A NEW HAPLOSPORIDIAN PARASITE, *COELOSPORIDIUM SCHMACKERIAE* FROM THE BODY CAVITY OF A MARINE COPEPOD *SCHMACKERIA SERRICAUDATA*

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While examining the marine planktonic copepod, *Schmackeria serricaudata*, we have frequently come across in the body cavity of the host multinucleate plasmodia and rounded cysts with uninucleate spores. On closer examination it was found that these are the developmental stages of what we consider to be a haplosporidian.

The only previous account of what apparently is the same parasite was given by Chatton (1920) from *Calanus* and other copepods in the Clyde sea area. Chatton provisionally assigned the parasite to the genus *Ichthyosporidium*. Jepps (1937) found in a single instance the same parasite growing steadily through the body cavity of a female *Calanus*.

We are convinced that the present parasite which appears to be identical with the one described by Chatton (1920) can no longer be placed in the genus *Ichthyosporidium* and for reasons discussed elsewhere in this paper we are describing it as a new species of the Haplosporidian genus, *Coelosporidium* for which we propose the name *C. schmackeriae* after the host.

Material and Methods

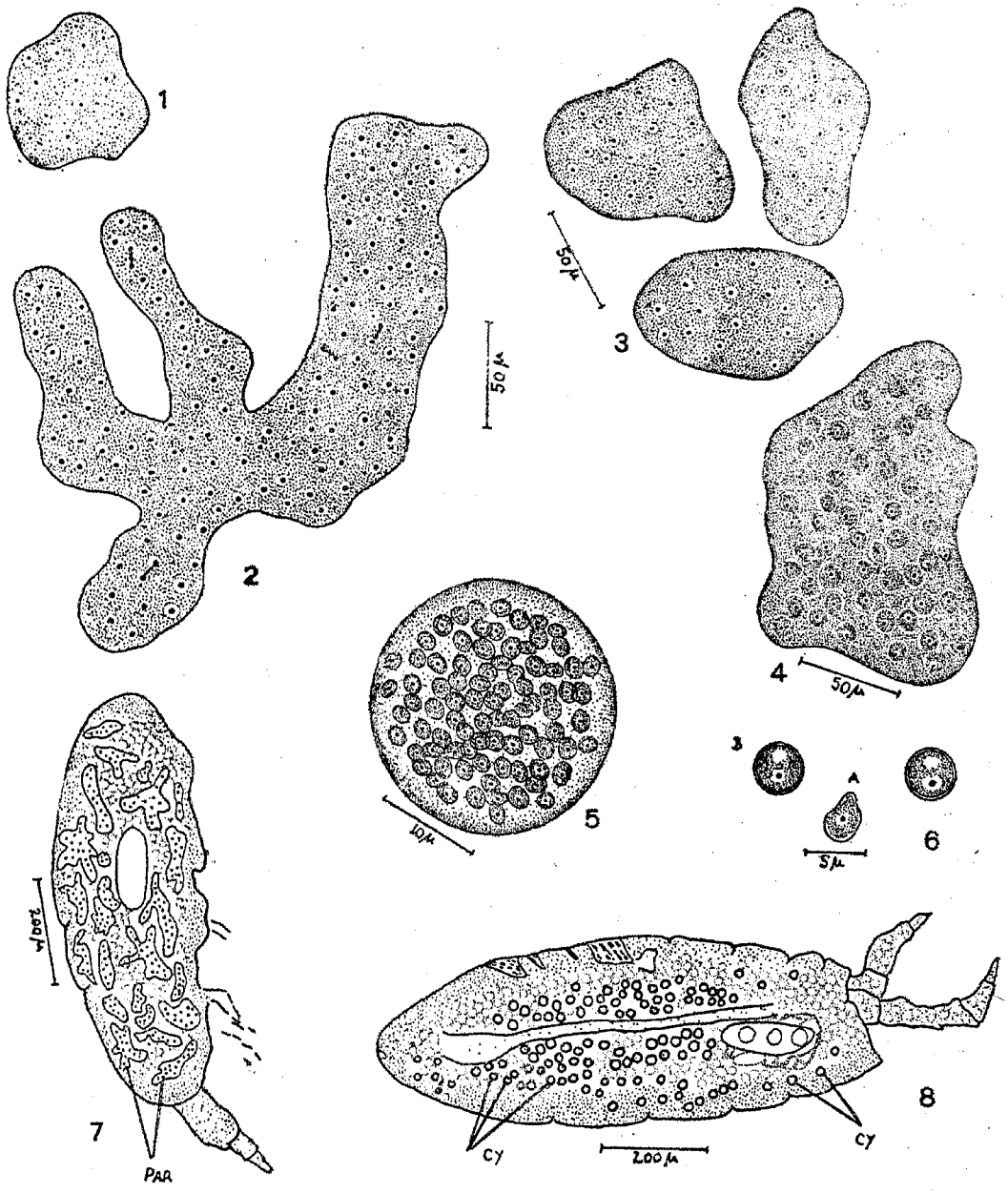
The infected hosts could readily be distinguished from healthy ones by their colour. When the infection was moderate the hosts appear orange to pink in colour and the heavily infected ones are shiny blue-black. The fresh parasites were observed by teasing out the host on a slide and examining it in a drop of Ringer's or normal saline. Smears and sections were prepared to study the developmental stages. Smears were fixed in methyl-alcohol or Schaudinn's fluid followed by staining with Giemsa's solution or iron-hamatoxylin respectively. The entire host was sectioned after fixation in alcoholic Bouin's fluid or Carnoy's fluid. Sections were cut 8 μ thick and stained with

