthus*, *B. guirali* and *B. martorelli* in Cameroon. Despite the comparable spore dimensions and the presence of unequal polar capsules, the parasite stands away from the species in description by the absence of folds on shell valves.

Seenappa and Manohar[39] described *Myxobolus vedavatiensis* in the gills of *Cirrhina mrigala* in India. Spore of this *Myxobolus* are more developed (13-15×8-10 µm) has an intercapsular triangle are devoid of shell valve folds, its polar capsules are more developed (6.2×3.4 µm and 3.9×2.6 µm on average respectively for the larger and the smaller). *Myxobolus bhadrensis*[39] is a parasite the muscle of *Labeo rohita* in India. The spore of this Myxosporidia is similar to that of the species presently described with its shape, the absence of an intercapsular triangle and the asymmetry observed in polar capsules. However, *M. bhadrensis* differs from the parasite of *Barbus callipterus* by the absence of folds on shell valves at the posterior end of spore and its less developed polar capsules (4.5 and 2.5 µm in length respectively for the larger and the smaller).

These differences lead one to think that the parasite of *Barbus callipterus* is new. The name *Myxobolus sanagaensis* sp. nov. is propose, referring to the Sanaga basin in which the host fish were caught.

Myxosporidia species with equal polar capsules and intercapsular triangle have been described in Africa and around the world.

Myxobolus njinei[23], a parasite of *Barbus camptacanthus*, *B. guirali* and *B. martorelli* in Cameroon, forms larger spores (16.17×13.46 µm on average) with apical truncation.

Myxobolus parvus[47] forms cysts in the gills of *Mugil cephalus* in India. Although having an intercapsular triangle and equal polar capsules, its spores are clearly distinguishable from those of the species we are describing by the following characteristics: intercapsular triangle less developed, lack of folds on the suture line, smaller spores (6.3×4.8 µm on average).

Sarkar[48] described *Myxobolus meglitschus*, a parasite forming cysts in gill lamellae of *Notopterus notopterus* in India. Although ovoid, spores of this species are less developed (8.8×6.96 µm on average). Its smaller polar capsules (4.42×2.07 µm on average) contain only 5-7 coils of the filament.

Spores of *Myxobolus gayerae*[49], parasite of the intestine of *Leuciscus cephalus* L. (Cyprinidae) in Hungary are ellipsoidal, with shell valve folds at the posterior end. They have an intercapsular triangle and unequal polar capsules. Compared to our species, *M. gayerae* has larger spores (15.1×12.7 µm on average), its piriform polar capsules contain only 6 coils of the filament.

In Brazil, Carriero *et al*.[50] described *Myxobolus pantanalis* in the gills of *Salminus brasiliensis*. Spores of this species are ovoid but less developed (9.3×6.5 µm on average), devoid of intercapsular triangle, its polar capsules are equal but contain only 4-5 coils of the filament.

Sakiti *et al.*[35] described *Myxobolus dossoui* in the gills of various cichlids (*Tilapia zillii*, *Hemichromis fasciatus* and *Tilapia* hybrid) in Benin. This parasite forms spores of comparable morphology with an intercapsular triangle. However, they are quite small (9.9×9.2 µm on average) with unequal polar capsules.

The parasite of *Barbus callipterus*, which differs from known Myxosporidia by many aspects, is new. We propose the name *Myxobolus sessabai* sp. nov. to recall the Sessaba River in which the host fish were captured.

CONCLUSION

Myxosporidia recorded in this study belong to the genus *Myxobolus*. Morphometric characteristics of spores indicate new species for which the names *Myxobolus ngassami* sp. nov., *Myxobolus sanagaensis* sp. nov. and *Myxobolus sessabai* sp. nov. are proposed. The infection with the three parasites species described does not cause observed significant economic loss because the infection was only found in wild Cyprinid. However, it seems to be dangerous if the infection occur in fish ponds. Further research will focus on the epidemiology of Myxosporidia parasites of cultured *Barbus callipterus*.

SIGNIFICANCE STATEMENT

This study provides the description of *Myxobolus ngassami* sp. nov., *Myxobolus sanagaensis* sp. nov. and *Myxobolus sessabai* sp. nov. parasites of *Barbus callipterus* Boulenger, 1907 (Cyprinidae). In Cameroon, 7 species of parasites of the genus *Myxobolus* are now known in six species of fish of the genus *Barbus*. The identified parasites affect many organs. The rupture of cysts implanted under these organs can provoke wound that would constitute entry door for secondary pathogens (bacteria and fungi).

