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ORIGINAL PAPER

Four new species of *Ceratomyxa* Thelohan 1892 (Myxozoa: Myxosporea: Ceratomyxidae) infecting the gallbladder of some Red Sea fishes

F. Abdel-Ghaffar · M. A. Ali · S. Al Quraishy · K. Al Rasheid · S. Al Farraj · A. S. Abdel-Baki · A.-R. Bashtar

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Abstract Four new *Ceratomyxa* species were described from the gallbladder of four Red Sea fishes at Suez and Hurghada, Egypt. These species are *Ceratomyxa bassoni* sp. n. from *Plectorhinchus gaterinus* (Forsskal 1775) at Suez and Hurghada, *Ceratomyxa entzerothi* sp. n. from *Valamugil seheli* (Forsskal 1775) at Suez and Hurghada, *Ceratomyxa swaisi* sp. n. from *Saurida undosquamis* (Richardson 1848) at Suez only and *Ceratomyxa hurghadensis* sp. n. from *Fistularia commersonii* Ruppell 1838 at Hurghada only. Their taxonomic affinities to other species are discussed.

Introduction

Ceratomyxa spp. are myxosporeans which have elongated crescent-shaped or arcuate spores with shell valves often conical, exceeding in length the axial diameter of the spore. Their polar capsules are subspherical with foramina near the sutural line at the anterior pole of the spore. Sometimes the spore containing binucleate sporoplasm does not completely fill the spore cavity and also, two uninucleate sporoplasms were reported (Lom and Dykova 1992). These parasites have a worldwide distribution and parasitize a wide range of fish species, usually infecting the gall bladder of the host (Eiras 2006). Also, Eiras (2006) listed 147 species of this parasite. With increasing interest in the myxosporeans of Egyptian fishes, we considered it is worthy to expand the area of the study to include the Red Sea. In this study, our aims were to contribute to the myxosporean fauna of fish hosts with special emphasis on genus *Ceratomyxa* and to establish a background for further studies on myxosporean in a definite area of the Red sea coast at Suez and Hurghada cities of Egypt.

F. Abdel-Ghaffar (✉) · A.-R. Bashtar
Zoology Department, Faculty of Science, Cairo University,
Giza, Egypt
e-mail: fathyghaffar@yahoo.com

M. A. Ali
National Institute of Oceanography and Fisheries (NIOF),
Cairo, Egypt

S. Al Quraishy · K. Al Rasheid
Zoology Department, College of Science, King Saud University,
Riyadh, Saudi Arabia

S. Al Farraj
Biology Department, Teachers College, King Saud University,
Riyadh, Saudi Arabia

A. S. Abdel-Baki
Zoology Department, Faculty of Science, Beni-Suef University,
Beni-Suef, Egypt

Materials and methods

A total of 162 fish samples representing four different species of the Red Sea fishes were caught in the Red Sea off the coast of Suez city, Gulf of Suez and Hurghada city, Red Sea, Egypt throughout the year. Fishes were identified according to Randall (1983) and their modern names follow Froese and Pauly (2004). These fish species are: *Plectorhinchus gaterinus* (14 from Hurghada and 16 from Suez), *Valamugil seheli* (23 from Hurghada and 24 from Suez), *Saurida undosquamis* (only 45 from Suez), and *Fistularia commersonii* (only 40 from Hurghada). Fish were necropsied and all organs and body fluids were examined for myxosporean infection. Fresh spores were measured and photographed using Zeiss Axiovert 135 microscope with Contax Camera. Descriptions and measurements of spores followed the guidelines of Lom and Arthur (1989). Measurements were based on 30 fresh spores and data were presented as: mean±SD (range). All measurements are in micrometer. Drawings were made with the aid of camera Lucida. For permanent preparation, air-dried smears were stained with Giemsa after fixation in acetone-free absolute methanol.

Results

Ceratomyxa bassoni sp. n.

