Three new species of *Henneguya* (Myxozoa: Myxosporea), parasites of fresh water fishes in Cameroon (Central Africa)

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ABSTRACT

Fomena, A., Lekeufack Folefack, G.B. & Bouix, G. 2008. Three new species of *Henneguya* (Myxozoa: Myxosporea), parasites of fresh water fishes in Cameroon (Central Africa) *J. Afrotrop. Zool.* 4: 93-103.
Examination of fishes belonging to the families of Anabantidae, Hepsetidae, Schilbeidae and Clariidae captured in Nkam and Bénoué basins in Cameroon revealed the presence of three new species of Myxosporidea of the genus *Henneguya* Thélohan, 1892, all gill parasites. The described species were: *Henneguya nkamensis* sp. n., parasite of *Hepsetus odoe* (Bloch, 1794), *Henneguya pethericii* sp. n., parasite of *Ctenopoma petherici* Günther, 1864 and *Henneguya ntondei* sp. n., parasite of *Schilbe mystus* (Linné, 1758). The diagnosis of *Henneguya fusiformis* Kostoïngué, Fall, Faye & Toguebaye, 1999, a parasite previously found in Chad, was supplemented by new characters.

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L'examen des poissons appartenant aux familles des Anabantidae, Hepsetidae, Schilbeidae et Clariidae capturés dans les bassins du Nkam et de la Bénoué au Cameroun, a révélé la présence de trois espèces nouvelles de Myxosporidies du genre *Henneguya* Thélohan, 1892, toutes parasites des branchies. Les espèces décrites sont: *Henneguya nkamensis* n. sp, parasite de *Hepsetus odoe* (Bloch, 1794), *Henneguya pethericii* n. sp., parasite de *Ctenopoma petherici* Günther, 1864 et *Henneguya ntondei* n. sp., parasite de *Schilbe mystus* (Linné, 1758). La diagnose de *Henneguya fusiformis* Kostoïngué, Fall, Faye & Toguebaye, 1999, parasite antérieurement décrit au Tchad, a été complétée par des caractères nouveaux.

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INTRODUCTION

Myxosporidia are almost exclusively fish parasites. Some species are very harmful and can weaken or kill their hosts, leading to important economic losses (Okaeme *et al.* 1988). Up to now, 2180 Myxosporean species assigned to a total of 62 genera have been established (Lom & Dyková 2006). In Africa, approximately 200 species of Myxosporidia are known today, affecting freshwater as well as brackish or marine fishes (Fomena & Bouix 1997a, Kostoïngué *et al.* 2001, Abakar-Ousman 2006). Lom & Dyková (1992) counted 119 species of *Henneguya* described throughout the world. Eiras (2002), in a synthesis on *Henneguya*, described and validated 146 species. Among the Myxosporidia, the genus *Henneguya* Thélohan, 1892, constitutes the third largest group after the genera *Myxobolus* Bütschli, 1882 and *Myxidium* Bütschli, 1882 (Lom & Dyková 2006).
In Africa, *Henneguya* of freshwater fishes are represented by 25 species (Obiekezie & Schmahl 1993, Fomena & Bouix 1997a, b, Kostoïngué 1997, Kostoïngué *et al.* 1997, Sakiti 1997, Fall *et al.* 2000, Fomena & Bouix 2000, Eiras 2002, Reed *et al.* 2003, Abakar-Ousman *et al.* 2006). *Clarias gariepinus* is probably the most widely distributed fish species in that continent. The economic importance of this fish species has increased greatly in recent years as a result of its extensive use in aquaculture (Skelton & Teugels 1992). Coinciding with the growing economic value of this fish is the interest in its parasite loads and what effect they might hold for the aquaculture industry (Reed *et al.* 2003). In Africa and Asia, numerous species of the genus *Henneguya* have been described from *C. gariepinus*: *H. clariae* Abolarin, 1971 (in Nigeria), *H. laterocapsulata* Landsberg, 1987 and *H. suprabranchiae* Landsberg, 1987 (in Israel), *H. branchialis* Ashmawy, Abu-Elwafa, Imam & El- Otifi, 1989 (in Egypt), *H. fusiformis* Kostoïngué, Fall, Faye & Toguebaye, 1999 (in Chad). In this contribution, we provide the description of three new species of *Henneguya* found in the gills of some freshwater fishes sampled in the River Sangé (affluent of Nkam) and in the Lagdo dam on the

Bénoué River in Cameroon. These species are: *Henneguya nkamensis* sp. n., parasite of *Hepsetus odoe* (Hepsetidae), *Henneguya pethericii* sp. n., parasite of *Ctenopoma petherici* (Anabantidae) and *Henneguya ntondei* sp. n., parasite of *Schilbe mystus* (Schilbeidae). Complementary data are also given on *Henneguya fusiformis* from a new host, *C. gariepinus.*