ACKNOWLEDGMENT

The authors are greatly indebted to Prof. AJEAGAH Gideon AGHAINDOUM who linguistically corrected the manuscript.

REFERENCES

1. Vivien, J., 2012. Guide to Mammals and Fish in Cameroon. Ediprint, Saint Berthevin, France.
2. Fomena, A., 1995. Myxosporidia and Microsporidia of fresh water fishes in Southern Cameroon: Faunal description, ultrastructure and biology. Ph.D. Thesis. Department of Animal Biology and Physiology, University of Yaounde I, Yaounde, Cameroon.
3. Folefack, G.B.L., 2010. Faunistic and biology of Myxosporidia (Myxozoa: Myxosporea) parasites of some teleosts in the Sange river (Wouri sub-tributary). Ph.D. Thesis, Department of Animal Biology and Physiology, University of Yaounde I, Yaounde, Cameroon.
4. Nchoutpouen, E., 2015. Myxosporidia (Myxozoa: Myxosporea) parasites of some Teleost of the Noun Basin (West Region, Cameroon): taxonomy and biology of species parasitizing *Oreochromis niloticus* Linneaus, 1758 and *Labeo parvus* Boulenger, 1902. Ph.D. Thesis, Department of Animal Biology and Physiology, University of Yaounde I, Yaounde, Cameroon.
5. Jurine, L.L., 1825. History of fish in Lake Lehman. Memoirs of the Society of Physics and Natural History of Geneva 3, Geneva, Switzerland.
6. Lom, J. and I. Dykova, 1992. Myxosporidia (Phylum Myxozoa). In: Protozoan Parasites of Fishes, Developments in Aquaculture and Fisheries Science, Lom, J. and I. Dykova (Eds.). Vol. 26, Elsevier, Amsterdam, pp: 159-235.
7. Lom, J. and I. Dykova, 2006. Myxozoan genera: Definition and notes on taxonomy, life-cycle terminology and pathogenic species. Folia Parasitol., 53: 1-36.
8. Eiras, J.C., 2002. Synopsis of the species of the genus *Henneguya* Thelohan, 1892 (Myxozoa: Myxosporea: Myxobolidae). Syst. Parasitol., 52: 43-54.
9. Eiras, J.C., 2006. Synopsis of the species of *Ceratomyxa* Thelohan, 1892 (Myxozoa: Myxosporea: Ceratomyxidae). Syst. Parasitol., 65: 49-71.
10. Eiras, J.C. and E.A. Adriano, 2012. A checklist of new species of *Henneguya* Thelohan, 1892 (Myxozoa: Myxosporea, Myxobolidae) described between 2002 and 2012. Syst. Parasitol., 83: 95-104.
11. Eiras, J.C., K. Molnar and Y.S. Lu, 2005. Synopsis of the species of *Myxobolus* Butschli, 1982 (Myxozoa: Myxosporea: Myxobolidae). Syst. Parasitol., 61: 1-46.
12. Eiras, J.C., A. Saraiva, C.F. Cruz, M.J. Santos and I. Fiala, 2011. Synopsis of the species of *Myxidium* Butschli, 1882 (Myxozoa: Myxosporea: Bivalvulida). Syst. Parasitol., 80: 81-116.
13. Eiras, J.C., J. Zhang and K. Molnar, 2014. Synopsis of the species of *Myxobolus* Butschli, 1882 (Myxozoa: Myxosporea, Myxobolidae) described between 2005 and 2013. Syst. Parasitol., 88: 11-36.
14. Fiala, I., P. Bartosova-Sojkova and C.M. Whipps, 2015. Classification and Phylogenetics of Myxozoa. In: Myxozoan Evolution, Ecology and Development, Okamura, B., A. Gruhl and J.L. Bartholomew (Eds.). Springer International Publishing, Switzerland, ISBN: 978-3-319-14752-9, pp: 85-110.

