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Four new myxozoans (Myxosporea: Bivalvulida) from intertidal fishes along the south coast of Africa

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Abstract. Current records of marine myxozoans from the coast of Africa are limited to the descriptions of 52 species from mostly Senegal, with a few from Tunisia and southern Africa. Between 1998 and 2000 several intertidal fishes from the southern Cape coast of South Africa were examined for the presence of myxozoan infections. Three new species, *Ceratomyxa dehoopi* sp. n., *C. cottoidii* sp. n. and *C. honckenii* sp. n. were identified from the gall bladders of *Clinus superciliosus* L., *C. cottoides* Valenciennes and *Amblyrhynchotes honckenii* (Bloch), respectively. A fourth new species *Henneguya clini* sp. n. was also identified from the gills and gill arches of *C. superciliosus*.

Very little is known about the distribution and diversity of marine myxozoans along Africa's coastline. Research on these parasites is restricted to the description of 52 species from the entire extent of the African coastline, the majority of which were described from Senegal. Early records of myxozoan infections in African marine fishes appeared from southern Africa between 1919 and 1979. Fantham (1919, 1930) recorded several myxozoan species from the bile of a number of intertidal fishes along the Cape south coast. Gilchrist (1924) described *Chloromyxum thyrsites* Gilchrist, 1924 from the muscles of Cape Sea fish, or "snoek", which is a species well-known around the world today as the notorious *Kudoa thyrsites* (Gilchrist, 1924). Subsequent to Gilchrist's (1924) description, Davies and Beyers (1947) recorded the presence of *K. thyrsites* in some of the South African trawled fishes and during the 1970s Dubina and Isakov (1976), Gaevskaya and Kovaleva (1979) as well as Schulman et al. (1979) described several new myxozoan species from deep sea fish off the coast of southern Africa.

After these initial myxozoan publications from southern Africa, approximately 15 years passed before a number of species descriptions started to appear from the North-West coast of Africa (Bahri et al. 1995, 1996, Bahri and Marqués 1996, Kpatcha et al. 1996a, b, 1997, 1999, Fall et al. 1997, Faye et al. 1997, 1999, Diebakate et al. 1999). Subsequent to these publications Ali (2000) described *Ortholinea basma* Ali, 2000 from the gall bladder of the agile klipfish *Clinus agilis*, from the West coast of South Africa.

This paper represents the first publication on the occurrence of myxozoans infecting intertidal fishes from the De Hoop Nature Reserve along the south coast of South Africa. Three new species of the genus *Ceratomyxa* Thélohan, 1892, are described from the gall bladders of *Clinus superciliosus* L., *C. cottoides* Valenciennes and *Amblyrhynchotes honckenii* (Bloch), respectively. A fourth new species from the genus *Henneguya* Thélohan, 1892 is described from the gills and gill arches of *C. superciliosus*.

MATERIALS AND METHODS

A total of 14 *Amblyrhynchotes honckenii*, 44 *Clinus cottoides* and 131 *C. superciliosus* were collected on several fieldtrips to the De Hoop Nature Reserve and Jeffrey's Bay, both of which are situated along the south coast of South Africa. Fishes were collected from intertidal rock pools using small hand nets and hand lines. Captured fish were identified using Branch et al. (1994) and subsequently euthanized using the anaesthetic Benzocaine (ethyl-4-aminobenzoate) (2.5×10^5 g/l), measured and examined for the presence of myxosporean infections. Squash preparations of the gall bladder contents were made and live mature myxosporean spores and plasmodia detected were transported to the laboratory, using sealed haematocrit tubes. Live spores and plasmodia were photographed on a layer of 0.5% non-nutrient agar, using an Axiophot microscope with differential interference contrast. The live spores were measured according to the guidelines provided by Lom and Arthur (1989). Minimum and maximum values of spore measurements are provided in micrometres (μm), followed in parentheses by the arithmetic mean and standard deviation. Spores were measured from several infected host specimens. Formalin-fixed spores were dehydrated, critical point dried, coated with gold and viewed using a JEOL Winsem JSM 6400 at 5 or 10 kV, respectively. Tissue