Host P. gaterinus (Forsskal 1775; Figs. 1 and 5a)

Site of infection Gallbladder

Prevalence The prevalence was 5/14 (35.7%) in Hurghada samples and the infection was confined only to January. While the prevalence was 4/16 (25%) in Suez and the infection was recorded only on March.

Vegetative stages No vegetative stages were observed. The infection was severe especially in the Suez samples. The bile was turbid due to the presence of large number of free-floating spores with cell debris.

Spore description Typical mature spores had two shapes, with the main difference in the posterior end of the spores. This end is nearly flat in about 60% of the spores and curved with variable degrees in the rest of the spores. Therefore, typical mature spores were crescent-shaped in the frontal view, with a convex anterior end and flat or curved posterior one. Shell valves were smooth without mucous envelope and with rounded ends. Spores measured (n=30) 6.1±0.6 (5.0–7.0) µm in length and 18.0±1.7 (15.0–20.0) µm in thickness. Polar capsules were subspherical to oval measuring 3.2±0.3 (3.0–4.0) µm in length and 2.4±0.3 (2.0–3.0) µm in width. The polar filament formed four turns arranged along the longitudinal axis of the capsule.

Sometimes, abnormal spores with three polar capsules and three shell valves were observed among the spores (Fig. 1).

Ceratomyxa entzerothi sp. n.

Host V. seheli (Forsskal 1775; Figs. 2 and 5b)

Site of infection Gallbladder

Prevalence The prevalence was 3/23 (13%) in Hurghada samples and the infection was observed only on January. While the prevalence was 4/24 (16.6%) in Suez and the infection was recorded only on March.

Vegetative stages The spores of this parasite were recorded from the bile mixed in most cases with scarce *Ortholinea* infection (Fig. 2f). The vegetative stages were not observed and only free mature spores were detected.

Spore description The free-floating mature spores were arcuate to crescent-shaped in the sutural view. Sutural line is prominent. Anterior and posterior margins of shell valves tapered gradually and terminated as thin rounded valvular tips. Spores measured 10.2±0.7 (9.0–11.0) µm in length and 36.5±4.3 (30.0–46.0) µm in thickness. Polar capsules are pyriform, nearly equal in size and measure 5.0±0.6 (4.0–6.0) µm in length and 3.1±0.2 (3.0–3.5) µm in width. The polar filament coiled with three to four turns, situated perpendicularly or slightly oblique to the longitudinal axis of the capsule.

Ceratomyxa swaisi sp. n.

Host S. undosquamis (Richardson 1848; Figs. 3 and 5c)

Site of infection Gallbladder

Prevalence The prevalence was 7/45 (15.5%) in Suez. Fish samples were collected only at Suez and the infection was observed on October and April.

Vegetative stages Vegetative stages were not observed. The infection was detected as a huge number of mature spores free floating in the bile.

Spore description Spores were transversely elongated with indistinct sutural line. Spore valves were straight and tapered to pointed tips. Spore measurements were (n=30) 7.8±0.8 (7.0–9.0) µm in length and 51.5±1.1 (43.0–55.0) µm in thickness. The nearly equal polar capsules were pyriform and measured 3.2±0.3 (3.0–4.0) µm in length and 1.8±0.3 (1.5–2.0) µm in width. Polar filament wounded into three to four turns, slightly oblique to the longitudinal axis of the capsule. Sporoplasm occupied nearly about half of each valve.

Ceratomyxa hurghadensis sp. n.

Host F. commersonii Ruppell 1838 (Figs. 4 and 5d)

Site of infection Gallbladder

Prevalence Fish samples were collected only at Hurghada. The prevalence was 12/40 (30%) and the infection was recorded only on January.

Vegetative stages Pseudoplasmodia were disporous and floated freely in the bile (Fig. 4f–h). They were subspherical to elliptical in shape with average dimensions of 27 (24–30) µm in length and 20 (18–21) µm in width.

