

Description of Three New Species of Myxosporidia (Cnidaria: Myxobolidae) Parasites of *Paramormyrops kingsleyae* Günther, 1896 (Mormyridae) in the Nyong Basin in Cameroon

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ABSTRACT

Parasitological examination of *Paramormyrops kingsleyae* Günther, 1896 caught in the Djolon River in Cameroon revealed the presence of three new species of Myxosporidia of the genus *Myxidium* Bütschli 1882 and *Henneguya* Thelohan, 1892 of which complete description is given in the present study. These species are: *Myxidium binguelai* sp. nov., parasite of the kidney that produce fusiform spores with a turgid medial part and both ends pointed. They measured 12.1 (11.1-12.9) µm long x 5.3 (4.8-5.8) µm broad; the polar capsules are ovoid, equal in size and measure 3.6 (3.0-4.1) µm x 2.5 (2.0-2.8) µm. *Myxidium djolonensis* sp. nov., a parasite of the gall bladder and urinary bladder, produce fusiform and elongated spores, that measure 16.3 (15.5-18.0) µm long x 6.1 (5-7.1) µm broad; its polar capsules are equal and measure 4.9 (4-5.6) x 3.5 (3-4.2) µm. *Henneguya paramormyropsi* sp. nov. form cyst in gill, eye and kidney. The total spore length is 29.2 (25.5-32.5) µm. The ovoid spore body, with narrowed anterior end measure 11.9 (10.7-12.8) µm x 4.5 (3.9-5.9) µm. The two separate caudal appendages measure 17.3 (14-20.3) µm. The 2 equal-sized thin and smooth valves surrounded 2 equal-sized pyriform, elongate polar capsules (5 (4.2-5.6) x 1.5 (1.2-1.9) µm) that contained 3 to 4 coils of the filament.

Keywords: Myxozoa; *Myxidium binguelai* sp. nov.; *Myxidium djolonensis* sp. nov.; *Henneguya paramormyropsi* sp. nov.; parasite; *Paramormyrops kingsleyae*; Cameroon

INTRODUCTION

Fish farming is one of the most important human activities because of the growing need of animal protein in the world [1]. Despite its food and economic importance, fish is also a favorable biotope for the development of a large number of parasites among which Myxosporidia [2,3].

Discovered by Müller [4], Myxosporidia Bütschli [5] are ubiquitous metazoans parasites of Vertebrates and Invertebrates [2]. They are of great importance in ichthyopathology because of lethal and sublethal effects related to their development in host fish, especially in fish farming [6]. More than a century after their first description based on the morphological and metrical characteristics of the spore, the worldwide Myxosporidia fauna is now estimated at 2200 species [7]. They represent 18% of Cnidaria species currently described and are distributed in 64 genera and 17 families [7]. Myxosporidia fauna in African freshwater fishes is estimated at about 280 species [8-12], while that of freshwater fish from Cameroon is represented

by about 80 species of which 11 belong to the genus *Myxidium* [11] and 12 to the genus *Henneguya* [8].

Molnár [13] believes that, most Myxosporidia species have strict specificity towards their hosts. In addition, Ali et al. [14] suggest the existence of geographical barriers between species of Myxosporidia. Thus, taking into consideration the fish species richness, the diversity of the environment and the geographical extent of the continent, the Myxosporidia biodiversity in Africa is certainly underestimated. Several Myxosporidia species have been described on Mormyrid fish in African [15]. However, no data are available on these parasites on *Paramormyrops kingsleyae* Günther [16] (Mormyridae).

In a more general study of myxosporidia parasites of some food and economic importance Teleosts in Cameroon, we found for the first time in *P. kingsleyae*, three new species whose full description is given in the present work. These species are: *Myxidium binguelai* sp. nov., *Myxidium djolonensis* sp. nov. and *Henneguya paramormyropsi* sp. nov.

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Received: December 18, 2019, **Accepted:** April 15, 2020, **Published:** April 22, 2020

Citation: Benoît LFG, Vanessa FTC, Abraham F (2020) Description of three new species of Myxosporidia (Cnidaria: Myxobolidae) parasites of *Paramormyrops kingsleyae* Günther, 1896 (Mormyridae) in the Nyong basin in Cameroon. Fish Aqua J. 11:274. doi: 10.35248/2150-3508.209.11.275

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MATERIALS AND METHODS

Fish examined during this study were harvested from March to July 2018 in the Djolon River (tributary of the Nyong River) at Binguéla, a village in the Mbankomo District in the Mefou and Akono Division, Central Region of Cameroon. This village is located between 3°31' to 4° North latitude and 11°13' to 12° East longitude.