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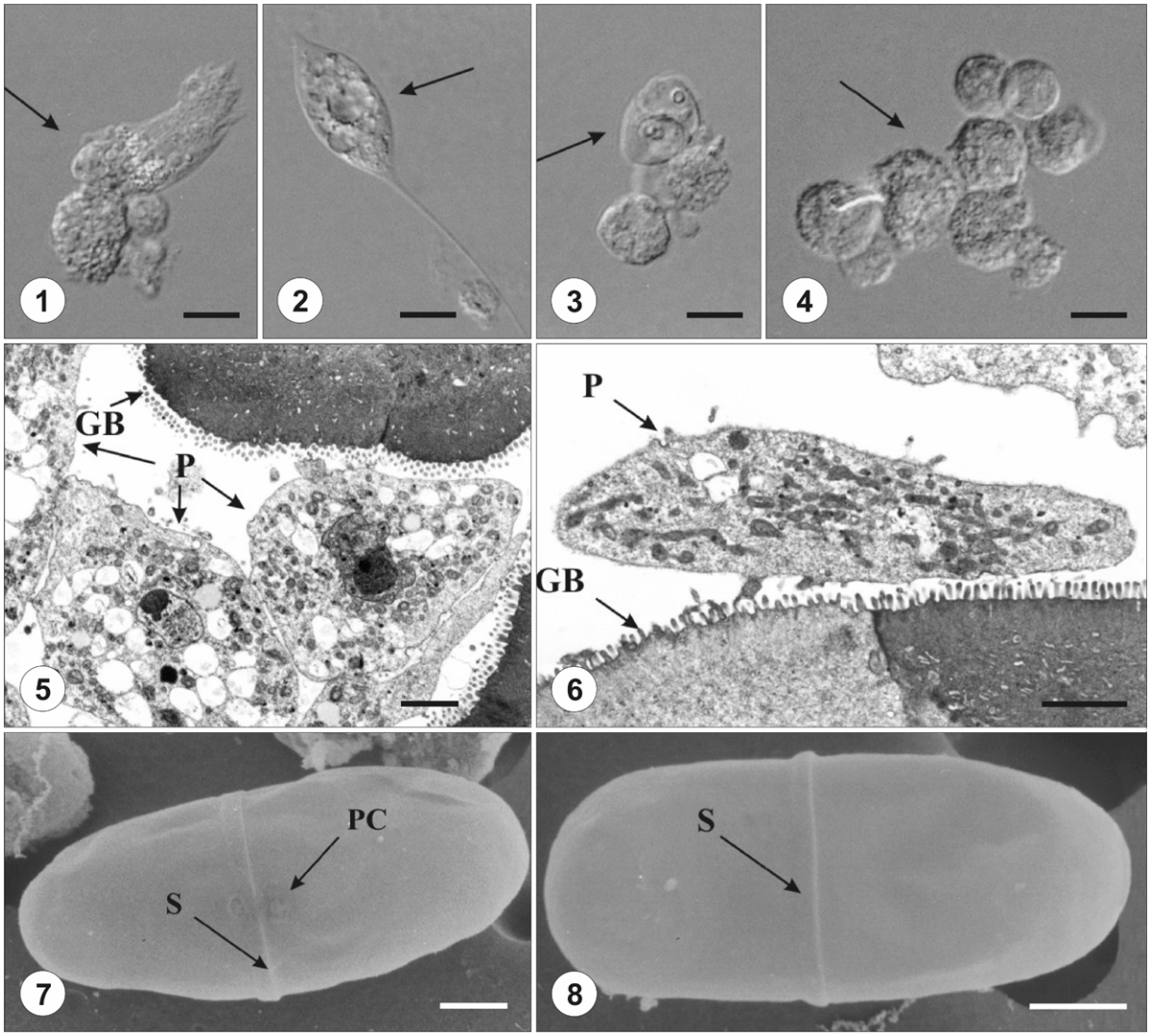
samples of gall bladder and gills containing plasmodia and spores were prepared for transmission electron microscopy using standard techniques. Tissue samples of gall bladder, liver and kidney containing plasmodia and spores were fixed in Davidson's solution and prepared for histological sectioning using standard techniques. Sections cut at 7 µm were stained using haematoxylin and eosin (H&E) and Giemsa stain.

RESULTS AND DISCUSSION

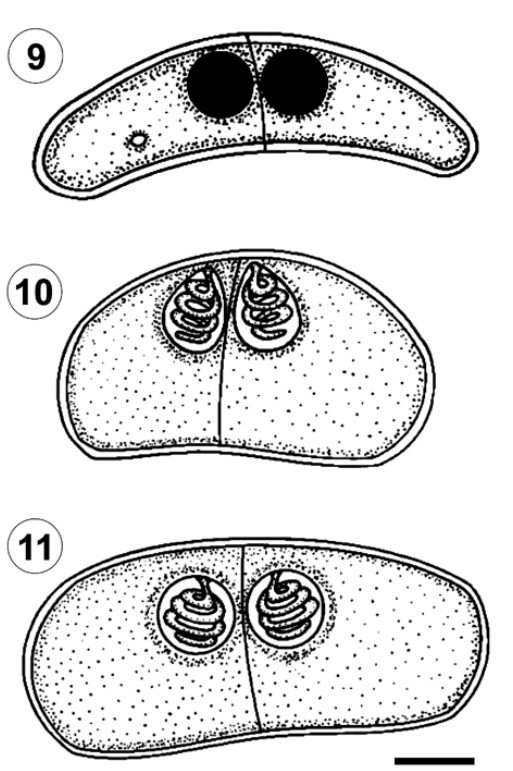
Ceratomyxa dehoopi sp. n. Figs. 1–9, 12, 17–19

Spores (n = 38 live spores): Mature spores transversely elongate and narrowly crescent-shaped with slightly convex anterior and concave posterior, 4.0–5.5 (4.5 ± 0.5) µm long × 12.0–17.5 (15.4 ± 1.4) µm wide. Spore shell valves equal in length, with smooth surface, each tapering to a rounded end. Sutural line thin and straight. Two spherical to ovoid polar capsules situated on either side of sutural line, 2.0–3.0 (2.7 ± 0.3) µm long × 2.0–2.5 (2.1 ± 0.2) µm wide. Number of coils per polar filament not observed. A single binucleate sporoplasm almost filling entire spore cavity and containing a single, small iodinophilous vacuole.

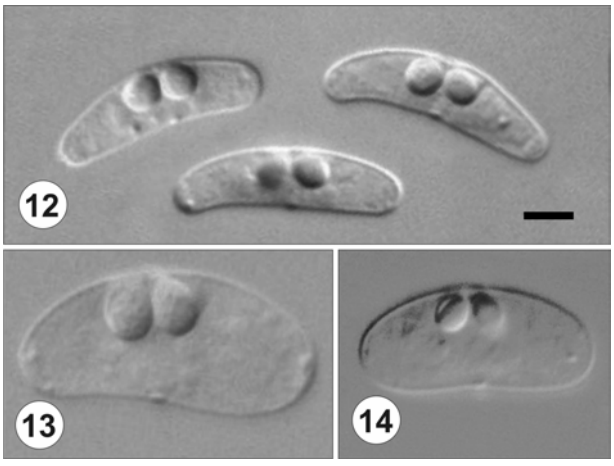
Vegetative stages: Plasmodia coelozoic and mostly spherical, transparent, with numerous refractile granules and inner generative cells, often with long extensions connecting disporous trophozoites. Some appeared attached to gall bladder epithelium. These varied greatly in size (5–20 µm) and shape.