MATERIALS & METHODS

The fishes studied were collected from January to July 2006 in the Nkam basin, in the Sangé River at Ntondé, a village of the district of Yabassi in the Littoral province and at the Lagdo dam built on the Benoué River in the North province. Fish were captured using gill nets. The species collected were: *Hepsetus odoe* (Bloch, 1794) (Hepsetidae), *Schilbe mystus* (Linné, 1758) (Schilbeidae), *Ctenopoma petherici* Günther, 1864 (Anabantidae) and *Clarias gariepinus* Burchell, 1822 (Clariidae).
In the laboratory, the fish were first examined macroscopically with the naked eye and then with a Olympus Bo 61 stereoscopic microscope to search for cysts. After dissection, all the body organs were examined (gills, liver, gall bladder, digestive tract, kidneys, spleen). The cysts found were taken and their contents identified at 1000X magnification. Fresh spores were stained with Lugol's iodine to examine the iodinophilous vacuole. Drawings of the fresh spores were made with the aid of a camera lucida of the microscope Wild-M20. The smears of the spores were fixed with methanol and stained with May-Grünwald-Giemsa. Photographs of the spores were taken using an Olympus CH-2 microscope. Measurements were taken of at least 40 mature fresh spores according to the guidelines proposed by Lom & Arthur (1989).

RESULTS & DISCUSSION

Henneguya nkamensis new species (Figs 1, 2, 7)

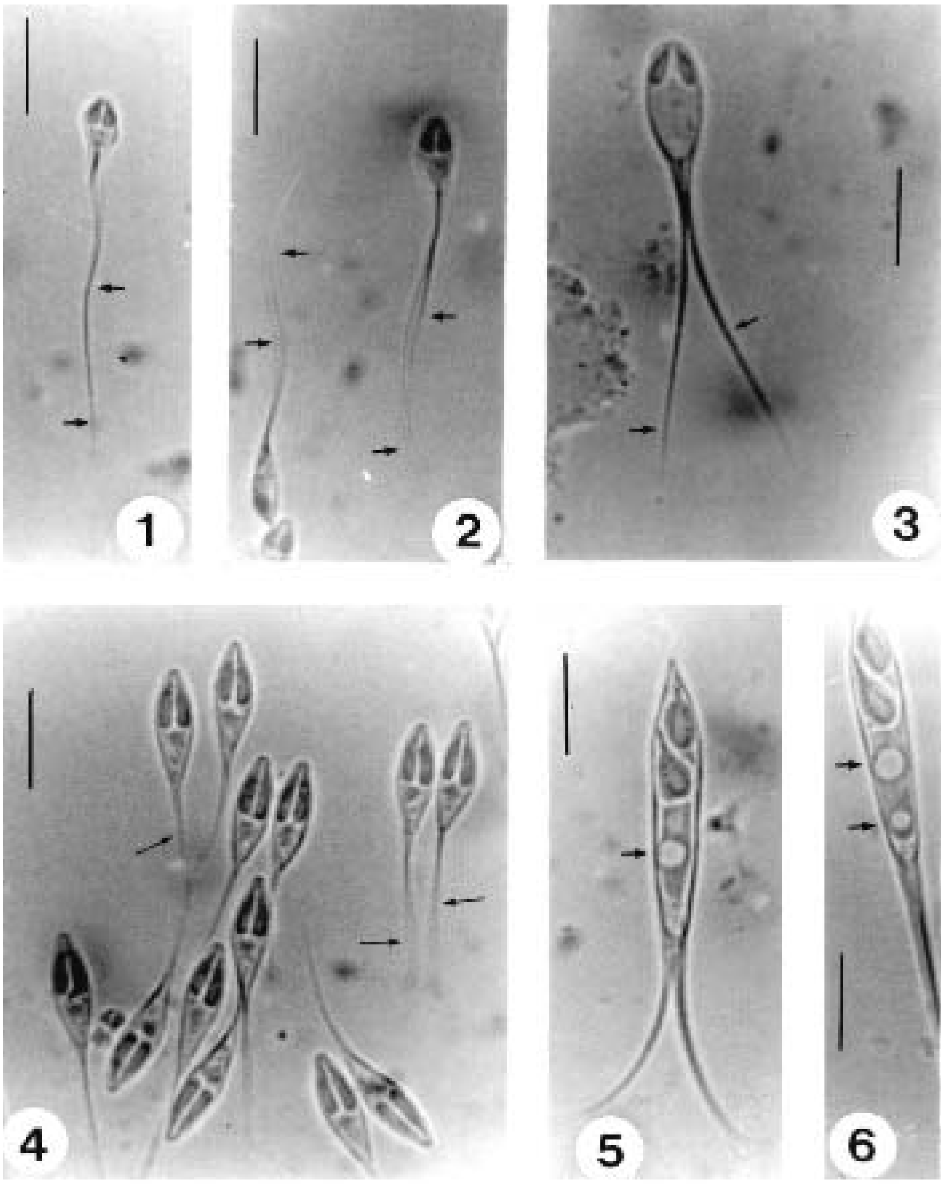
Description of vegetative stages White-yellow, ovoid and polysporous plasmodia measuring 120 to 250 μm in length and 48 to 90 μm in width found between the secondary gill lamellae. As many as 600 cysts were found in an individual host.
Description of spores Total length including the caudal appendages: 36 to 46 μm. Spore body ovoid, with a narrow anterior end (Figs 1-2, 7). Shell valves thin and smooth. Caudal appendages long, thin and separated (Figs 1, 2). Polar capsules pyriform and of equal size (Figs 1, 2, 7). Coils of polar filament not apparent on fresh spores. Sporoplasm filling the rest of the spore cavity (Figs 1, 7).
Measurements: see Table 1.
Type host *Hepsetus odoe* (Bloch, 1794) (Hepsetidae).
Location Gills.
Prevalence 75 % (15/20).
Type locality Ntondé (Littoral Province in Cameroon).
Type material Glass slides with spores (syntypes) as well as cysts preserved in 10 % buffered neutral formalin were deposited in the collection of the Laboratory of General Biology of the Faculty of Science of the University of Yaoundé I, Cameroon.
Etymology Named after the Nkam basin where fishes examined were captured.