15. Fomena, A., 1986. Contribution to the study of Myxosporidia (Protozoa: Myxozoa) parasites of freshwater fish in South Cameroon: Systematics, ultrastructure, host-parasite relationships. M.Sc. Thesis, Department of Animal Biology and Physiology, University of Yaounde, Yaounde, Cameroon.
16. Fomena, A. and G. Bouix, 1986. Contribution to the study of Myxosporidian of fresh water fishes in Cameroon. I. New species of *Myxidium* Butschli, 1882. Acta Trop., 43: 319-333.
17. Fomena, A. and G. Bouix, 1987. Contribution to the study of Myxosporidian of fresh water fishes in Cameroon. III. New species of the genera *Henneguya* Thelohan, 1892 and *Thelohanellus* Kudo, 1933. Rev. Zool. Afr., 101: 43- 53.
18. Fomena, A. and G. Bouix, 1994. New Myxosporidea species (Myxozoa) from freshwater teleosts in Southern Cameroon (Central Africa). J. Afr. Zool., 108: 481-491.
19. Fomena, A. and G. Bouix, 1996. New species of *Henneguya* Thelohan, 1892 (Myxozoa: Myxosporea) parasites of fresh water fishes in Cameroon. J. Afr. Zool., 110: 413-423.
20. Fomena, A. and G. Bouix, 1997. Myxosporea (Protozoa: Myxozoa) of freshwater fishes in Africa: Keys to genera and species. Syst. Parasitol., 37: 161-178.
21. Fomena, A. and G. Bouix, 1997. Myxosporidia (Myxozoa) from Southern Cameroon: New or little known species of parasites of fresh water teleosts. Bull. de l'IFAN. A. Diop. Ser. A, 49: 117-132.
22. Fomena, A. and G. Bouix, 2000. *Henneguya mbakaouensis* sp. nov., *Myxobolus nounensis* sp. nov. and *M. hydrocyni* Kostoingue and Toguebaye, 1994. Myxosporea (Myxozoa) parasites of Centropomidae, Cichlidae and Characidae (Teleosts) of the Sanaga basin in Cameroon (Central Africa). Parasite, 7: 209-214.
23. Fomena, A., G. Bouix and E. Birgi, 1985. Contribution to the study of Myxosporidian of fresh water fishes in Cameroon. II. New species of *Myxobolus* Butschli, 1882. Bull. I.F.A.N. T. Ser. A., 46: 167-192.
24. Fomena, A., A. Marques and G. Bouix, 1993. Myxosporidea (Myxozoa) of *Oreochromis niloticus* (Linnaeus, 1757) (Teleost, Cichlidae) in fish-farming pools at Melen (Yaounde, Cameroon, Central Africa). J. Afr. Zool., 197: 45-56.
25. Fomena, A., A. Marques, G. Bouix and T. Njine, 1994. *Myxobolus bilongi* sp. n., *Thelohanellus assambai* sp. n. and *Thelohanellus sanagaensis* sp. n., Myxosporidian parasites of *Labeo* sp. (Teleostei: Cyprinidae) in the Sanaga Basin in Cameroon Central Africa). Annales de la Faculte des Sciences de l'Universite de Yaounde I., 3: 131-142.
26. Fomena, A., C. Farikou-Oumarou, I.I. Tang and G. Bouix, 2007. *Thelohanellus njinei* sp. nov. and *T. Lagdoensis* sp. nov, Myxosporidia (Myxozoa: Myxosporea) parasites of schilbeidae and citharinidae fishes in Cameroon (Central Africa). Parasite, 14: 113-119.