Fish catches were done using gill nets. In the field, once fish were caught, a buttonhole was made on the ventral surface of each individual. They were immediately immersed in a 10% formalin solution before being brought to the laboratory. Systematic position of sampled fish was taken from Stiassny et al. [17]. In the laboratory, the fish were firstly examined with naked eye (eyes, fins, operculum, scales, skin) and then with the Olympus BO61 binocular stereoscopic microscope for the presence of cysts. After dissection of the fish hosts, internal organs such as gills, heart, liver, kidneys, spleen, gall bladder, urinary bladder, gonads, intestine and urethra were taken individually and examined. The contents of the cysts were identified with the objective 100x of an IVYMEN light microscope. The content of the gall bladder, urinary bladder and swim bladder was also examined between glass and glass cover slide under the microscope. Smears from kidney, spleen, liver, gonads, heart and urethra were carefully examined at the 40x objective of the microscope. Spore smears were fixed with methanol and stained with May-Grünwald-Giemsa. Drawings of unstained spores were performed using a Wild M-20 microscope equipped with a camera Lucida. Fifty spores were measured using an objective micrometer. Variables taken into consideration were those proposed by Lom et al. [18]. Microphotographs of spores were performed using an Olympus BH-2 microscope equipped with a microphotograph device.

RESULTS

Myxidium binguelai sp. nov.m

Vegetative form: Not observed; numerous spores are dispersed in the kidney.

Spore: Small in size (12.1 x 5.3 µm on average), spores are fusiform with a turgid medial part and both ends pointed (Figures 1 and 2). Each valve carries 6 to 7 longitudinal striations (Figures 2 and 3). The suture line is straight. Polar capsules are ovoid, of equal size and open at the opposite extremities of the spore (Figures 4 and 5). Within each of them, there are 4 coils of the filament (Figure 5). The sporoplasm, located in the extra-capsular space, is finely granular and contains a large iodophilous vacuole (Figures 1, 2 and 5).

Measurements: Measurements are given in Table 1.

Type host: *Paramormyrops kingsleyae* Günther [16] (Mormyridae).

Type locality: Binguéla (3° 42' 11" N; 11° 22' 34" E) in Djolon River (Center Region; Cameroon).

Location in the host: kidney.

Prevalence: 18.8% (13 parasitized fish out of 69 examined).

Type material: Glass slides with stained spores (syntype) and parasitized kidney preserve in 10% buffered neutral formalin are deposited in the parasitological collection of the Laboratory of Parasitology and Ecology, Faculty of Science, University of Yaounde



Figure 1: Microphotograph (optical microscopy) of unstained spores of *Myxidium binguelai* sp. nov. Scale bar: 5 µm.



Figure 2: Microphotograph (optical microscopy) of unstained spores of *Myxidium binguelai* sp. nov. with well-developed sporoplasm containing well-developed iodophilous vacuole. Scale bar: 5 µm.

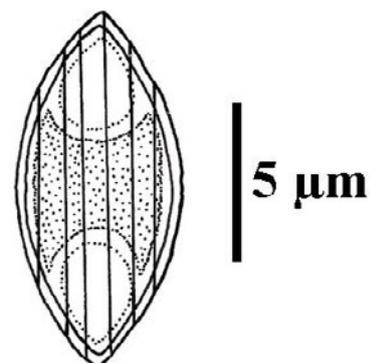


Figure 3: Line drawing of a spore of *Myxidium binguelai* sp. nov. showing longitudinally striated shell valves.

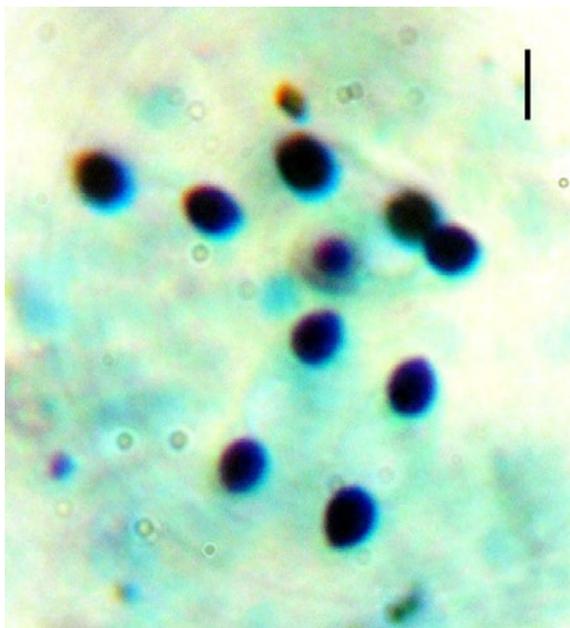


Figure 4: Microphotograph (optical microscopy) of spores of *Myxidium binguelai* sp. nov. stained with May-Grünwald-Giemsa. Scale bar: 5 μ m.