Figs. 1–8. Light micrographs, transmission electron micrographs and scanning electron micrographs of *Ceratomyxa dehoopi* sp. n. infecting the gall bladder of *Clinus superciliosus* from the Cape south coast of South Africa. **Figs. 1–4.** Live plasmodia (arrows). **Figs. 5, 6.** Plasmodia (P) seen associated with the gall bladder epithelium (GB). **Figs. 7, 8.** Spores showing the sutural ridge (S) and polar filament discharge ducts (PC). Scale bars: Figs. 1–4 = 10 µm; Figs. 5, 6 = 1 µm; Figs. 7, 8 = 2 µm.



Figs. 9–11. Line drawings of *Ceratomyxa* Thélohan, 1892 species infecting the gall bladders of intertidal fishes along the Cape south coast, South Africa. **Fig. 9.** *Ceratomyxa dehoopi* sp. n. from *Clinus superciliosus* (polar capsules represented by black circles as polar filaments could not be seen). **Fig. 10.** *Ceratomyxa cottoidii* sp. n. from *C. cottoides*. **Fig. 11.** *Ceratomyxa honckenii* sp. n. from *Amblyrhynchotes honckenii*. Scale bar (Figs. 9–11) = 10 µm.



Figs. 12–14. Light micrographs of live spores of *Ceratomyxa* Thélohan, 1892 species infecting the gall bladders of intertidal fishes along the Cape south coast, South Africa. **Fig. 12.** *Ceratomyxa dehoopi* sp. n. from *Clinus superciliosus*. **Fig. 13.** *Ceratomyxa cottoidii* sp. n. from *C. cottoides*. **Fig. 14.** *Ceratomyxa honckenii* sp. n. from *Amblyrhynchotes honckenii*. Scale bar (Figs. 12–14) = 10 µm.

Type host: *Clinus superciliosus* (Linnaeus, 1758) – endemic to southern Africa from the coast of Namibia (19˚S) to the Kei River mouth on the southeast coast of South Africa.

Type locality: De Hoop Nature Reserve (34°28'S, 20°30'E), South Africa.

Other localities: Jeffrey's Bay (34°2.2'S, 24°56.5'E), South Africa.

Site of infection: Gall bladder and bile ducts.

Prevalence: De Hoop Nature Reserve, 83% (76/92); Jeffrey's Bay, 92% (35/38).

Etymology: Named after the original collection locality of the type host.

Photo-reference: Deposited in the National Museum Bloemfonteins' Parasite Collection; reference number: NMBP 299.

Remarks

In Africa only nine *Ceratomyxa* species have been described from marine fish hosts (Dubina and Isakov 1976, Gaevskaya and Kovaleva 1979, Kpatcha, et al. 1996b) (see Table 1). The majority of these were described from fishes collected off the coast of Senegal by Kpatcha et al. (1996b). *Ceratomyxa dehoopi* shows morphological similarities with only two of these species. *Ceratomyxa fistulariae* Kpatcha, Diebakate, Faye et Toguebaye, 1996, described from the bile ducts of *Fistularia petimba* in Senegal by Kpatcha et al. (1996b), is similar in general spore shape, but has a much greater spore width than *C. dehoopi* (Table 2). Comparatively, *C. truncata* Thélohan, 1895 found infecting the bile ducts of *Sardinella madarensis* also in Senegal by Kpatcha et al. (1996b), has a much broader spore (Table 2), is more strongly arched and has a prominent sutural ridge, unlike the smaller less arched spores of *C. dehoopi*. Compared with species from around the world, *C. dehoopi* resembles *C. arripica* Su et White, 1994 described from the gall bladder of *Arripis trutta* in Tasmania, Australia by Su and White (1994). The spores of *Ceratomyxa dehoopi* are, however, broader and do not have an almost straight posterior end, as in the case of *C. arripica*. *Ceratomyxa dehoopi* is most similar to *C. sparusaurati* Sitjà-Bobadilla, Palenzuela et Álvarez-Pellitero, 1995 described from the gall bladder of *Sparus aurata* in Spain by Sitjà-Bobadilla et al. (1995). The spore dimensions are very similar, but the spores of *C. sparusaurati* have a slightly more convex anterior and concave posterior end, compared with the more straightened spores of *C. dehoopi*.

Pathogenicity

Histological sections and transmission electron micrographs of infected gall bladders of *Clinus superciliosus* revealed that the plasmodia of *Ceratomyxa dehoopi* appear attached to the gall bladder epithelium (Figs. 5, 6, 17–19). A similar observation was noted by Alvarez-Pellitero and Sitjà-Bobadilla (1993) working on *Ceratomyxa labracis* and *C. diplodae* that parasitize the Mediterranean sea bass *Dicentrarchus labrax*. In both

Table 1. *Ceratomyxa* Thélohan, 1892 species described from marine fishes along the coast of Africa. Key to references: 1 – Dubina and Isakov (1976); 2 – Gaevskaya and Kovaleva (1979); 3 – Kpatcha et al. (1996b).