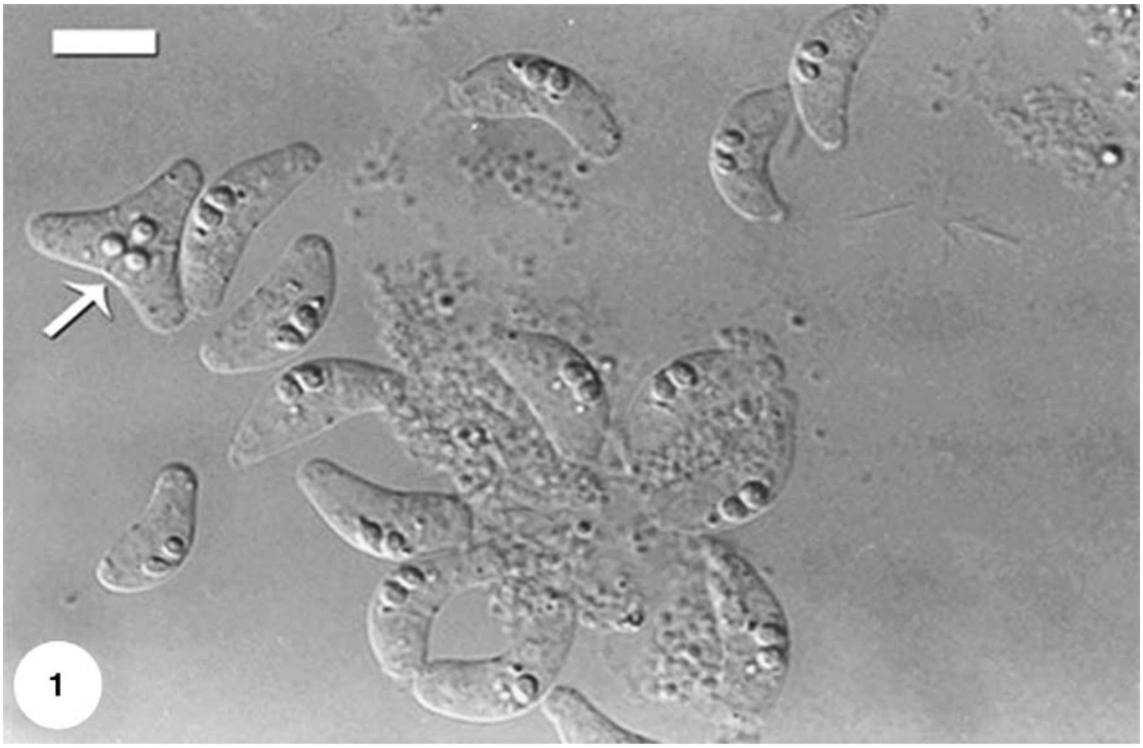

Fig. 1 Fresh spores of *C. bassoni* sp. n. Note abnormal spore with three polar capsules and three shell valves (*arrow*; *scale bar*=10 μm)