DISCUSSION

The general form of our spores recall that of *Henneguya mormyri* Kostoïngué, Diebakate, Faye & Toguebaye, 2001, a gill parasite of *Mormyrus cashive* (Mormyridae) in Chad. The parasite of *Mormyrus cashive*, however, shows less long spores (30 to 34 μm in total length). *Henneguya mbakaouensis* Fomena & Bouix, 2000, a gill parasite of *Lates niloticus* (Centropomidae) in Cameroon, presents a subspherical spore body and longer caudal appendages (40 to 59 μm). *Henneguya sarotherodoni* Fall, Fomena, Kostoïngué, Diebakate, Faye & Toguebaye, 2000, a gut parasite of *Sarotherodon galilaeus* (Cichlidae) in Chad, form spores with a total length comparable to that recorded in this study (39 to 42 μm) but with a rather broad and rounded spore body, and caudal appendages always fused. The spores of *Henneguya samochimensis* Reed, Basson & Van As, 2003, parasite of *Clarias gariepinus* in Botswana, are longer (47 to 53 μm). The species in description differs from *Henneguya malapteruri*, *Henneguya ctenopomae* and *Henneguya odzai*, parasites previously found in Cameroon (Fomena & Bouix 1996 and 1997b) by the following characteristics: shape and dimensions of the spore body, length of the caudal appendages, shape and proportion of the sporoplasm in the spore cavity, shape and dimensions of the polar capsules. The parasite under consideration is believed to be a new species for which the name *Henneguya nkamensis* sp. n. is proposed with respect to the basin of Nkam where host fishes were captured.

Henneguya pethericii new species (Figs 3, 8)

Description of vegetative stages Subspherical and polysporous cysts established between the secondary



Figures 1-6. Photomicrographs of fresh spores of species studied.

Figs 1-2. *Henneguya nkamensis* sp. n., caudal appendages are long and thin (arrows). Scale bars = 10 µm.
Fig. 3. *Henneguya pethericii* sp. n. Scale bar = 10 µm.
Fig. 4. *Henneguya ntondei* sp. n., caudal appendages are separated (arrows). Scale bar = 10 µm.
Figs 5-6. *Henneguya fusiformis* Kostoïngué, Fall Faye & Toguebaye, 1999. The sporoplasm contain one or two iodinophilous vacuoles (arrows). Scale bars = 10 µm.

gill lamellae and measuring 80 to 125 μm in length x 80 to 110 μm in width.

Description of spores Spore body ovoid and elongated, rounded anterior end (Figs 3, 8). Shell valves smooth. Polar capsules pyriform and of equal dimensions. Caudal appendages long (Figs 3, 8). Sporoplasm often containing an iodinophilous vacuole of variable shape and size (Fig. 8).

Measurements: see Table 1.

Type host *Ctenopoma petherici* Günther, 1864 (Anabantidae).

Location Gills.

Prevalence 80 % (8/10).