Species	Hosts	Organ	Country	Reference
Ceratomyxa acanthuri Kpatcha, Diebakate, Faye et Toguebaye, 1996	*Acanthurus monroviae*	gall bladder	Senegal	3
Ceratomyxa australis Gaevskaya et Kovaleva, 1979	*Trachurus trachurus capensis*	gall bladder	Namibia	2
Ceratomyxa fistulariae Kpatcha, Diebakate, Faye et Toguebaye, 1996	*Fistularia petimba*	gall bladder	Senegal	3
Ceratomyxa lagocephali Kpatcha, Diebakate, Faye et Toguebaye, 1996	*Lagocephalus laevigatus*	gall bladder	Senegal	3
Ceratomyxa schulmani Dubina et Isakov, 1976	*Alepocephalus australis*	gall bladder	South Africa	1
Ceratomyxa syacii Kpatcha, Diebakate, Faye et Toguebaye, 1996	*Syacium micrurum*	gall bladder	Senegal	3
Ceratomyxa trachinocephali Kpatcha, Diebakate, Faye et Toguebaye, 1996	*Trachinocephalus myops*	gall bladder	Senegal	3
Ceratomyxa trichiuri Kpatcha, Diebakate, Faye et Toguebaye, 1996	*Trichiurus lepturus*	gall bladder	Senegal	3
Ceratomyxa truncata Thélohan, 1895	*Sardinella maderensis*, *S. aurita*	gall bladder	Senegal	3
Ceratomyxa dehoopi sp. n.	*Clinus superciliosus*	gall bladder and liver	South Africa	present study
Ceratomyxa cottoidii sp. n.	*Clinus cottoides*	gall bladder	South Africa	present study
Ceratomyxa honckenii sp. n.	*Amblyrhynchotes honckenii*	gall bladder	South Africa	present study

Table 2. Spore measurements (in μm) of African marine *Ceratomyxa* Thélohan, 1892 species, including those from the present study. Key: np – not provided in original description; PC – polar capsule; * – species has both spherical and pyriform polar capsules. Key to references: 1 – Dubina and Isakov (1976); 2 – Gaevskaya and Kovaleva (1979); 3 – Kpatcha et al. (1996b).

Species	Spore length	Spore width	PC length	PC width	Reference
Ceratomyxa acanthuri	10.54 ± 0.8 (10.0–12.0)	16.57 ± 0.9 (16.0–18.0)	2.75 ± 0.6 (2.0–3.20)	np	3
Ceratomyxa australis	4.0–5.3	13.3–15.0	2.0–2.6	1.3	2
*Ceratomyxa fistulariae**	10.25 ± 0.6 (10.0–12.0)	39.64 ± 0.56 (38.8–40.0)	5.21 ± 0.5 (4.5–5.5) in diameter	np	3
			5.15 ± 0.38 (4.5–6.0)	4.21 ± 0.41 (4.0–4.5)	
Ceratomyxa lagocephali	21.68 ± 0.6 (20.0–22.5)	9.28 ± 0.4 (9.0–10.50)	4.29 ± 0.48 (3.5–4.5) in diameter	np	3
Ceratomyxa schulmani	17	120	11.0	10.0	1
Ceratomyxa syacii	23.0 ± 0.9 (22.5–25.0)	23.55 ± 0.9 (22.5–25.0)	1.87 ± 0.1 (1.5–2.0) in diameter	np	3
Ceratomyxa trachinocephali	11.5 ± 0.8 (10–12)	49.66 ± 0.7 (48–50)	2.7 ± 0.4 (2.0–3.0) in diameter	np	3
Ceratomyxa. trichiuri	10.62 ± 0.9 (10.0–12.0)	99.2 ± 0.9 (98.0–100.0)	4.85 ± 0.2 (4.5–5.0) in diameter	np	3
Ceratomyxa truncata	6.08 ± 0.16 (5.0–7.0)	26.05 ± 0.7 (25.5–27.0)	2.17 ± 0.1 (2.0–2.25) in diameter	np	3
Ceratomyxa dehoopi sp. n.	4.0–5.5 (4.5 ± 0.5)	12.0–17.5 (15.4 ± 1.4)	2.0–3.0 (2.7 ± 0.3)	2.0–2.5 (2.1 ± 0.2)	present study
Ceratomyxa cottoidii sp. n.	6.5–8.0 (7.1 ± 0.6)	17.0–22.0 (18.2 ± 1.7)	2.3–3.0 (2.7 ± 0.4)	2.0–3.0 (2.4 ± 0.4)	present study
Ceratomyxa honckenii sp. n.	7.5–8.0 (7.8 ± 0.3)	18.0–21.0 (19.0 ± 1.4)	3.0–3.2 (3.1 ± 0.08)	3.0–3.1 (3.0 ± 0.04)	present study

wild and cultured conditions trophozoites appeared to line the gall bladder epithelium frequently, closely attached to the cell surface and even forming invaginations in it. Histopathological damage to the gall bladder of the infected fish might include vacuolation, deformation and even necrosis of epithelial cells (Alvarez-Pellitero and Sitjà-Bobadilla 1993).

In many cases the livers of infected *C. superciliosus* individuals were very light in colour and the bile appeared thick, opaque and dark green. Histological sections of liver showed that plasmodial stages of *C. dehoopi* develop mostly in the intra- but also in the extrahepatic bile ducts. The masses of spores appear to cause severe obstruction in the bile ducts and in the infected specimens the bile ducts were all distended and packed full with plasmodial stages and developing spores (Figs. 17–19). It is possible that the normal bile drainage of the liver was affected due to the extremely reduced diameter of the lumen. Interestingly, a regular centripetal arrangement of the long axis of the spores was observed in the spores maturing in the plasmodial stages (Fig. 19). Thickening and inflammation of the subepithelial connective tissue and damage to the neighbouring pancreatic tissue might also occur. In other ceratomyxoses, spread of the parasites to other organs was observed in very intense infections and stress situations, such as starvation (Sitjà-Bobadilla et al. 1995).

Ceratomyxa cottoidii sp. n. Figs. 10, 13

Spores (n = 20 live spores): Mature spores broadly elliptical to crescent-shaped with rounded convex anterior and almost straight posterior, 6.5–8.0 (7.0 ± 0.6) µm long × 17.0–22.0 (18.2 ± 1.7) µm wide. Shell valves smooth with one occasionally tapering to a greater degree than the other. Sutural line straight with two spherical to ovoid polar capsules situated medially. Polar capsules 2.3–3.0 (2.7 ± 0.4) µm long × 2.0–3.0 (2.4 ± 0.4) µm wide. Three to four coils per polar filament. Uninucleate sporoplasm transversely elongate, extending into both shell valves.