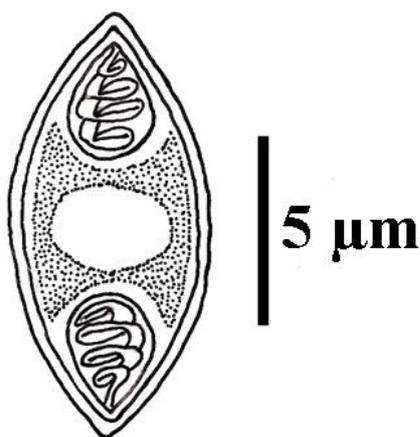


Figure 5: Line drawing of a spore of *Myxidium binguelai* sp. nov.: the spore is fusiform with a well-developed iodophilous vacuole.

1, Cameroon (No. Myxo/2019/LPE-001).

Etymology: The species is related to the locality of Binguela where host fish were captured.

***Myxidium djolonensis* sp. nov.**

Vegetative form: Not observed, only mature and free spores were found in the bile and urinary bladder.

Spores: Fusiform, elongated (2.7 times longer than wide) and sometimes slightly arched, the spores have truncated ends (Figures 6-8). Each valve has 7 to 9 longitudinal striations (Figures 7 and 8). The polar capsules are ovoid and equal in size (Figures 9 and 10). Within each of them, there are 5 to 7 coils of the filament (Figure 10). The sporoplasm occupies the extracapsular space.

Measurements: Measurements are given in Table 2.



Figure 6: Microphotograph (optical microscopy) of unstained spores of *Myxidium djolonensis* sp. nov. Scale bar: 5 μ m.

Table 1: Comparative description of *Myxidium binguelai* sp. nov. with morphologically similar species (measurements in micrometre).

<i>Myxidium</i> species	Host	Site of infection	Country	LS	WS	LPC	WPC	FC	StV	Reference
<i>M. binguelai</i> sp. nov.	<i>Paramormyrops kingsleyae</i>	kidneys	Cameroon	12.1 (11.1-12.9)	5.3 (4.8-5.8)	3.6 (3.0-4.1)	2.5 (2.0-2.8)	4	6-7	Present study
<i>M. clariae</i>	<i>Clarias lazera</i>	Gall bladder	Israel	13.4-15.1	4.5-6.0	3.6-4.8	3.0-3.8	5-6	7-9	Landsberg [25]
<i>M. distichodi</i>	<i>Distichodus enycephalus</i>	Gall bladder	Chad	16.3 (16-17)	6.5 (6-7)	4.9 (4.5-5.5)	3.2 (3-3.5)	-	±	Kostoingué et al. [24]
<i>M. chrysichthyi</i>	<i>Chrysichthys nigrodigitatus</i>	Gall bladder	Benin	14.4 (13-16)	8.3 (7-10)	3.6 (2.5-4.5)	2.3 (2-2.5)	-	-	Sakiti [23]
<i>M. mendehi</i>	<i>Barbus guirali</i> , <i>B. martorelli</i>	Kidneys	Cameroon	9.9 (7.8-13.2)	4.1 (3.1-4.9)	3.4 (2.7-4.5)	2.3 (1.8 -3.1)	5-7	5	Fomena et al. [19]
<i>M. nkamensis</i>	<i>Clarias pachynema</i>	Gall bladder	Cameroon	25.4 (24-27.5)	11.7(10-13)	10.2 (10-11)	7.7 (7-8)	10-12	10-13	Fomena et al. [21]
<i>M. schalli</i>	<i>Synodontis shall</i>	Gall bladder	Egypt	11-12.5	4.5-6.5	2.5-3.5	1.5-2	-	-	Ghaffar et al. [22]
<i>Myxidium</i> sp.	<i>Tilapia zillii</i>	Liver ; kidney	Burkina Faso	12 (11-13)	4.8 (4-6)	2.9 (2.5-3.5)	1.9 (1.5-2)	4-5	±	Kabré [20]

Averages of the parameters measured are followed by minimal and maximal values in brackets.

LS: length of the spore; **WS:** width of the spore; **LPC:** length of the polar capsules; **WPC:** width of the polar capsules; **FC:** number of polar filament coils; **StV:** Number of striations on shell valves; -: absent or not reported in the species description; ±: shell valves striations are present, but the number was not reported in the species description.