iron-haematoxylin. For observations on the nucleus the sections were stained with Feulgen's stain.

OBSERVATIONS ON THE PARASITE

The earliest stage of the parasite observed in fresh material was an amoebula measureng $3 \cdot 5\mu \times 3 \cdot 0\mu$ with hyaline cytoplasm and a rounded nucleus in the centre. In stained preparations the cytoplasm was clear and the nucleus was Feulgen positive and stained deep with iron haematoxylin. With the growth of the parasite the nucleus undergoes repeated divisions resulting in a plasmodium. In the living plasmodium the cytoplasm was clear and the nuclei appeared as scattered refringent granules. In fixed and stained preparations of such plasmodia the cytoplasm appeared finely granular and the nuclei stained deep with iron-haematoxylin. Surrounding each nucleus there was a clear halo: A distinct nuclear membrane, however, could not be seen. Some of the nuclei appeared to be in a dividing stage with two clumps of chromatin material connected by a thin strand of similar material but neither a spindle nor anything like chromosomes could be detected. The nuclear division appeared to take place by amitosis. In heavily infected copepods the entire body cavity in the cephalo-thoracic region was filled with highly branched multinucleate plasmodia (Fig. 7). There were indications to show that each plasmodium may undergo plasmotomy and result in the formation of smaller plasmodia (Fig. 3): This process of asexual multiplication may also be repeated. Ultimately inside each plasmodium the cytoplasm appeared to break up into as many as 400–500 uninucleate bodies (Fig. 4). Each uninucleate body measured $3{\cdot}0\mu \times 2 \cdot 5\mu$. In addition to these uninucleate bodies a number of slightly larger bodies with two nuclei were also seen. It seems probable that the binucleate bodies result from the cytoplasmic fusion of the two of the uninucleate bodies. If this interpretation is correct the uninucleate bodies may be considered as gametes which after fusion will give rise to the zygotes. The zygotes will subsequently transform themselves into the spores.

The uninucleate bodies aggregate into groups of 70–80 cells and acquired an enveloping membrane or cyst wall (Fig. 5). It appeared possible that a number of cysts may get differentiated within the same plasmodium. The cysts are spherical or slightly oval measuring $28 \cdot 0\mu \times 24 \cdot 0\mu$ (Fig. 5). The cyst membrane is transparent and highly resistant to most chemicals and stains. Each uninucleate body inside the cyst acquired a tough and rigid envelope and developed into a spore (Fig. 6). The spore is spherical or oval measuring $3 \cdot 0\mu \times 2 \cdot 5\mu$ with a double envelope. We could not make out