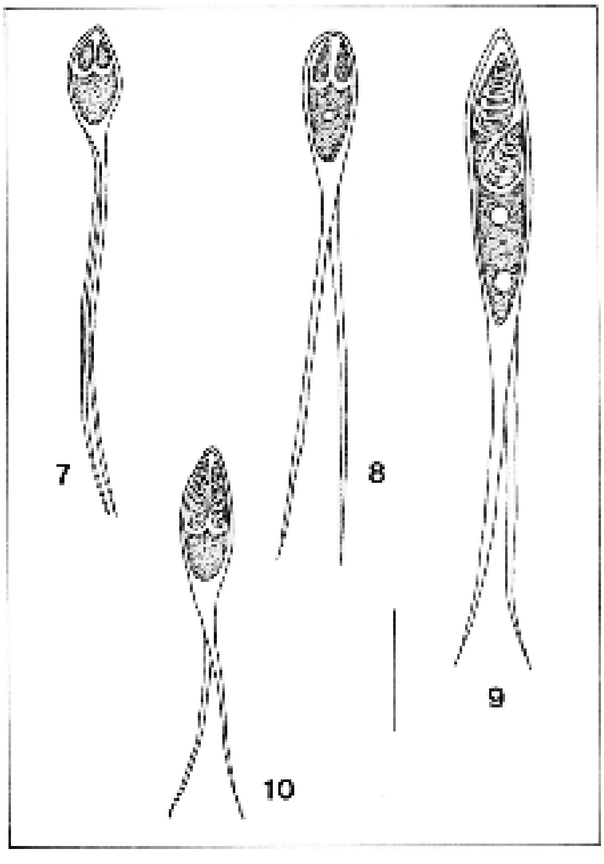
Type locality Ntondé (Littoral province in Cameroon).

Type material Slides with stained spores (syntypes) as well as cysts preserved in 10 % buffered neutral formalin were deposited in the collection of the Laboratory of General Biology of the Faculty of Science, University of Yaounde I, Cameroon.

Etymology Named after the type host fish.

DISCUSSION

This myxosporidian differs from *Henneguya nkamensis* sp. n. (found in *Hepsetus odoe* in the same river) by its spore body more elongated and its polar capsules lengthened. In Africa, two species of *Henneguya* have previously been described in Anabantidae fishes of the genus *Ctenopoma*: *Henneguya ctenopomae* Fomena & Bouix, 1999b in *Ctenopoma nanum* in Cameroon and *H. somahiensis* Sakiti, 1997, in *Ctenopoma Kingsleyae* in Benin. The spores in description cannot be confused with those of *H. ctenopomae* of which the average total length is of 21 µm and they possess very short caudal appendages measuring only 2 to 10 µm. Although having a comparable spore body length (13.32 µm), spores of *H. somahiensis* are shorter (27.59 µm), with caudal appendages that rarely exceed the length of the spore body (constant characteristic). Although presenting a comparable shape of spore body, *Henneguya auchenoglanii* and *H. mailaoensis* (Kostoïngué, Diebakate, Faye & Toguebaye, 2001), parasites of Bagridae and Mormyridae in Chad, form longer spores (52-58 and 58-63 µm), respectively, with fused caudal appendages in *H. auchenoglanii*. *H. samochimensis* Reed, Basson & Van As, 2003, is characterised by its longer spores (47-53 µm), with fused caudal appendages. *Henneguya curvata* Barassa, Adriano, Arana & Cordeiro, 2003, a parasite of the Characidae in Brazil, forms arched spores with longer spore body and polar capsules (16.4 and 7.8 µm, respectively).
The currently described species is new and is named *Henneguya pethericii* sp. n., with respect to the host fish.



Figures 7-10. Line drawings of fresh mature spores.

Fig. 7. *Henneguya nkamensis* sp. n., a gill parasite of *Hepsetus odoe*.
Fig. 8. *Henneguya pethericii,* a gill parasite of *Ctenopoma petherici*.
Fig. 9. *Henneguya fusiformis* Kostoïngué Fall, Faye & Toguebaye, 1999, parasite of *Clarias gariepinus*. Two iodinophilous vacuoles are often observed in the sporoplasm.
Fig. 10. *Henneguya ntondei* sp. n., parasite of Schilbe mystus. Scale bar = 10 µm.

Henneguya ntondei new species (Figs 4, 10)

Description of vegetative stages Ovoid or subspherical cysts of variable size (170-335 x 70-285 µm) established between the secondary gill lamellae. An individual host can harbour up to 150 cysts.
Description of spores Variable size (24-35 µm in total length). Spore body ovoid, with a narrow anterior end (Figs 4, 10). Shell valves thin. Polar capsules pyriform and elongated (3.7 times longer than broad), reaching half the length of the spore body (Figs 4, 10).
Of equal size, they contain about ten coils of the polar filament (Fig. 10). Caudal appendages fine, and separated (Figs 4, 10).
Measurements: see Table 1.
Type host *Schilbe mystus* (Linné, 1758) (Schilbeidae).
Location Gills.
Prevalence 75 % (15/20).
Type locality Ntondé (Littoral province in Cameroon).
Type material Slides with stained spores (syntypes) as well as cysts preserved in 10 % buffered neutral formalin were deposited in the collection of the Laboratory of General Biology of the Faculty of Science, University of Yaounde I, Cameroon.
Etymology Named after the type locality.