Figure 7: Microphotograph (optical microscopy) of unstained spore of *Myxidium djolonensis* sp. nov. : spore with truncated ends. Scale bar: 5 μ m.

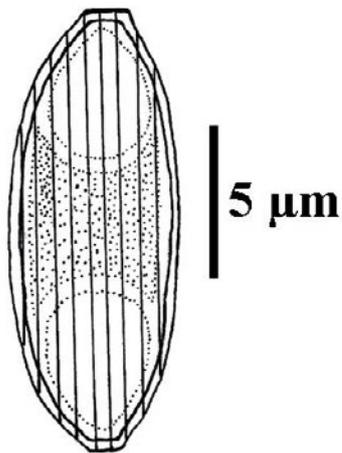


Figure 8: Line drawing of a spore of *Myxidium djolonensis* sp. nov. showing longitudinally striated shell valves.

Type host: *Paramormyrops kingsleyae* Günther [16] (Mormyridae).

Type locality: Binguela (3° 42' 11" N; 11° 22' 34" E) in Djolon River (Center Region; Cameroon).

Locations in the host: Gall bladder and urinary bladder.

Prevalence: 24.6% (17 parasitized fish out of 69 examined).

Type material: Glass slides with stained spores (syntype) and parasitized organs (gall bladder and urinary bladder) preserve 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/2019/LPE-002).

Etymology: The species is related to the Djolon River in which host fish were captured.

***Henneguya paramormyropsi* sp. nov.**

Vegetative form: Elongated, spherical or subspherical whitish cysts were observed in the secondary gill lamellae and the aqueous humor of the eye. These cysts are polysporous and measure 590-396 x 310-252 μ m. On a parasitized host fish, one can count an average

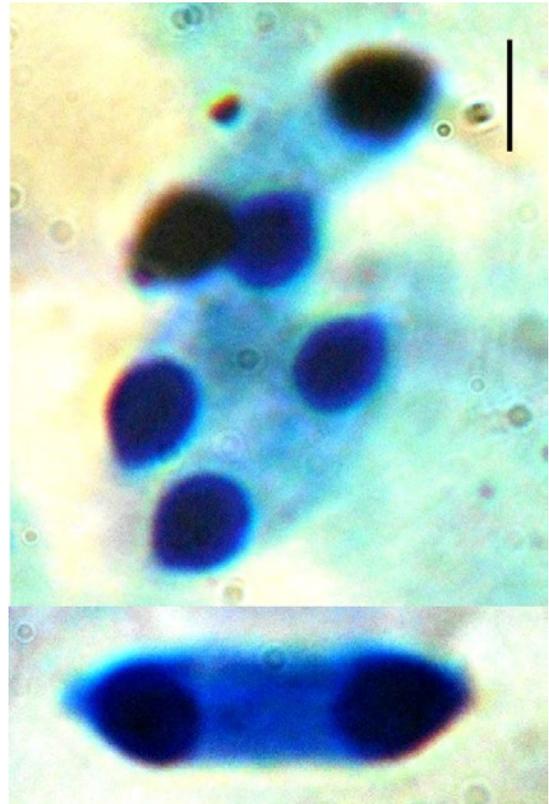


Figure 9: Microphotograph (optical microscopy) of spores of *Myxidium djolonensis* sp. nov. stained with May-Grünwald-Giemsa. Scale bar: 5 μ m.

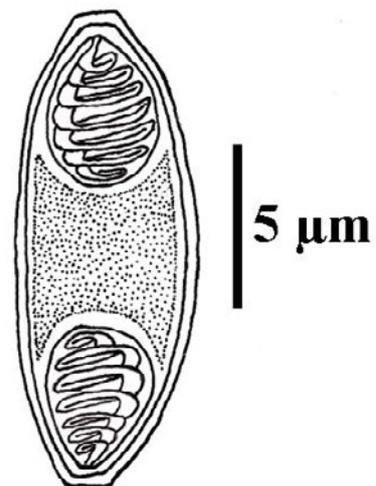


Figure 10: Line drawing of a spore of *Myxidium djolonensis* sp. nov.: the spore is fusiform with truncated ends; polar capsules are ovoid, equal in size and contain up to seven coils of the filament.

of 10 cysts. Vegetative stages were not observed in the kidney but isolated or grouped spores were found.

Spore: Spore body ovoid with narrowed anterior end (Figure 11). Shell valves smooth and extend posteriorly with two separate caudal appendages (Figure 11). Polar capsules are pyriform, elongated (3.3 times longer than wide) and of equal size (Figures 12 and 13). In each of them, there are three to four coils of the filament (Figure 14). The sporoplasm occupies the rest of the spore cavity (Figures 11 and 14).