FIGS. 1–8. Fig. 1. An early plasmodium showing granular cytoplasm and vesicular nuclei. Fig. 2. An advanced stage in the development of the plasmodium. Fig. 3. Formation of three small plasmodia as a result of plasmotomy. Fig. 4. A portion of cytoplasm showing differentiation of uninucleate bodies. Fig. 5. A cyst showing a number of fully formed spores. Fig. 6. (A) An amoebula stage; (B) An enlarged view of the spore. Fig. 7. Sagittal section of a copepod showing the distribution of the plasmodia in the body cavity of the host. Fig. 8. Sagittal section of another copepod showing the distribution of the cysts of the parasite in the body cavity of the host.

an operculum or bivalve nature of the spore wall. The cytoplasm was hyaline and the nucleus was situated eccentrically. The nucleus was surrounded by a clear halo without a distinct nuclear membrane.

SYSTEMATIC POSITION

The differentiation of the various genera in the Haplosporidia is based on the nature of the habitat, host and the structure of the spore. Of these the genus *Nephridiophaga* was created by Ivanic (1937) for a parasite from the malpighian tubules of the honey-bee, *Apis mellifica*, and according to him one of the most important characters of the genus was its intracellular development. He noted a close similarity between the life-history of *Nephridiophaga apis* and *Coelosporidium periplanateae* and having accepted the observation of Debaisieux (1927) regarding the occurrence of intracelluar development in *C. periplanateae* transferred it to the genus *Nephridiophaga* created by him.

Sprague (1940) did not agree to this transfer because in his opinion " the presence of intra-cellular stages in neither of the parasites has been conclusively demonstrated ". Subsequently Ganapati and Narasimhamurti (1960) described *Nephridiophaga xenoboli* from the millipede, *Xenobolus carnifex*. Definite intra-epithelial stages in the development of *N. xenoboli* have been demonstrated by these authors.

The present parasite from the copepod undergoes its entire development in the body cavity of the host without any intracellular phase. In this respect and in the presence of a simple uninucleate spore it resembles *Coelosporidium* while it differs from *Nephridiophaga* in the absence of intracellular development. It therefore appears to us necessary to retain both *Coelosporidium* and *Nephridiophaga* as distinct genera, the former to include the parasites inhabiting the body cavity and the latter to accommodate the typically intracellular forms.

The parasite described by Chatton (1920) and Jepps (1937) from *Calanus* and other copepods was provisionally assigned to the genus *Ichthyosporidium*. The exact systematic position of the genus *Ichthyosporiduim* is still obscure. The genus appears to be almost exclusively a group of fish parasites which invade the tissues and often prove fatal to the host (Caullery and Mesnil, 1905). A similar parasite causing heavy mortality from " Taumelkrankheit " on a trout farm in France was described by Laveran and Petit (1910) as having affinities with *Rhinosporidium*. The latter is shown to be a fungus by Ashworth (1923). Plehn and Mulsow (1911) who found what appears to be the same organism in two dead rainbow trout place *Ichthyosporidium* definitely among

the fungi, in the Chytridineae, under the name *Ichthyophonus hoferi*. Kudo (1954) mentions it to be "often looked upon as microsporidia". There is no evidence to show that either the present form or those described by Chatton and Jepps from copepod hosts invade the tissues or are pathogenic. We therefore feel that the parasites from the copepod hosts rightly belong to the genus *Coelosporidium*.

Summary

1. The morphology and life-history of a new haplosporidian parasite, *Coelosporidium schmackeriae*, from the body cavity of the copepod *Schmackeria serricaudata* is described.

2. The earliest stage observed was an amoebula which developed into multinucleate plasmodia.

3. The plasmodia may undergo a process of asexual multiplication or plasmotomy and this may be repeated.

4. Spore formation took place inside the plasmodia by the fragmentation of the cytoplasm into uninucleate bodies and these bodies ultimately developed into uninucelate simple spores enclosed in a common cyst.

5. Cysts are ovoid measuring 25·0 μ in diameter and enclose 70–80 spores. The spore is ovoid measuring 3·0 $\mu \times 2 \cdot 5 \mu$ and provided with a rigid double envelope. Neither an operculum nor a bivalve nature of the spore was noticed.

6. The systematic position of the parasite is discussed.

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