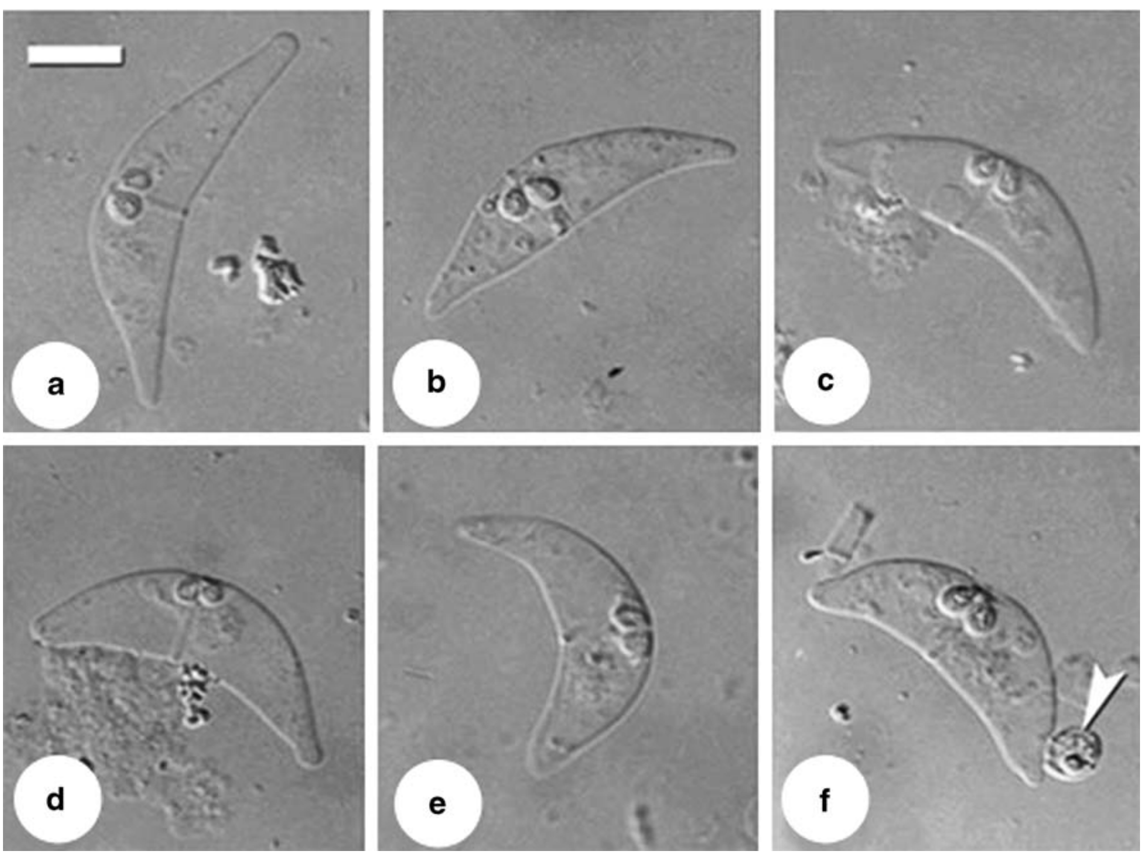

Fig. 2 **a**–**f** Fresh spores of *C. entzerothi* sp. n. from *V. seheli*. The infection was mixed with *Ortholinea* forms (**f**; *arrow*; *scale bar*=10 μm)