Measurements: Measurements are given in Table 3.

Type host: *Paramormyrops kingsleyae* Günther [16] (Mormyridae).

Type locality: Binguela (3° 42' 11" N; 11° 22' 34" E) in Djolon River (Center Region; Cameroon).

Locations in the host: Gills, eye and kidney.



Figure 11: Microphotograph (optical microscopy) of unstained spores of *Henneguya paramormyropsis* sp. nov. Scale bar: 5 μ m.

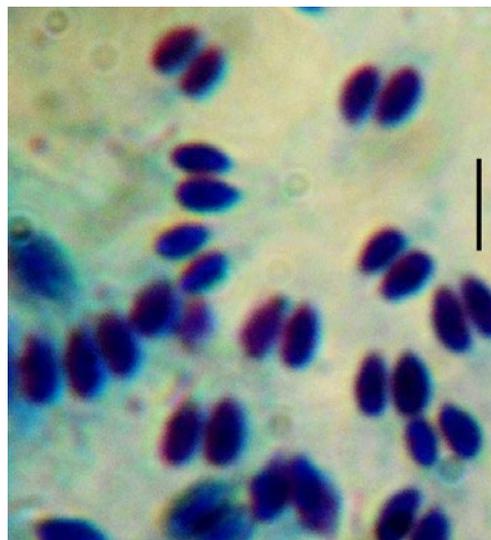


Figure 12: Microphotograph (optical microscopy) of spores of *Henneguya paramormyropsis* sp. nov. stained with May-Grünwald-Giemsa. Scale bar: 5 μ m.

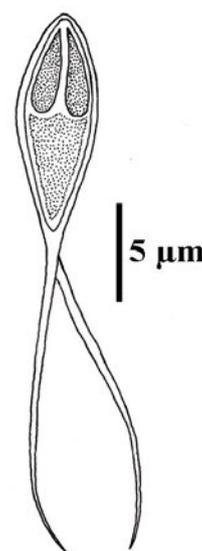


Figure 13: Line drawing of a spore of *Henneguya paramormyropsis* sp. nov.: the spore body is ovoid with narrowed anterior end; caudal appendages are separate

Table 2: Comparative description of *Myxidium djolonensis* sp. nov. with morphologically similar species (measurements in micrometre).

Myxidium species	Host	Site of infection	Country	LS	WS	LPC	WPC	FC	StV	Reference
<i>M. djolonensis</i> sp. nov.	<i>Paramormyrops kingsleyae</i>	Gall bladder; urinary bladder	Cameroon	16.3 (15.5-18.0)	6.1 (5-7.1)	4.9 (4-5.6)	3.5 (3-4.2)	5-7	7-9	Present study
<i>M. brienomyri</i>	<i>Brienomyrus brachyistius</i>	Gall bladder	Cameroon	13.7 (12.2-16.2)	6.5 (5.5-9)	4.2 (3.5-5)	4.2 (3.5-5)	3-5	6-12	Fomena et al.[27]
<i>M. clariae</i>	<i>Clarias lazera</i>	Gall bladder	Israel	13.4-15.1	4.5-6.0	3.6-4.8	3.0-3.8	5-6	7-9	Landsberg [25]
<i>M. distichodi</i>	<i>Distichodus engycephalus</i>	Gall bladder	Chad	16.3 (16-17)	6.5 (6-7)	4.9 (4.5-5.5)	3.2 (3-3.5)	-	±	Kostoingue et al. [24]
<i>M. molnari</i>	<i>Cirrhina reba</i>	Gall bladder	India	10.9 (8.3-10.0)	3.8 (2.9-5.0)	3.9 (3.3-5.0)	2.5 (2.0-3.3)		6-7	Yatindra et al. [26]
<i>M. nkamensis</i>	<i>Clarias pachynema</i>	Gall bladder	Cameroon	25.4 (24-27.5)	11.7(10-13)	10.2 (10-11)	7.7 (7-8)	10-12	10-13	Fomena et al. [21]
<i>M. sangei</i>	<i>Parachanna obscura</i>	Gall bladder	Cameroon	13.3 (12-14.5)	4.2 (3.5-5)	4.3 (4-5)	2.9 (2.8-3)	3-4	5-6	Fomena et al. [21]

Averages of the parameters measured are followed by minimal and maximal values in brackets.

LS: length of the spore; **WS:** width of the spore; **LPC:** length of the polar capsules; **WPC:** width of the polar capsules; **FC:** number of polar filament coils; **StV:** Number of striations on shell valves; -: absent or not reported in the species description; ±: shell valves striations are present, but the number was not reported in the species description.