DISCUSSION

Paperna (1973) noted without description the presence of *Henneguya* species in the gills of *Schilbe mystus* in Ghana (West Africa) and may be *H. ntondei* sp. n. *Henneguya mystusia* Sarkar, 1985, which forms cysts in the gills of *Mystus* sp. in India but the spores of this species are longer (27 to 40 µm in total

length) and less broad (3-4 µm). The general morphology of the spore body of our parasite is similar to that of *Henneguya chrysichthyi* Obiekezie & Enyenihi, 1988. However, this parasite of Bagridae has unequal polar capsules and caudal appendages. *Henneguya camerounensis* Fomena & Bouix, 1987, a gill parasite of *Synodontis batesii* and *Eutropius multitaeniatus* in Cameroon, forms shorter spores (16.75 µm in total length) with very short caudal appendages (4.1-11 µm). The spores of *Henneguya doori* Guilford, 1963, although showing a comparable spore body shape, are longer (31-45 µm). *Henneguya dini* kabré, Sakiti, Marques & Sawadogo, 1997, a gill parasite of *Heterotis niloticus* in Burkina-Faso, forms spores with a comparable total length (29.73 µm on average), but with less broad body (3.47 µm) and shorter polar capsules (3.43 x 1.02 µm). *Henneguya logonensis* is a gill parasite of *Citharinus citharus* in Chad (Kostoïngué *et al.* 2001). Its spore body is oval with attenuated anterior end, but this parasite differs from our species in having unequal polar capsules and longer caudal appendages (20-25 µm). In the gills of C*tenopoma nanum* in Cameroon, Fomena & Bouix (1997b) described *Henneguya ctenopomae.* Despite its comparable total length (17-25 µm), *H. ctenopomae* has a spore body with a larger anterior end. In its polar capsules, the polar filament is coiled only three times. Its caudal appendages are shorter (2-10 µm). *Henneguya pilosa* Azevedo & Mattos (2003) forms spherical plasmodia in the gills of *Serrasalmus altuvei* in Brazil. Compared to our species, the spores of *H. pilosa* are longer (52.3-56 µm in total length).
The species under description is new and we propose to name it *Henneguya ntondei* sp. n. after the type locality where fishes examined were collected.

Henneguya fusiformis

Kostöngué, Fall, Faye & Toguebaye, 1999.
(Figs 5, 6, 9)

Description of vegetative stages White-yellow and ovoid cysts, measuring 200-390 x 160-240 µm, located on the gills. As many as 17 cysts were found in an individual host.
Description of spores Spore body spindle-shaped and long (5.5 times longer than broad), with a narrow anterior end (Fig. 5). Polar capsules pyriform and symmetrical, with one oriented to the anterior pole of the spore, the second laterally (Figs 5, 9). Polar filament with 7-8 coils (Figs 5, 6, 9). Sporoplasm containing one or two iodinophilous vacuoles of variable shape and size (Figs 5, 6).
Measurements: see Table 1.
Host *Clarias gariepinus* (Burchell, 1822) (Clariidae).
Location Gills.
Prevalence 75 % (9/12).
Locality Lagdo (Northern province in Cameroon).

DISCUSSION

Kostoïngué *et al.* (1999) described *Henneguya fusiformis* in the gills of *Clarias anguillaris* in Chad. The morphometric characteristics of our spores, the parasitised organ, the host family (Clariidae), correspond to the data on *Henneguya fusiformis*. New characters must be added to the diagnosis of this myxosporidian: presence of 7-8 threads of polar filament within the polar capsules (Kostöngué *et al.* 1999 having found only 5-6 coils), presence of one or two iodinophilous vacuoles in the sporoplasm. *Clarias gariepinus* is a new host for this parasite which seems to be specific to fishes of the family Clariidae.

Host specificity, geographical distribution and some pathogenic effects of African fresh water *Henneguya* species

Among the Myxosporidia, the genus *Henneguya* constitutes the third largest group after the genera *Myxobolus* and *Myxidium* (Lom & Dyková, 2006). These parasites are histozoic in fresh water, sometimes in marine fishes. In the host, they generally form polysporous plasmodia, usually large, appearing like cysts.
With the description of *H. nkamensis* sp. n., *H. pethericii* sp. n. and *H. ntondei* sp. n., 28 *Henneguya* species are known to infest freshwater fish in Africa (Table 2). The species observed colonise hosts that belong to 12 families. From a decreasing order of importance, the host families can be classified thus: Clariidae (6 *Henneguya* species found), Mormyridae (5), Centropomidae (4), Anabantidae (3), Bagridae (3), Schilbeidae (2), Cichlidae (2), Citharinidae (1), Malapteruridae (1), Mochokidae (1), Osteoglossidae (1) and Hepsetidae (1).
In the host, the species found affect various organs (gills, accessory breathing organ, intestine, muscles and skin). It is found that the gills are the preferred organs for implantation and growth of Myxosporidia of the *Henneguya* genus (89, 28 % cases found). Similar observations had been found by previous authors: Landsberg (1985), Fomena (1995), Sakiti (1997), Eiras (2002), Abakar-Ousman (2006).
In freshwater African fishes, a host species can harbour up to six different *Henneguya* species; for example, *Clarias gariepinus* (Syn = *C. lazera*) is parasitised by the following species: *H. branchialis*, *H. clariae*, *H. fusiformis*, *H. laterocapsulata*, *H. samochimensis* and

H. suprabranchiae. *Lates niloticus* is affected by four species (*H. massii*, *H. maraensis*, *H. ghaffari* and *H. mbakaouensis*). *Clarias anguillariis* is favourable for the development of three species (*H. fusiformis*, *H. suprabranchiae* and *H. branchialis*).