Vegetative stages: Disporous, coelozoic trophozoites floating within gall bladder bile. Plasmodia mostly spherical to elongate and refractile, with numerous granules and inner generative cells ranging in size from 5 to 20 µm.

T y p e h o s t : *Clinus cottoides* Valenciennes, 1836 – endemic to South Africa from the Olifants River mouth on the west coast to the Kei River mouth on the southeast coast.

T y p e l o c a l i t y : De Hoop Nature Reserve (34°28'S, 20°30'E), South Africa.

S i t e o f i n f e c t i o n : Gall bladder.

P r e v a l e n c e : 59% (26/44).

E t y m o l o g y : Named after the type host species.

P h o t o - r e f e r e n c e : Deposited in the National Museum Bloemfonteins' Parasite Collection; reference number: NMBP 300.

Remarks

Ceratomyxa cottoidii is possibly the same species collected from gall bladders of intertidal fishes in Table Bay and False Bay in South Africa by Fantham (1930). The species descriptions by Fantham (1930) unfortunately do not contain sufficient descriptive information and illustrations, making it impossible to distinguish them from other similar species and as a result are considered *nomina nuda*. Amongst the other *Ceratomyxa* species found infecting African marine fishes, *C. cottoidii* closely resembles *C. australis* Gaevskaya et Kovaleva, 1979 (Gaevskaya and Kovaleva 1979). The spores of *C. australis* are, however, smaller and have a shorter spore length (Table 2) giving them a narrower appearance compared to the more broadly rounded spores of *C. cottoidii*. The polar capsules of *C. australis* are also more teardrop-shaped compared to the almost spherical polar capsules of *C. cottoidii*. *Ceratomyxa cottoidii* resembles *C. lagocephali* Kpatcha, Diebakate, Faye et Toguebaye, 1996 described from the gall bladder of *Lagocephalus laevigatus* off the coast of Senegal by Kpatcha et al. (1996b). The spores of *C. lagocephali* are more broadly crescent-shaped than *C. cottoidii*. Furthermore, the spherical polar capsules of *C. lagocephali* are larger than the smaller, almost spherical polar capsules of *C. cottoidii*. Compared with species from around the world, *C. cottoidii* resembles *C. arripica* described from Tasmania by Su and White (1994). The spores of *C. arripica* are, however, smaller than *C. cottoidii*. Furthermore, the spores of *C. arripica* have a very prominent convex anterior, tapering to two equally rounded ends, unlike the spores of *C. cottoidii*, which have more broadly rounded ends, with one end occasionally tapering to a greater degree. *Ceratomyxa cottoidii* has some morphological similarities with *C. buri* Yokoyama et Fukuda, 2001 described from the gall bladder of *Seriola quinqueradiata* in Japan by Yokoyama and Fukuda (2001). The spores of *C. buri* have the same average spore length, but have a narrower spore width than the spores of *C. cottoidii*. *Ceratomyxa cottoidii* differs from *C. dehoopi* in having more broadly arched spores as opposed to the more narrow spores of *C. dehoopi*. *Ceratomyxa dehoopi* also has rounded polar capsules which differ from the teardrop-shaped polar capsules of *C. cottoidii*.

Ceratomyxa honckenii sp. n. Figs. 11, 14

Spores (n = 20 live spores): Mature spores transversely elongate, very slightly crescent-shaped and broadly concave, 7.5–8.0 (7.8 ± 0.3) µm long × 18.0–21.0 (19.0 ± 1.4) µm wide. Shell valves smooth, equal in size, tapering to broadly rounded end while sutural line is straight with two almost spherical polar capsules situated medially. Polar capsules 3.0–3.2 (3.1 ± 0.1) µm long × 3.0–3.1 (3.0 ± 0.04) µm wide, with polar filaments that have two to three coils in each polar capsule. Uninucleate sporoplasm transversely elongate extending into each of two shell valves, almost filling entire spore cavity.

Vegetative stages: Disporous spherical trophozoites observed floating within gall bladder bile. Trophozoites mostly transparent with refractile granules, ranging in size 5 to 20 µm.

T y p e h o s t : *Amblyrhynchotes honckenii* (Bloch, 1795) – Indo-Pacific species.

T y p e l o c a l i t y : De Hoop Nature Reserve (34°28'S, 20°30'E), South Africa.

O t h e r l o c a l i t i e s : Jeffrey's Bay (34°2.2'S, 24°56.5'E), South Africa.

S i t e o f i n f e c t i o n : Gall bladder.

P r e v a l e n c e : De Hoop Nature Reserve, 58% (7/12); Jeffrey's Bay, 50% (1/2).

E t y m o l o g y : Named after type host species.

P h o t o - r e f e r e n c e : Deposited in the National Museum Bloemfonteins' Parasite Collection; reference number: NMBP 301.

Remarks

Amongst the three *Ceratomyxa* species collected from the De Hoop Nature reserve, *Ceratomyxa honckenii* has the longest spore length and most box-like appearance. Morphologically the most similar African species is *C. lagocephali*, but this species has a relatively longer spore body length than *C. honckenii* (Kpatcha et al. 1996b) (Table 2), giving the spores of *C. honckenii* a narrower appearance than the broader spores of *C. lagocephali*. Another similar African species is *C. acanthuri* Kpatcha, Diebakate, Faye et Toguebaye, 1996 described from the gall bladder of *Acanthurus monroviae* in Senegal (Kpatcha et al. 1996b). *Ceratomyxa acanthuri* does, however, have a much longer spore length and narrower spore width (Table 2) than the slightly more transversely elongate spores of *C. honckenii*. Compared with species throughout the world, *C. honckenii* is similar to *C. buri* described from Japan by Yokoyama and Fukuda (2001). The spores of *C. buri* have a narrower spore width and are anteriorly more convex, compared to the broadly crescent-shaped spores of *C. honckenii*. The bile of *A. honckenii* individuals tended to be normally thick and dark green in colour, with the gall bladder linings being naturally thick. No abnormal discolouring or thickening of this organ was noted in the infected individuals.