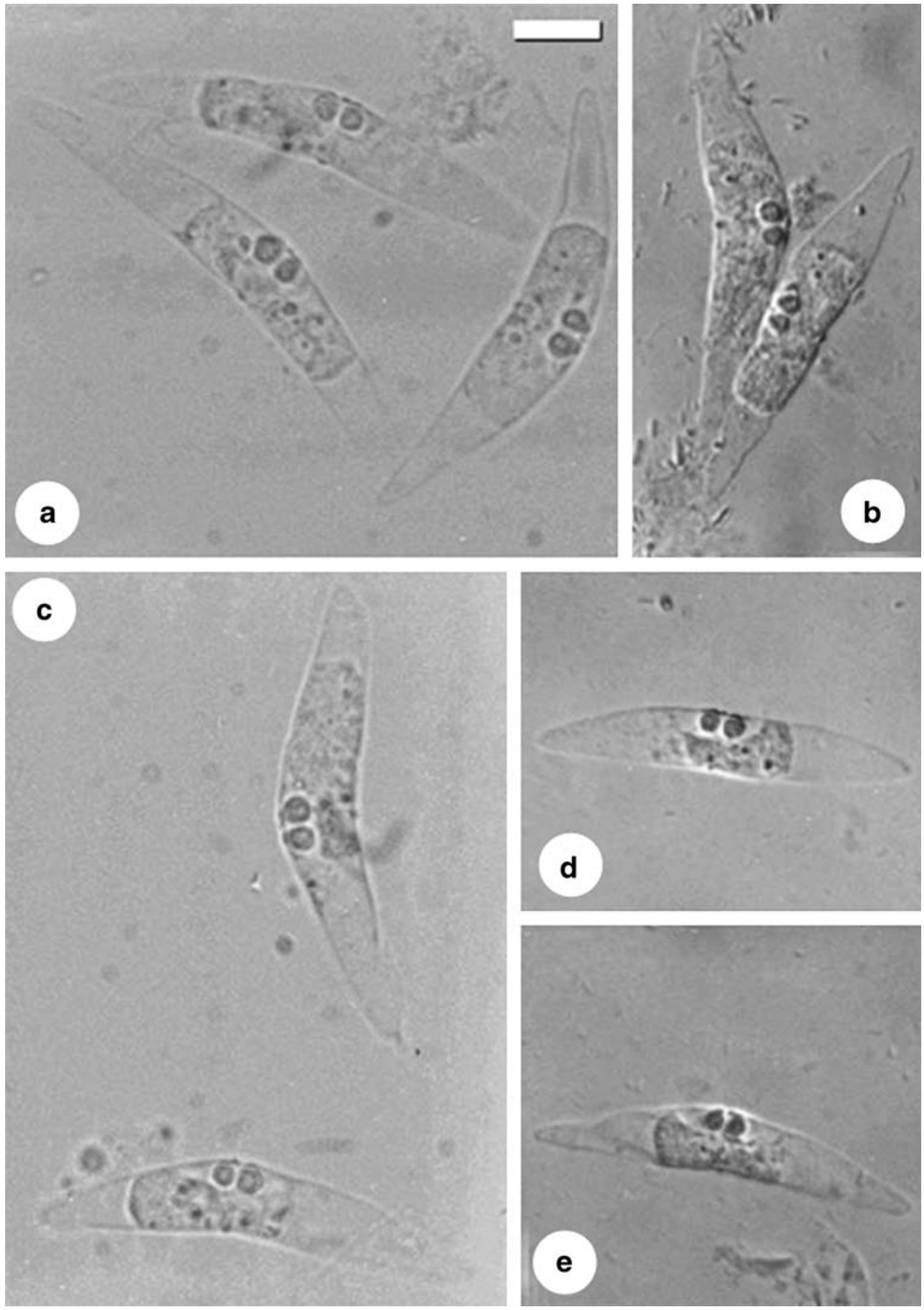

Fig. 3 **a**–**e** Fresh spores of *C. swaisi* sp. n. from the gallbladder of *S. undosquamis* (*scale bar*=10 μm)

Spore description Mature spores were slightly crescentic in the sutural view, with convex anterior end and slightly bent posterior one. Anterior and posterior margins tapered gradually and terminated as blunted valvular tips. The average dimensions of the spore were 9.0±0.7 (8.0–11.0) μm in length and 48.0±0.9 (46.0–52.0) μm in thickness. The two polar capsules were equal in size, pyriform in shape, and 4.5±0.4 (4.0–5.0) μm in length and 2.5±0.3 (2.0–3.0) μm in width. Usually, four to five coils of polar filaments could be seen inside the polar capsules.

Discussion

C. bassoni sp. n.

Some species of *Ceratomyxa* fall within the morphological and dimensional ranges of the present species. These species are: *Ceratomyxa caspia* Dogel 1938 (from Shulman 1966); *Ceratomyxa castigatoides* Meglitsh 1960 (Sitja-Bobadilla et al. 1995); *Ceratomyxa gibba* Meglitsh 1960 (Sitja-Bobadilla et al. 1995); *Ceratomyxa sprenti* (Moser et