Polyparasitism by Myxosporidia is very frequent: that is the case of Cichlid fishes in Israel (Landsberg 1985), the case of Cichlid fishes in Nigeria (Obiekezie & Okaeme 1990), the case of *O. niloticus* in Cameroon (Fomena *et al.* 1993), *O. niloticus* and *S. galilaeus* in Chad (Abakar-Ousman *et al.* 2007).

Little is known about the host specificity of Myxosporean, the number of species with a large host range is low and most appear to be strictly host specific or capable of developing only in close related fishes (Molnár *et al.* 1998). From the distribution of *Henneguya* of the freshwater fish in Africa (Table 2), three types of specificity towards the host were revealed. A strict specificity was found in 78.51 % species observed (*H. claria*e, *H. bopeleti*, *H. chrysichthyi*, *H. odzai*, *H. ntemensis*, *H. dini*, *H. ctenopomae*, *H. malapteruri*, *H. maraensis*, *H. somahiensis*, *H. ghaffari*, *H. sarotherodoni*, *H. mbakaouensis*, *H. auchenoglanii*, *H. logonensis, H. mbailaoensis, H. massii, H. mormyri, H. samochimensis*, *H. nkamensis* sp. n., *H. pethericii* sp. n. and *H. ntondei* sp. n.). Other species were found in closely related fish, *e.g.* *H. laterocapsulata*, *H. fusiformis* and *H. suprabranchiae* in Clariid fish, and *H. nyongensis* in Mormyrid fish. *H. camerounensis* and *H. branchialis* show a large host range. Our remarks are close to those of Fomena (1995), Sakiti (1997) and Kostoïngué (1997), whose studies focused on the Myxosporidia fauna of freshwater fishes of Cameroon, Benin and Chad, respectively.

Site preference of fish Myxosporeans has been studied (Molnár 2002). *Myxobolus*, *Henneguya* and *Thelohanellus* species are characterised by strict tissue specificity, and species showing affinity to the epithelium, connective tissue, cartilage or vascular tissue usually occur in a strictly defined location within the gill apparatus (Molnár 2002). *H. nkamensis* sp. n., *H. pethericii* sp. n. and *H. ntondei* sp. n. can be ranged among interlamellar forms. *H. suprabranchiae* is strictly specific to the accessory breathing organ in *C. gariepinus* and *C. anguillaris*.

From a close examination of the geographical distribution of *Henneguya* species found in African freshwater fishes, two categories can be distinguished: ubiquist species and species with a restricted distribution. The ubiquist species comprise: *H. branchialis*, *H. laterocapsulata*, *H. fusiformis*, *H. nyongensis* and *H. suprabranchiae* (Table 2). It is known that many species occur naturally over large geographical areas (Lom & Dyková 1992). Other Myxosporeans have been introduced to new continents along with their hosts through human activities. Among the ubiquist species, some had been initially described in Israel, *e.g.* *H. laterocapsulata* and *H. suprabranchiae*. These parasites could have been introduced in Africa during the transfer of their hosts for breeding purposes.

Most Myxosporean infections are rather innocuous, causing little harm to the hosts. However, numerous histozoic species have been reported to be highly pathogenic to their hosts (Lom & Dyková 1992, 2006; Fomena & Bouix 1996; Gbankoto *et al.* 1999; Feist & Longshaw 2005). *Henneguya psorospermica* has been reported to cause breathing troubles in its hosts in spring (Dyková & Lom 1978).

Henneguya found in freshwater African fish are all histozoic and form cysts preferentially implanted on the gill of the hosts. Heavy infections owing to *H. chrysichthyi* result in distortion of lamellar arrangement. It was estimated that over 40 % of total gill surface was unavailable for gaseous exchange and such fishes were generally in poor condition (Obiekezie & Enyenihi 1988). The rupture of *H. odzai* cysts is accompanied by secondary bacterial and fungal infections that can ultimately be lethal for the fish (Fomena & Bouix 1996). Infection of *Clarias lazera* by *H. clariae* impairs the branchial vascular system, destroys blood vessels and reduces circulation (Abolarin 1971). Plasmodia of *H. suprabranchiae* leads to pressure on the host's cartilaginous tissue which is subsequently compressed (El-Mansy & Bashtar 2002). If these parasites of African freshwater fishes are not directly lethal to their hosts, they can damage or disturb some vital functions and in heavy infections reduce the productivity of pisciculture. The transfer of hosts from one continent or country to another must be preceded by careful study of their parasitofauna.