Table 3: Comparative description of *Henneguya paramormyropsi* sp. nov. with morphologically similar species (measurements in micrometre).

<i>Henneguya</i> species	Host	Site of infection	Country	LSB	WSB	PC	LPC	WPC	LS	LCA	FC	Reference
<i>H. paramormyropsi</i> sp. nov.	<i>Paramormyrops kingsleyae</i>	Gills, eye, kidney	Cameroon	11.9 (10.7-12.8)	4.5 (3.9-5.9)	=	5 (4.2-5.6)	1.5 (1.2-1.9)	29.2 (25.5-32.5)	17.3 (14-20.3)	3-4	Present study
<i>H. dini</i>	<i>Heterotis niloticus</i>	Gills	Burkina-Faso	11.47 (11-12)	3.47 (3-5)	=	3.43 (3-4)	1.02 (1-1.5)	29.73 (27-32)	18.37 (16-20)	5-8	Kabré et al. [31]
<i>H. mailaoensis</i>	<i>Mormyrus cashive</i>	Gills	Chad	17.6 (15-18)	5.7 (5-6)	=	5.9 (5-7)	2.2 (2-3)	61.7 (58-63)	44.5 (41-46)	-	Kostoïngué et al. [29]
<i>H. mormyri</i>	<i>Mormyrus cashive</i>	Gills	Chad	8.4 (8-9)	4.5 (4-5)	=	3.3 (3-4)	1.9 (1-3)	32.2 (30-34)	23.1 (23-25)	3-4	Kostoïngué et al. [29]
<i>H. ntondei</i>	<i>Schilbe mystus</i>	Gills	Cameroon	12.8 (10.5-14)	5.4 (4-7)	=	6.4 (5.5-8)	1.7 (1.2-2)	27.7 (24-35)	14.8 (10-23)	10	Fomena et al. [30]
<i>H. nyongensis</i>	<i>Marcusenius moorii</i>	Gills; muscles	Cameroon	12.6 (10-14)	5.4 (4.5-6.5)	=	6.2 (5.5-7)	2.3 (2-2.8)	33.6 (30.5-36.5)	21 (20-23.5)	4-5	Fomena et al. [28]
<i>H. odzai</i>	<i>Marcusenius moorii</i>	Gills	Cameroon	14.4 (13-16)	3.9 (3.3-4.6)	=	3.9 (3.2-4.9)	1.3 (1-1.6)	32.9 (29.2-36)	18.5 (15-21.5)	4	Fomena et al. [28]
<i>H. suprabranchiae</i>	<i>Clarias lazera</i>	Accessory breathing organ	Israel	13.5 (12.2-14.3)	6.4 (5.6-6.9)	≠	7.6 (7.0-8.1)* 7.3 (6.6-8.0)**	2.1 (1.8-2.3)	37.5 (30.7-43.3)	24.0 (18.5-29.0)	-	Landsberg [25]

Averages of the parameters measured are followed by minimal and maximal values in brackets.

LSB: length of the spore body; WSB: width of the spore body; PC: relative length of the polar capsules (= equal; ≠ unequal); LPC: length of the polar capsules; WPC: width of the polar capsules; LS: total length of the spore; LCA: length of the caudal appendages; FC: number of polar filament coils (-: not reported in the species description); * Referring to the largest polar capsule; ** referring to the smallest polar capsules.

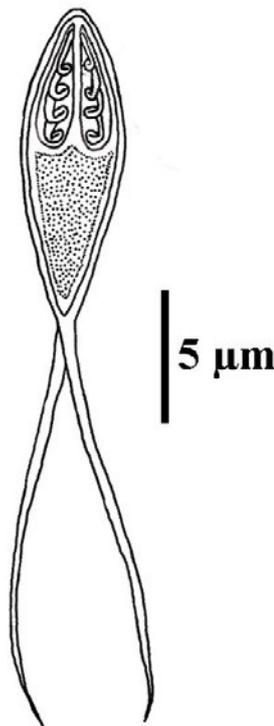


Figure 14: Line drawing of a spore of *Henneguya paramormyropsi* sp. nov.: polar capsules are pyriform, elongated, equal in size and each of them contain up to four coils of the filament.

Prevalence: 27.5 % (19 parasitized fish out of 69 examined).

Type material: Glass slides with stained spores (syntype) and cyst preserve 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/2019/LPE-003).

Etymology: The species is related to the generic name of the host fish.

DISCUSSION

Myxidium binguelai sp. nov.