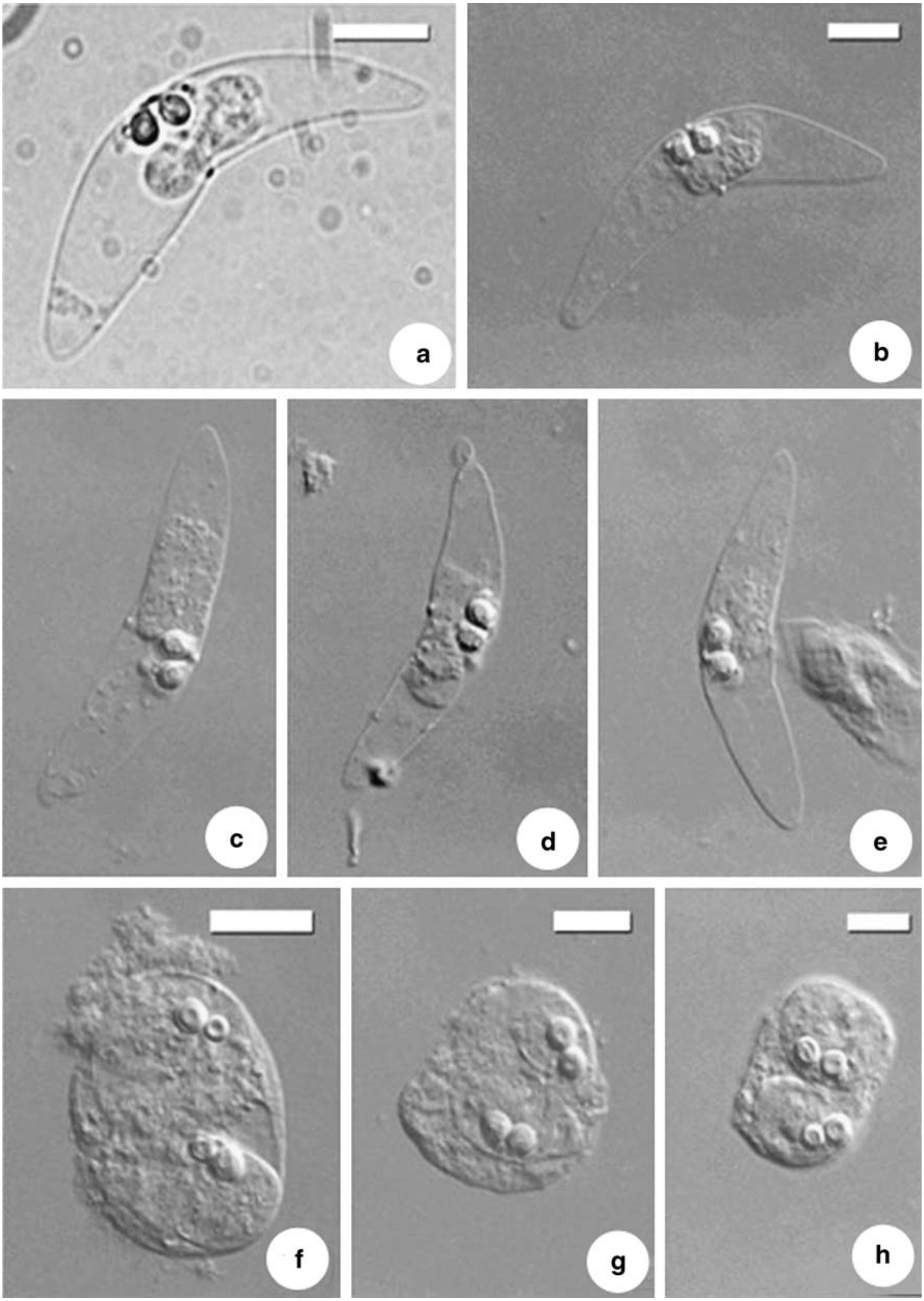

Fig. 4 *C. hurghadensis* sp. n. from the gallbladder of *F. commersonii*. **a**–**e** Fresh spores of *C. hurghadensis* with normal light (**e**) and with Nomarski interference contrast (**b**–**e**; *scale bar*=10 μm). **f**–**h** Disporic pseudoplasmodia of *C. hurghadensis* (*scale bar*=10 μm)