27. Fomena, A., G.B.L. Folefack and C. Tang, 2007. New species of *Myxobolus* (Myxosporea: Myxobolidae) parasites of fresh water fishes in Cameroon (Central Africa). J. Biol. Sci., 7: 1171-1178.
28. Fomena, A., G.B.L. Folefack and G. Bouix, 2008. [Three new species of *Henneguya* (Myxozoa: Myxosporea), parasites of fresh water fishes in Cameroon (central Africa)]. J. Afr. Zool., 4: 93-103.
29. Fomena, A., G.B.L. Folefack and G. Bouix, 2010. [Two new species of *Myxidium* (Myxosporea: Myxidiidae) parasites of fresh water fish in Cameroon]. Parasite, 17: 9-16.
30. Nchoutpouen, E. and A. Fomena, 2011. [The study of three new species of *Myxobolus* (Myxosporea: Myxobolidae) parasites of *Labeo parvus* Boulenger, 1902, Cyprinid fish in Cameroon]. J. Applied Biosci., 38: 2508-2517.
31. Stiassny, M.L.G., G.G. Teugels and C.D. Hopkins, 2007. Freshwater and Brackish Fish from Lower Guinea, Western Central Africa. In: Tropical Fauna and Flora Collection, IRD (Ed.). Institute of Research for Development, Paris, France.
32. L'Hote, Y., P. Dubreuil and J. Lerique, 1996. Map of the types of climate in Black Africa in western Congo. Reminder and extension to hygrological regime. Int. Assoc. Hydrol. Sci., 238: 55-65.
33. Olivry, J.C., 1986. Rivers and Streams of Cameroon. MESRES-ORSTOM, Paris, France.
34. Lom, J. and J.R. Arthur, 1989. A guideline for the preparation of species descriptions in *Myxosporea*. J. Fish. Dis., 12: 151-156.
35. Sakiti, N., E. Blanc, A. Marques and G. Bouix, 1991. [*Myxobolus* spp. (Myxozoa, Myxosporea) Butschli, 1882 parasite on Cichlidae of Lake Nokoue in Benin (West Africa)]. J. Afr. Zool., 105: 173-186.
36. Basu, S., B.K. Modak and D.P. Haldar, 2015. Two new species of *Myxobolus* Butschli, 1882 (Myxozoa: Myxosporea: Bivalvulida) from food fishes of West Bengal, India-a light and scanning electron microscopy study. Acta Protozool., 48: 83-89.
37. Madhavan, R., P.B. Bandyopadhyay and B. Santosh, 2013. Observations on two new species of *Myxobolus* Butschli, 1882 from minor carps of Tripura, India. J. Parasitic Dis., 37: 56-61.
38. Kabre, G.B., N.G. Sakiti, A. Marques and L. Sawadogo, 1995. *Myxobolus comoei* sp. nov. and *Myxobolus burkinei* sp. nov., New histozoic myxosporidia in two Teleosteens: *Clarias anguillaris* and *Labeo coubie* caught in the fisheries of Burkina Faso (West Africa). Bull. I.F.A.N. T. Ser. A, 448: 49-55.
39. Seenappa, D. and L. Manohar, 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 & Manohar, 1980. J. Protozool., 28: 358-360.