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Table 1. Comparative measurements (in μm) of spores of different parasite species studied and similar *Henneguya* species from African freshwater fishes.

Henneguya spp. (Authors)	LSB	WSB	PC	LPC	WPC	LS	LCA	FC
H. nkamensis sp. n. (Present study)	9.0 (8-10)	4.5 (4-5.5)	Equal	3.2 (3-3.5)	1.5 (1.6-1.8)	39.8 (36-46)	30.8 (26-36)	–
H. pethericii sp. n. (Present study)	12.5 (11-14)	5.0 (4.5-5.5)	Equal	4.5 (4.5-5.5)	1.5 (1.3-2)	46.1 (40-52)	33.5 (27-39)	–
H. ntondei sp. n. (Present study)	12.8 (10.5-14)	5.4 (4-7)	Equal	6.4 (5.5-8)	1.7 (1.2-2)	27.7 (24-35)	14.8 (10-23)	10
H. fusiformis (Kostoïngué *et al.* 1999)	31.2 (28-35)	5.5 (5-6)	Equal	7.3 (6.5-8.5)	3.4 (3-4)	57.5 (50.5-64)	26.3 (21.5-32)	7-8
H. chrysichthyi (Obiekezie & Enyenihi 1988)	15.5 (13.7-16)	5.2 (4.6-6.3)	Unequal	5.3 (4.6-5.7)	2.0 (1.6-2.2)	29 (27-32)	13.5 (10-15)	9-11
H. odzai (Fomena & Bouix 1996)	14.4 (13-16)	3.9 (3.3-4.6)	Equal	3.9 (3.2-4.9)	1.3 (1-1.6)	32.9 (29.2-36)	18.5 (15-21.5)	4
H. malapteruri (Fomena & Bouix 1997b)	16.2 (14-18)	9.6 (8.3-11)	Equal	5.9 (5-7.3)	3.3 (2.8-4)	46.4 (42-53)	30.2 (24-36.5)	4-6
H. ctenopomae (Fomena & Bouix 1997b)	14.9 (13-17)	9.1 (8-10.5)	Equal	6.2 (5.5-7)	2.3 (2-3)	21.2 (17-25)	6.2 (2-10)	3
H. mbakaouensis (Fomena & Bouix 2000)	10.8 (10-12)	7.5 (7-9.9)	Equal	4.0 (3.5-4.7)	2.5 (2-3)	61.8 (51.5-9.2)	50.9 (40-59)	4-5
H. sarotherodoni (Fall *et al.* 2000)	11.7 (11-12)	6.9 (6-8)	Equal	3.9 (3-5)	2.3 (2-3)	40.8 (39-42)	29.2 (28-30)	–
H. camerounensis (Fomena & Bouix 1987)	10.2 (9-11)	4.4 (3.8-5.5)	Equal	5.3 (4.7-6.5)	1.3 (1-2)	16.7 (13.6-1.7)	6.5 (4.1-11.6)	–
H. somahiensis (Sakiti 1997)	13.3 (12-15)	4.2 (4-5.5)	Equal	4.2 (4-5)	1.9 (1.5-2)	27.5 (22-34)	14.2 (10-19)	–
H. logonensis (Kostoïngué *et al.* 2001)	12.0 (11-13)	3.2 (3-4)	Unequal	3.7 (3-4)* 2.2 (2-3)**	1.6 (1-2)* 1.4 (1-2)**	34.6 (33-39)	22.5 (20-25)	–
H. auchenoglanii (Kostoïngué *et al.* 2001)	12.0 (11-13)	3.2 (3-4)	Equal	6.3 (6-7)	2.1 (2-3)	56.4 (52-58)	39.4 (37-40)	–
H. mormyri (Kostoïngué *et al.* 2001)	8.4 (8-9)	4.5 (4-5)	Equal	3.3 (3-4)	1.9 (1-3)	32.2 (30-34)	23.1 (23-25)	3-4
H. samochimensis (Reed *et al.* 2001)	13.7 (12.3-15)	6.0 (5.0-7.0)	Equal	5.6 (5-6)	1.6 (1.3-1.9)	50.3 (47-53)	36.6 (34.7-35.3)	8

Averages of the parameters measured are followed by minimal and maximal values in brackets.
LBS, length of the spore body; WSB, width of the spore body; PC, relative length of the polar capsules; 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.
* Referring to the largest polar capsule; ** referring to the smallest polar capsules.