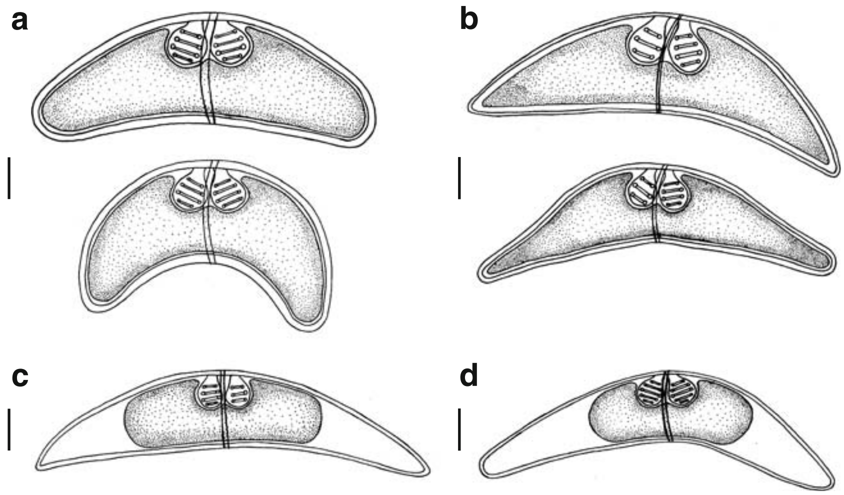

Fig. 5 **a** Line diagram of the spores of *C. bassoni* sp. n. (*scale bar*=5 μm). **b** Line diagram of the spores of *C. entzerothi* sp. n. (*scale bar*=5 μm). **c** Line diagram of the spore of *C. swaisi* sp. n. (*scale bar*=5 μm). **d** Line diagram of the spore of *C. hurghadensis* sp. n. (*scale bar*=5 μm)

al. 1989); *Ceratomyxa hungarica* (Molnar 1992); and *Ceratomyxa sparusaurati* (Sitja-Bobadilla et al. 1995).

Although the spore thickness of *C. caspia* and *C. hungarica* fall in the same range of the present species, they differ in having longer spores and rounded polar capsules with higher number of polar filament turns (6 vs. 4). In addition, these species infect the kidney while the present species infects the gallbladder. Also, *C. hungarica* was reported from freshwater host fish.

C. gibba is distinguished from the present species by having unequal polar capsules and valves. Moreover, the polar capsules are rounded and smaller than that of the present species.

Spores of *C. castigatoides* are narrower and have rounded smaller polar capsules.

C. sprenti can be separated from the present species by its rounded polar capsules with higher number of polar filament turns (5–6 vs. 4). In addition, their spores are almost straight with anterior and posterior margin tapers to rounded ends.

C. sparusaurati has thinner spores and rounded polar capsules with higher number of filament coils (6 vs. 4).

Based on all these morphological differences and the host records, the present species is considered distinct and designated as a new species. The species name *C. bassoni* sp. n. is proposed after Prof. Linda Basson, Professor of Parasitology, University of Orange Free State, South Africa.

C. entzerothi sp. n.

On analyzing the morphology and quantitative data of the present material, it was found that five species could be compared. These species are: *Ceratomyxa appendiculata* Thelohan 1892 (Lubat et al. 1989); *Ceratomyxa drepanopsettae* Awerinzew 1908 (Wierzbicka 1990); *Ceratomyxa agregatat* Davis 1917 (from Lom and Dykova 1992); *Ceratomyxa auerbachi* Kabata 1962 (from Lom and Dykova 1992); and *Ceratomyxa kudoi* (Kalavati and Anuradha 1993).