Henneguya clini sp. n. Figs. 15, 16, 22

Spores (n = 20 live spores): Mature spores ovoid to spherical in valvular view and bi-convex in sutural view. Anterior and posterior ends equally rounded, spore body 9.0–11.0 (10.0 ± 0.6) µm long × 7.0–8.5 (7.9 ± 0.4) µm wide. Shell valves smooth, equal with wide sutural ridge. Two separate, very long, thin filiform caudal projections extending from posterior of spore. Total length of spores 43.0–46.0 (44.6 ± 2.0) µm. Two pyriform polar capsules in anterior of spore, 4.0–4.2 (4.0 ± 0.1) µm long × 2.0–2.5 (2.2 ± 0.2) µm wide. Four to five coils in polar filament. Binucleate sporoplasm situated directly behind two polar capsules, almost filling entire spore cavity.

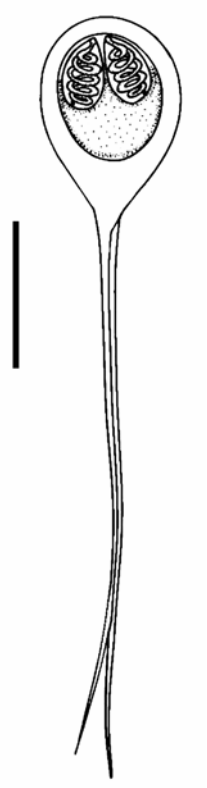


Fig. 15. Line drawing of live spore of *Henneguya clini* sp. n. from the gills of *Clinus superciliosus* collected from the Cape south coast, South Africa. Scale bar = 10 µm.

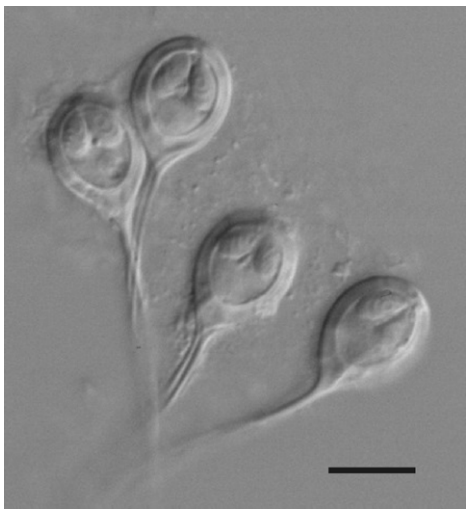
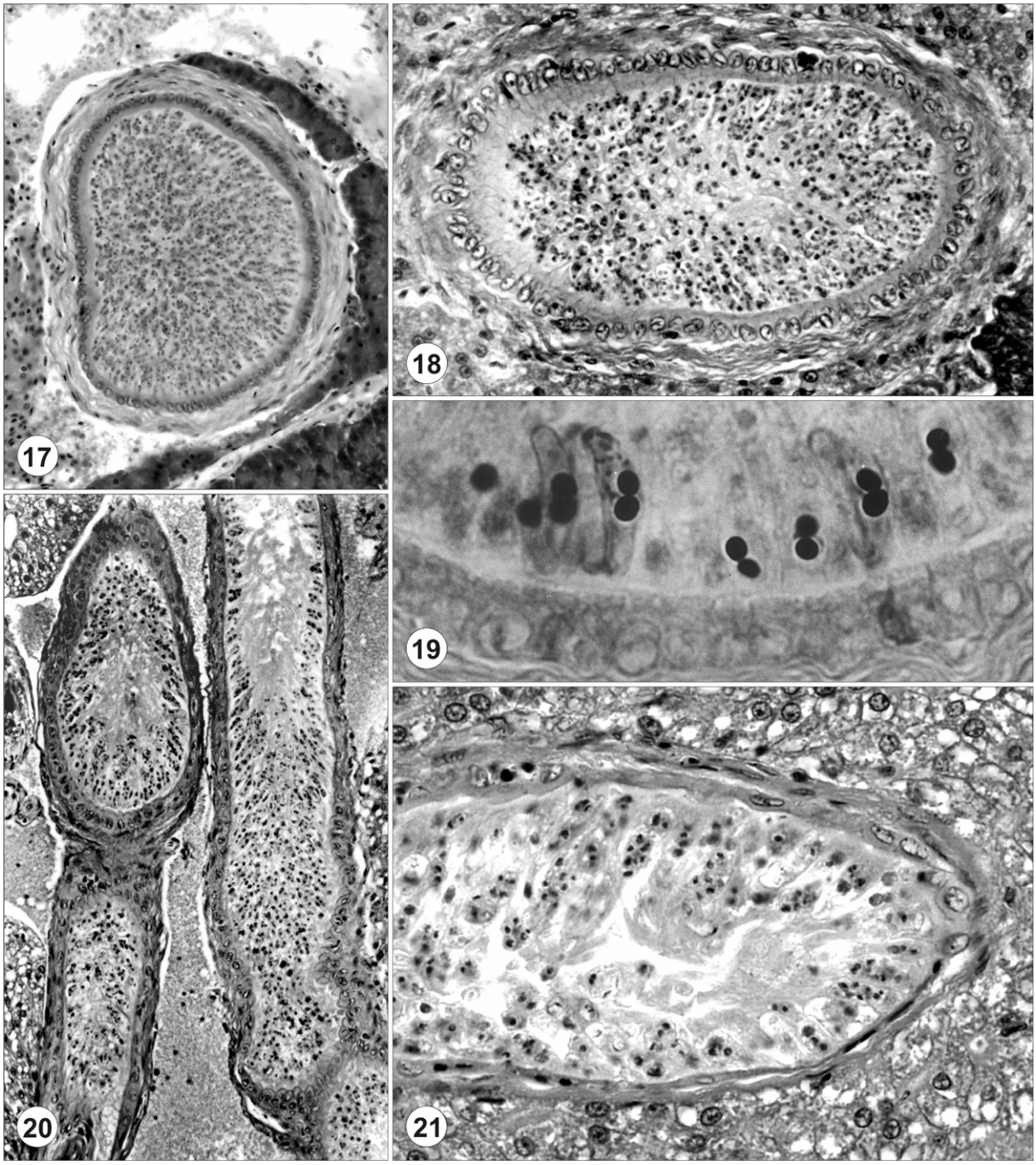


Fig. 16. Light micrograph of live spores of *Henneguya clini* sp. n. from the gills of *Clinus superciliosus* collected from the Cape south coast, South Africa. Scale bar = 10 µm.