Table 2. ***Henneguya*** **spp. of freshwater fishes in Africa: hosts, infected organs and geographical distribution.**

Parasite species	Hosts (families)	Organs	Country	Reference
H. auchenoglanii	*Auchenoglanis occidentalis* (Bagridae)	Gills	Chad	Kostoïngué *et al.* (2001)
H. bopeleti	*Chrysichthys nigrodigitatus* (Bagridae)	Gills	Cameroon	Fomena & Bouix (1987)
H. branchialis	*Clarias lazera* (Clariidae)	Gills, intestine	Egypt	Ashmawy *et al.* (1989)
	Clarias anguillaris (Clariidae)	Gills	Chad	Kostoïngué *et al.* (2001)
	Clarias anguillaris S. galilaeus (Cichlidae)	Gills	Burkina-Faso	Kabré (1997)
	Tilapia zillii (Cichlidae)			
H. camerounensis	*Synodontis batesii* (Mochokidae)	Gills	Cameroon	Fomena & Bouix (1987)
	Eutropius multitaeniatus (Schilbeidae)	Gills		
H. chrysichthyi	*Chrysichthys nigrodigitatus* (Bagridae)	Gills	Nigeria	Obiekezie & Enyenihi (1988)
H. clariae	*Clarias lazera* (Clariidae)	Gills, opercular depression	Nigeria	Abolarin (1971)
H. ctenopomae	*Ctenopoma nanum* (Anabantidae)	Gills	Cameroon	Fomena & Bouix (1997b)
H. dini	*Heterotis niloticus* (Osteoglossidae)	Gills	Burkina-Faso	Kabré *et al.* (1997)
H. fusiformis	*Clarias gariepinus*	Gills	Cameroon	Present study
	Clarias anguillaris (Clariidae)	Gills	Chad	Kostoingué *et al.* (1999)
H. ghaffari	*Lates niloticus* (Centropomidae)	Gills, intestine, pyloric caecae	Egypt	Ali (1999)
H. laterocapsulata	*Clarias lazera* (Clariidae)	Gills	Nigeria	Obiekezie & Schmahl (1993)
	Heterobranchus bidorsalis hybrid (Clariidae)			
	Clarias gariepinus (Clariidae)	Gills	Cameroon	Fomena (Personal Communication)
	Clarias lazera	Dermis	Israel	Landsberg (1987)
H. logonensis	*Citharinus citharus* (Citharinidae)	Gills	Chad	Kostoïngué *et al.* (2001)
H. malapteruri	*Malapterurus electricus* (Malapteruridae)	Muscles and skin	Cameroon	Fomena & Bouix (1997b)
H. massii	*Lates niloticus* (Centropomidae)	Gills	Chad	Kostoïngué *et al.* (2001)
H. maraensis	*Lates niloticus* (Centropomidae)	Gills Intestine	Chad	Kostoïngué (1997)
H. mbailaoensis	*Mormyrus cashive* (Mormyridae)	Gills	Chad	Kostoïngué *et al.* (2001)
H. mbakaouensis	*Lates niloticus* (Centropomidae)	Gills	Cameroon	Fomena & Bouix (2000)
H. mormyri	*Mormyrus cashive* (Mormyridae)	Gills	Chad	Kostoïngué *et al.* (2001)
H. nkamensis sp. n.	*Hepsetus odoe* (Hepsetidae)	Gills	Cameroon	Present study
H. ntemensis	*Brienomyrus brachyistus* (Mormyridae)	Gills	Cameroon	Fomena & Bouix (1996)
H. ntondei sp. n.	*Schilbe mystus* (Schilbeidae)	Gills	Cameroon	Present study

Parasite species	Hosts (families)	Organs	Country	Reference
H. nyongensis	*Marcusenius moorii* (Mormyridae)	Gills and muscles	Cameroon	Fomena & Bouix (1996)
	Brienomyrus niger			
	Hyperopisus bebe	Gills	Benin	Sakiti (1997)
	Marcusenius senegalensis			
	Mormyrus rume (Mormyridae)			
H. odzai	*Marcusenius moorii* (Mormyridae)	Gills	Cameroon	Fomena & Bouix (1996)
H. pethericii sp. n.	*Ctenopoma petherici* (Anabantidae)	Gills	Cameroon	Present study
H. samochimensis	*Clarias gariepinus* (Clariidae)	Gills	Botswana	Reed *et al.* (2003)
H. sarotherodoni	*Sarotherodon galilaeus* (Cichlidae)	Intestine	Chad	Fall *et al.* (2000)
H. somahiensis	*Ctenopoma kingsleyae* (Anabantidae)	Gills	Benin	Sakiti (1997)
H. suprabranchiae	*Clarias gariepinus* (Clariidae)	Accessory breathing organ	Botswana	Reed *et al.* (2003)
	Clarias anguillaris	Accessory breathing organ	Chad	Abakar-Ousman *et al.* (2006)
	Clarias gariepinus	Accessory breathing organ	Cameroon	Fomena (Personnal communication)
	Clarias lazera	Accessory breathing organ	Israel	Landsberg (1987)