40. Gupta, S. and S. Khera, 1989. Observations on *Myxobolus haldari* sp. nov. (Myxozoa: Myxosporea) from freshwater shes of North India. Res. Bull. Punjab Univ. New Ser. Sci., 40: 281-291.
41. Longshaw, M., P. Frear and S.W. Feist, 2003. *Myxobolus buckei* sp. n.(Myxozoa), a new pathogenic parasite from the spinal column of three cyprinid fishes from the United Kingdom. Folia Parasitol., 50: 251-262.
42. Chen, Q.L. and C.L. Ma, 1998. Fauna Sinica, Myxozoa, Myxosporea. Science Press, Beijing, China.
43. Bykhovskaya-Pavlovskaya, I.E. and B.E. Bykhovski, 1940. Parasite fauna of fishes of Akhtarinsk Bays (Azov Sea, River Kuban Delta). Parasitologicheskij Sbornik (Leningrad), 8: 131-161.
44. Keysselitz, G., 1908. On pathological changes caused by sporozoa (myxosporidia). Verhandlungen der Gesellschaft Deutscher Naturforscher und Arzte, 2: 542-543.
45. Ma, C.L., 1993. On the myxosporidians from the shes of Tai Lake. J. Chongqing Normal College (Nat. Sci. Edn.), 10: 1-17.
46. Masoumian, M., F. Baska and K. Molnar, 1996. Description of *Myxobolus bulbocordis* sp. nov. (Myxosporea: Myxobolidae) from the heart of *Barbus sharpeyi* (Gunther) and histopathological changes produced by the parasite. J. Fish Dis., 19: 19-21.
47. Shulman, S.S. and G.H. Shtein, 1962. Phylum Protozoa-Unicellular Animals. In: Key to Parasites of Freshwater Fish of the USSR, Pavloski, E.N. (Ed.). Zoological Institute, Academy of Sciences, URSS., Moscow, pp: 5-235.
48. Sarkar, N.K., 1996. On two new myxosporidian parasites (Myxozoa: Myxosporea) of a fresh water teleost Notopterus notopterus (Pallas) from West Bengal, India. Proc. Zool. Soc. (Calcutta), 49: 5-10.
49. Molnar, K., S. Marton, E. Eszterbauer and C. Szekely, 2007. Description of *Myxobolus gayerae* sp. n. and re-description of *M. Leuciscini* infecting European chub from the Hungarian stretch of the river Danube. Dis. Aquat. Organisms, 78: 147-153.
50. Carriero, M.M., E.A. Adriano, M.R.M. Silva, P.S. Ceccarelli and A.A.M. Maia, 2013. Molecular phylogeny of the *Myxobolus* and *Henneguya* genera with several new South American species. PLoS ONE, Vol. 8. 10.1371/journal.pone.0073713
51. Kumari, P.S., 1969. Studies on parasitic protozoa (Myxosporidia) of fresh water fishes of Andhra Pradesh, India. Riv. Parasitol., 30: 153-226.
52. Ibragimov, S.R., 1977. New myxosporidian species of the genus *Myxobolus* (Protozoa: Myxosporidia) from barbels of the River Leukoranchai (Azerb. SSR). Parazitologiya, 11: 537-538.
53. Tripathi, Y.R., 1952. Studies on parasites of Indian shes. I. Protozoa myxosporidia together with a check list of parasitic protozoa described from Indian shes. Rec. Indian Museum, 50: 63-88.
54. Markevitsch, A.P., 1932. Knowledge of the myxosporidia of freshwater fish of Ukraine. Zool. Anz., 99: 297-303.
55. Molnar, K., E. Eszterbauer, S. Marton, C. Szekely and J.C. Eiras, 2012. Comparison of the *Myxobolus* fauna of common barbel from Hungary and Iberian barbel from Portugal. Dis. Aquat. Org., 100: 231-248.
56. Ali, M.A., K.A.S. Al-Rasheid, T. Sakran, A.A. Abdel-Baki and F.A. Abdel-Gha ar, 2002. Some species of the genus *Myxobolus* (Myxozoa: Myxosporea) infecting freshwater fish of the River Nile, Egypt and the impact on their hosts. Parasitol. Res., 88: 9-15.
57. Alvarez-Pellitero, M.D.P. and C. Gonzalez-Lanza, 1985. Studies on *Myxobolus* spp. of *Barbus barbus bocagei* from the river Esla (Leon, NW Spain). Angewandte Parasitol., 26: 3-12.
58. Reed, C.C., L. Basson and L.L. van As, 2002. *Myxobolus* species (Myxoa), parasite of fishes in the Okavango River and Delta, Botswana, including descriptions of two new species. Folia Parasitol., 49: 81-88.
59. Landsberg, J.H. and J. Lom, 1991. Taxonomy of the genera of the *Myxobolus/Myxosoma* group (Myxobolidae: Myxosporea), current listing of species and revision of synonyms. Syst. Parasitol., 18: 165-186.
60. Miroshnichenko, A.I., 1980. *Myxobolus impressus* n. sp., a new myxosporidian (Cnidosporidia, Myxosporidia) from freshwater sh in the Crimea. Biol. Nauki., 9: 38-39.
61. Molnar, K., M. Masoumian and S. Abasi, 1996. Four new *Myxobolus* spp. (Myxosporea: Myxobolidae) from Iranian barboid fishes. Archiv fur Protistenkunde, 147: 115-123.
62. Daniyarov, M.R., 1975. New species of the genus *Myxobolus* (Myxosporidia, Bivalvulea) of sh from Ka rnigan River Basin and Chilu-Char Chashma Springs (Tadzhik SSR). Doklady Akademii Nauk Tadzhikskoi SSR, 18: 67-68.
63. Masoumian, M., F. Baska and K. Molnar, 1994. Description of *Myxobolus karuni* sp. n. and *Myxobolus persicus* sp. n. (Myxosporea, Myxozoa) from *Barbus grypus* of the River Karun, Iran. Hung. Nat. Hist. Museum Parasit. Hung., 27: 21-26.
64. Fantham, H.B., 1930. Some parasitic protozoa found in South Africa-13. S. Afr. J. Sci., 27: 376-390.
65. Thelohan, P., 1895. Recherches sur les Myxosporidies. Bull. Sci. Fr. Belg., 26: 100-394.
66. Lom, J., 1969. On a new taxonomic character in Myxosporidia, as demonstrated in descriptions of two new species of *Myxobolus*. Folia Parasitol., 16: 97-103.
67. Dogel, V.A., 1932. The fresh water Myxosporidia of the USSR. Leningrad, Lensnabtekhizdat, URSS.