In Africa, two Myxosporidia species belonging to the genus *Myxidium* have been described in the kidney of freshwater fishes, these are: *Myxidium mendehei* Fomena and Bouix [19], parasite of *Enteromius guirali* and *E. martorelli* in Cameroon; *Myxidium* sp. Kabré [20], parasite of the kidney and liver of *Tilapia zillii* in Burkina-Faso. The spores of *M. mendehei* are significantly smaller [9.9 (7.8-13.2) x 4.1 (3.1-4.9) μm] than those presently described. The general shape of the spore of *Myxidium* sp. recalls that of the species we are describing; however, this parasite forms arched spores with narrowed medial part and narrower polar capsules (1.5-2 μm).

Regarding the general shape of the spore, our parasite is close to *Myxidium nkamensis* Fomena, Lekeufack Folefack and Bouix [21] (host: *Clarias pachynema* (Clariidae) in Cameroon), *M. schalli* Ghaffar, El-Shahawi and Naas [22] (host: *Synodontis schalli* (Mochokidae) in Egypt) and *Myxidium chrysiichthyi* Sakiti [23] (hosts: *Chrysiichthys nigrodigitatus* and *C. auratus* (Bagridae) in Benin). *Myxidium nkamensis* forms significantly larger spores that are 25.4 (24 -27.5) μm long and 10.2 (10-11) μm wide. Its polar capsules are more developed (10.2 x 7.7 μm on average). *Myxidium schalli* forms spores of comparable size (12.3 x 5.4 μm on average) to those of the parasite described here. However, its polar capsules are pear-shaped. No data were provided on the number of valvular striations and the number of loops of the filament within the polar capsules when describing *M. schalli*. The spores of *M. chrysiichthyi* are more developed (14.4 x 8.39 μm on average).

Although spindle-shaped with pointed ends, our spores, are less developed compared to those of *Myxidium distichodi* Kostoïngué,

Faye and Toguebaye [24] (host: *Distichodus engycephalus* in Chad) which measure $16.34 \times 6.53 \mu\text{m}$ on average. The spores of *Myxidium clariae* Landsberg [25] (host: *Clarias lazera* (synonym: *Clarias gariepinus*) in Israel) are similar in shape to those of the species presently described, but they are longer (14, 3 (13, 4 -15, 1) μm) and their polar capsules are more developed (4.2 (3.6-4.8) \times 3.3 (3-3.8) μm).

The parasite of *Paramormyrops kingsleyae* differs from species of Myxosporidia previously described by many characters. We believe that, this parasite is new and propose to name it *Myxidium binguelai* sp. nov., a name that refers to the locality of Binguela where fish hosts were captured.

***Myxidium djolonensis* sp. nov.**

With the general shape of its spore, the presently described Myxosporidia approaches species previously described in Africa or other continents. Thus, the spores of *Myxidium nkamensis* Fomena, Lekeufack Folefack and Bouix [21] (host: *Clarias pachynema* (Clariidae) in Cameroon), *Myxidium molnari* Yatindra and Mathur [26] (host: *Cirrhina reba* (Cyprinidae) in India) recall by their shape, that of the species here described. However, the spores of *M. nkamensis* are more developed (25.4 \times 11.7 μm on average). *Myxidium molnari* produces less developed spores (10.42 \times 3.81 μm on average) with polar capsules measuring 3.93 \times 2.5 μm on average.

Because of their shape sometimes arched, the spores of the presently described species recall those of *Myxidium clariae* Landsberg [25] and *Myxidium sangei* Fomena, Lekeufack Folefack and Bouix [21]. However, *M. clariae*, described in the gallbladder of *Clarias lazera* (synonym: *Clarias gariepinus*) in Israel forms less developed spores (14.3 \times 5.3 μm on average), with pointed extremities and up to 9 striations per valve. *M. sangei*, described on *Parachanna obscura* (Chanidae) in Cameroon, forms significantly smaller spores that are 13.3 (12-14.5) μm long and 4.2 (3.5-5) μm wide.

M. distichodi Kostoingué, Faye and Toguebaye [24] (host: *Distichodus engycephalus* (Cyprinidae) in Chad) forms spores whose length (16.3 \times 6.5 μm on average) is comparable to that of the spores of the species presently describe. However, the spores of *M. distichodi* are spindle-shaped, with pointed ends and a turgid medial part.

Myxidium brienomyri forms large trophozoites in the gall bladder of *Brienomyrus brachyistus* (Mormyridae) in Cameroon [27]. The spores of this species, being ellipsoid with rounded ends measured 13.7 \times 6.47 μm on average. The maximum number of striations found on the valves is greater (12 striations) compared to 9 striations found on spores of the presently described species. In addition, their polar capsules are spherical.

These differences between the parasite of *Paramormyrops kingsleyae* and previously described species lead to the creation of a new species. We propose to name it *Myxidium djolonensis* sp. nov., a name that refers to the Djolon River in which host fish were caught.