Among the above species, *C. appendiculata* differs from the present myxosporean species by having shorter spores and quite smaller rounded polar capsules.

C. drepanopsettae, *C. agregatat*, and *C. auerbachi* can be readily distinguished from the present species by their markedly thicker spores and rounded polar capsules compared to the pyriform ones of the present species.

So far, 34 species of myxosporean parasites belonging to six genera, *Myxidium*, *Zschokkella*, *Ceratomyxa*, *Sphaerospora*, *Myxobolus*, and *Kudoa*, have been described from the mullets all over the world. Of these, two species namely *Kudoa valamugil* and *C. kudoi* (Kalavati and Anuradha 1993) were described from *Valamugil*. The *Ceratomyxa* recorded in the present study is markedly larger in all dimensions than *C. kudoi* and quite dissimilar in its morphology.

Therefore, the present species carries enough criteria in our view to be allocated as a new species and *C. entzerothi* sp. n. is proposed after Prof. Rolf Entzeroth, Professor of Parasitology and Special Zoology, Technical University of Dresden, Germany.

C. swaisi sp. n.

The present species exhibited some similarities with other members of the genus *Ceratomyxa*, parasitizing fish from different families and different geographical distribution. These species are: *C. appendiculata* Thelohan 1892 (Lubat et al. 1989); *C. drepanopsettae* Awerinzew 1908 (Wierzbicka 1990); *Ceratomyxa schulmani* Dubina and Isakov 1976 (from Lom and Dykova 1992); *Ceratomyxa rohdei* (Moser et al. 1989); and *Ceratomyxa daysciaenae* (Sarker and Pramanik 1994).

Spore thickness and polar capsule length of *C. appendiculata* are less than the minimum ranges of the present species.

On the contrary, the spore length and thickness of *C. drepanopsettae* are much larger. In addition, the polar capsule of *C. drepanopsettae* is rounded compared to pyriform ones characterizing the present species.

C. schulmani is markedly larger in all body dimensions than the present species.

C. rohdei has shorter and thinner spores and shows rounded polar capsule with higher number of filament coils (6–8 vs. 3–4). Also, *C. daysciaenae* can be distinguished from the present species by its thinner spores which have "broad ellipsoidal centers" and also the shorter polar capsules which are nearly half of the present species.

Reviewing the literature revealed that no myxosporean infection is recorded in the present fish species. Thus, since the present spores cannot be identified with any known *Ceratomyxa* species, we propose to establish it as *C. swaisi* sp. n. after its locality (Swais = Suez in Arabic).

C. hurghadensis sp. n.

Comparing with other related species of *Ceratomyxa*, some species are found to be comparable to the present species. These species are *C. drepanopsettae* Awerinzew 1908 (Wierzbicka 1990); *C. rohdei* (Moser et al. 1989); *Ceratomyxa sagarsampadae* (Narasimhamurti et al. 1990); and *C. daysciaenae* (Sarkar and Pramanik 1994).

C. drepanopsettae can be distinguished from the present species in having thicker spores and rounded polar capsules compared to pyriform ones in the present species.

C. rohdei differs from the present species by having shorter spores (nearly half of the present spores). Moreover, the polar capsules of *C. rohdei* are rounded with six to eight coils compared to pyriform ones with four to five coils.

In the same way, *C. sagarsampadae* can be distinguished from the present species by having larger spores in all dimensions with different number of polar filament turns (6–7 vs. 4–5).

The shorter and thicker spores of *C. daysciaenae* separated it from the present species. In addition, *C. daysciaenae* exhibited shell valves twisted near the spore midpoint and rounded polar capsules.

The present fish host is endemic to the Red Sea (Randall 1983) and has no record of any myxosporean infection. Accordingly, the present myxosporean is presented as a new one and *C. hurghadensis* sp. n. is proposed after its locality (Hurghada).

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