Vegetative stages: Large histozoic polysporic plasmodia found within blood vessels of gills and gill arches. Plasmodia white, varying in shape and size, measuring 1 to 3 mm in length.



Figs. 17–21. Histological sections of fish organs infected with myxosporeans from the Cape south coast of South Africa. **Figs. 17–19.** Bile ducts of *Clinus superciliosus* showing *Ceratomyxa dehoopi* sp. n. plasmodia and spores closely associated with epithelium. H&E, ×290, ×460 and ×1,600, respectively. **Figs. 20, 21.** Extrahepatic and intrahepatic bile ducts of *C. superciliosus* showing plasmodia and spores of *Ceratomyxa cottoidii* sp. n. H&E, ×250 and ×560, respectively.

Type host: *Clinus superciliosus* (Linnaeus, 1758).

Type locality: De Hoop Nature Reserve (34°28'S, 20°30'E), South Africa.

Other hosts at type locality: *Clinus cottoides* Valenciennes, 1836.

Other localities in type host: Jeffrey's Bay (34°2.2'S, 24°56.5'E), South Africa.

Site of infection: Gills and gill arches.

Prevalence: *Clinus superciliosus*, 1% (1/92); *Clinus cottoides*, 2% (1/44); at De Hoop Nature Reserve. *Clinus superciliosus* at Jeffrey's Bay, 2% (1/38).

Table 3. *Henneguya* Thélohan, 1892 species known from marine fishes along the African coast. Key to references: 1 – Bahri et al. (1996); 2 – Faye et al. (1997); 3 – Kpatcha et al. (1997).

Species	Hosts	Organ	Country	Reference
Henneguya brachydeuteri Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Brachydeuterus auritus*	heart	Senegal	3
Henneguya joalensis Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Cephalopholis taeniops*	kidney	Senegal	3
Henneguya kayarensis Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Galeoides decadactylus*	liver	Senegal	3
Henneguya lutjani Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Lutjanus agennes*	gills	Senegal	3
Henneguya mbourensis Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Dentex canariensis*	kidney	Senegal	3
Henneguya ouakamensis Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Mugil cephalus*	gills and heart	Senegal	3
Henneguya priacanthi Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Priacanthus arenatus*	gills	Senegal	3
Henneguya yoffensis Kpatcha, Faye, Diebakate, Fall et Toguebaye, 1997	*Pagrus caeruleostictus*	gills and heart	Senegal	3
Henneguya sp.	*Sparus aurata*	gills	Tunisia	1
Henneguya sp. 1	*Brachydeuterus auritus*	heart	Senegal	2
Henneguya sp. 2	*Pagrus caeruleostictus*	heart	Senegal	2
Henneguya sp. 3	*Mugil cephalus*	heart	Senegal	2
Henneguya clini sp. n.	*Clinus superciliosus*, *C. cottoides*	gills	South Africa	present study

Table 4. Spore measurements (in μm) of African marine *Henneguya* Thélohan, 1892 species, including those from the present study. Key: CL – caudal length;; PC – polar capsule; R – reference; SBL – spore body length; SBW – spore body width; TL – total length. Key to references: 1 – Kpatcha et al. (1997); P – present study.

Species	TL	SBL	CL	SBW	PC length	PC width	R
Henneguya brachydeuteri	37.18 ± 0.98 (36.0–41.0)	11.5 ± 0.5 (10.0–12.0)	26.9 ± 0.9 (26–29)	8.36 ± 0.75 (7–9)	4.33 ± 0.5 (4.0–5.0)	2.6 ± 0.5 (2.0–3.0)	1
Henneguya joalensis	44.81 ± 0.2 (44.5–45.0)	8.9 ± 0.1 (8.5–9.0)	35.25 ± 0.97 (34.0–36.0)	6.37 (6.0–7.0)	Smaller: 3.73 ± 1.18 (3.4–4.5) Larger: 4.78 ± 0.45 (4.5–5.5)	Smaller: 1.86 ± 0.09 (1.8–2.0) Larger: 2.53 ± 0.21 (2.25–3.0)	1
Henneguya kayarensis	54.70 ± 0.83 (52.0–56.5)	8.41 ± 0.65 (7.0–9.0)	46.29 ± 0.98 (45.0–47.5)	6.6 ± 0.41 (6.0–7.0)	4.32 ± 0.19 (4.0–4.5)	2.36 ± 0.11 (2.25–2.5)	1
Henneguya lutjani	49.96 ± 0.98 (47.25–50.4)	11.86 ± 0.6 (11.25–13.0)	37.22 ± 0.98 (36.0–38.25)	7.29 ± 0.73 (6.0–8.0)	3.84 ± 0.58 (3.0–4.5)	2.96 ± 0.44 (2.25–3.5)	1
Henneguya mbourensis	29.62 ± 0.99 (28.0–33.)	10.26 ± 0.44 (10.0–11.0)	20.66 ± 0.99 (20.0–22.5)	7.98 ± 0.98 (6.5–9.0)	4.78 ± 0.5 (3.5–5.0)	2.4 ± 0.5 (2.0–3.5)	1
Henneguya ouakamensis	20.86 ± 1.47 (16.0–24.0)	10.9 ± 0.57 (9.0–13.0)	9.9 ± 1.36 (6.0–14.0)	9.0 ± 0.44 (5.0–9.0)	3.78 ± 0.48 (3.0–4.0)	2.43 ± 0.42 (2.0–3.0)	1
Henneguya priacanthi	39.74 ± 0.99 (36.5–41.0)	9.18 ± 0.22 (9.0–9.5)	28.12 ± 0.1 (22.5–31.5)	7.32 ± 0.5 (6.5–8.0)	2.16 ± 0.1 (2.0–2.5)	1.34 ± 0.1 (1.0–2.0)	1
Henneguya yoffensis	46.18 ± 0.36 (37.0–50.0)	13.38 ± 0.19 (12.0–15.0)	32.13 ± 0.27 (24.0–36.0)	9.13 ± 0.31 (8.0–11.0)	3.47 ± 0.19 (3.0–4.0)	2.30 ± 0.13 (2.0–3.0)	1
Henneguya clini sp. n.	43.0–46.0 (44.6 ± 2.0)	9.0–11.0 (10.0 ± 0.6)	34.0–35.0 (34.0 ± 1.4)	7.0–8.5 (7.9 ± 0.4)	4.0–4.2 (4.0 ± 0.1)	2.0–2.5 (2.2 ± 0.2)	P