***Henneguya paramormyropsi* sp. nov.**

Four species of *Henneguya* were previously described in Mormyrid fish in Africa. *Henneguya nyongensis* Fomena and Bouix [28] forms innumerable cysts between secondary gill lamellae of *Marcusenius moorii* (Mormyridae) in Cameroon. The spores of this species are longer (33 μm on average), with longer caudal appendages (20 to 23.5 μm). The polar capsules are more developed (6.2 \times 2.3 μm on average) and open to the anterior end by a "neck like" structure.

Henneguya odzai Fomena and Bouix [28] parasitizes the gills of *Marcusenius moorii* (Mormyridae) in Cameroon. Although having a total length of 29.2 to 36 μm , the spores of *H. odzai* have elongated spore body (3.69 times longer than wide) and a broad and rounded anterior end. Kostoingué et al. [29] described *Henneguya mormyri* and *Henneguya mailaoensis* on the gills of *Mormyrus cashiue* (Mormyridae) in Chad. With comparable general spore morphology, *H. mormyri* have a less developed spore body (8-9 \times 4-5 μm) and shorter polar capsules (3-4 μm). The spores of *Henneguya mailaoensis* are longer (58 to 63 μm) with a more developed spore body (17.6 μm long).

The general morphology of our spores recalls that of *Henneguya ntondei* Fomena, Lekeufack Folefack and Bouix [30], a parasite of the gills of *Schilbe mystus* (Schilbeidae) in Cameroon. However, the spore of *H. ntondei* has shorter caudal extensions (14.8 μm on average) and longer polar capsules (6.4 μm on average) containing 10 coils of the filament.

Henneguya suprabranchiae Landsberg [25], parasitizes tree organs of *Clarias lazera* in Israel. Although of comparable general morphology, the spore of *H. suprabranchiae* has a more developed spore body (13.5 \times 6.4 μm on average) and longer polar capsules (7-8.1 μm) containing 9 to 10 coils of the filament.

Henneguya dini Kabre et al. [31], a gill parasite of *Heterotis niloticus* (Osteoglossidae) in Burkina-Faso, differs from our parasite by its spore body which is 3.3 times longer than wide and less wide (3.43 μm on average). Moreover, their polar capsules are less developed (3.43 \times 1.02 μm on average).

The parasite of *Paramormyrops kingsleyae*, which differs from known Myxosporidia species, is new. We propose to name it *Henneguya paramormyropsi* sp. nov. with respect to the generic name of the host fish.

CONCLUSION

In ichthyopathology, it is important to report new parasites and pathological conditions when they are discovered because such information may be useful in the future as a baseline for assessing the health of ecosystems in the face of global warming. Thus, the present work makes available new data on Myxosporidia parasites of *Paramormyrops kingsleyae*. *Myxidium binguelai* sp. nov., a parasite of the kidney of *P. kingsleyae* contains a large iodophilous vacuole in its sporoplasm. Although the iodophilous vacuole is not a species identification criterion for Myxobolidae, it is important to note that this is the first time that the iodophilous vacuole is reported in a species of the genus *Myxidium*. The description of *Myxidium binguelai* sp. nov. and *Myxidium djolonensis* sp. nov. bring to 20 the number of species of *Myxidium* known in African freshwater fish and to 13 the number of species of the genus described in freshwater teleosts of Cameroon. With the description of *Henneguya paramormyropsi* sp. nov., 28 *Henneguya* species are known to infest freshwater fish in Africa while 13 are parasites of freshwater fish in Cameroon. In case of heavy infection, the rupture of cysts of *Henneguya paramormyropsi* sp. nov. implanted in the secondary gill lamellae and the aqueous humor of the eye can lead to a malfunction of these organs and may create lesions that would be gateways for secondary pathogens (Bacteria and Fungi). In view of the above-mentioned pathogenic effects, particular attention should be paid to the epidemiology of these parasite species in order to prevent their adverse effects on the population of *Paramormyrops kingsleyae* in the Nyong basin so as to handle this fish species in cultivation and promote fish yields.

COMPLIANCE WITH ETHICAL STANDARDS

Animals used followed a protocol approved and authorized by Institutional Animal Care and Use Committee at Animals Biology and Physiology Department, Faculty of Science, University of Yaounde I, Cameroon.

ACKNOWLEDGEMENT

The authors are thankful to the Faculty of Science, University of Yaounde I, Yaounde-Cameroon, for providing all the facilities to complete this work.

CONFLICT OF INTEREST STATEMENT

The authors declared: There is no conflict of interest.

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