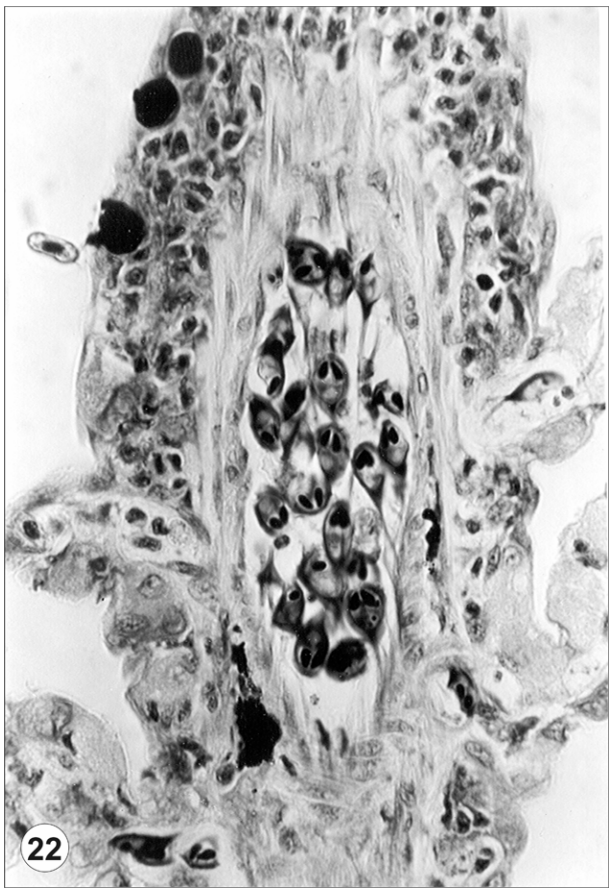


Fig. 22. Histological section of *Clinus superciliosus* gills showing spores of *Henneguya clini* sp. n. released from mature plasmodium. Giemsa stain, ×900.

Remarks

Henneguya clini does not conform to the description of any of the species listed in Eiras's (2002) comprehensive world-wide synopsis of the species of the genus *Henneguya*. All eight African marine *Henneguya* species described from fishes along the Senegalese coast by Kpatcha et al. (1997) (Table 3) have very similar morphological appearances. One very prominent characteristic that they all exhibit is a very wide sutural ridge. The same characteristic was found in *H. clini*.

Although all the species described from Senegal are very similar to *H. clini*, they each exhibit one or more distinguishing characteristics. The spores of *H. brachydeuteri* from the heart of *Brachydeuterus auritus* are generally shorter in total length (Table 4) and appear to have a much wider sutural ridge than *H. clini*. *Henneguya joalensis* from the kidney of *Cephalopholis taeniops* has the same average total spore length, but has a shorter spore body length (Table 4) compared to that of *H. clini*. The spores of *H. kayarensis* from the liver of *Galeoides decadactylus* are much longer in total spore length and generally have a smaller spore body (Table 4) than *H. clini*. *Henneguya lutjani* from the gills of *Lutjanus agennes* also has much longer spores that are generally larger than those of *H. clini*. The spores of *H. mbourensis* from the kidney of *Dentex canariensis* are much shorter in total length than the spores of *H. clini.* Morphologically the spores of *H. ouakamensis* from the gills of *Mugil cephalus* are most distinct from *H. clini*. These are much shorter and have an almost spherical spore body, compared with the more elongate spores of *H. clini* that do not have a totally spherical spore body. *Henneguya priacanthi* from the gills of *Priacanthus arenatus* is most similar to *H. clini*, but has a relatively shorter total spore length and generally smaller polar capsules (Table 4). The spores of *H. yoffensis* from the gills and heart of *Sparus caeruleostictus* have the same average total spore length, but have a larger spore body (Table 4) than *H. clini*.

Pathogenicity

Histological sections of infected gill arches revealed that the massive plasmodia severely distorted the entire gill arch and many of the gill lamellae. Although none of the fish showed infections with more than half of the gills appearing severely distorted, the large plasmodia did compress many of the smaller gill filaments in the infected individuals. These fish spend their entire lives in intertidal pools, which are subjected to daily variations in oxygen concentrations, salinity and temperature as a result of tidal movements. It is possible that such infections affect the respiratory function of gills. This could potentially have an adverse effect on the ability of infected individuals to survive in harsh tidal pool environments, particularly during low tides when oxygen concentrations in intertidal pools drop dramatically.

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