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THE TEGUMENT OF *SCHISTOSOMA HIPPOPOTAMI* FROM *HIPPOPOTAMUS AMPHIBIUS* IN THE KRUGER NATIONAL PARK

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ABSTRACT

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Schistosoma hippopotami were collected from the right heart chambers and pulmonary arteries of *Hippopotamus amphibius* culled in the Kruger National Park. The schistosomes were subjected to scanning electron microscopy as well as optical microscopy. The results indicate that *S. hippopotami* is not conspecific to *S. mansoni* as suggested in the literature. On account of the morphology of certain tegumental structures of both male and female parasites, it is suggested that *S. hippopotami* is adapted to the pulmonary arterial circulation of its host.

INTRODUCTION

Two schistosome species have been described from *Hippopotamus amphibius*, namely, *Schistosoma hippopotami* (Thurston, 1963) and *S. edwardiense* (Thurston, 1964). The life cycle of *S. edwardiense* has been investigated by Pitchford & Visser (1981), who found that the adults occur in the mesenteric veins and the ova are excreted in the faeces. *Biomphalaria pfeifferi* probably acts as intermediate host, as it has been succesfully infected with *S. edwardiense* miracidia by Pitchford & Visser (1981).

The type specimens of *S. hippopotami* described by Thurston (1963) were obtained from hippopotami which were culled in the Queen Elizabeth National Park in Western Uganda. McCully, Van Niekerk & Kruger (1965) attended a culling operation of hippopotami from the Letaba River in the Kruger National Park and in 1967 they published the results of a detailed study on the pathology caused by *S. hippopotami*. They reported a 100 % prevalence of the parasite in 100 hippopotami from the Letaba River. Adult schistosomes were encountered in the heart (especially in the right heart chambers), aorta, pulmonary arteries and veins, posterior vena cava and a number of veins draining into the posterior vena cava. Because of this unusual distribution of adults and low ovogenesis in females, these authors considered the hippopotamus to be an aberrant host for *S. hippopotami*. Thurston (1971) examined a further 31 hippopotami from Uganda and agreed that the hippopotamus appears to be an abnormal host.

Pitchford & Visser (1981) also believed the hippopotamus to be an aberrant host for *S. hippopotami* and suggested that this schistosome is to be regarded as synonymous with *S. mansoni*. Fripp (1981) conducted an electrophoretic study and found that the alpha naphthyl acetate esterases of *S. hippopotami* differed from those of *S. mansoni* and *S. rodhaini*. However, during a subsequent study, he obtained unspecified isoenzyme patterns which closely resemble those of *S. mansoni* (appendix to Pitchford & Visser, 1981).

We report here on the results of scanning electron microscopy (SEM) and optical microscopy (OM) performed on *S. hippopotami* collected from hippopotami culled in the Kruger National Park during August 1987. The aim of the study was to obtain more clarity on the taxonomic status of the above species.

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MATERIAL AND METHODS

Adult *S. hippopotami* were collected from the right heart chambers and pulmonary arteries of 4 hippopotami from the Sabie River and 2 from the Crocodile River. The schistosomes were removed from the endothelium with the aid of a fine forceps and transferred to normal saline. Upon arrival at a field laboratory they were fixed in Karnovsky fixative (Bullock, 1984) in which they were left for at least 24 h. They were then dehydrated through a graded series of ethanol. Optical microscopy of the specimens was performed in absolute ethanol prior to preparation for SEM.

For SEM the ethanol was substituted with freon and the schistosomes were critical point-dried. Thereafter they were carbon and gold sputter coated to a thickness of approximately 5 μm and studied by means of a Cambridge Stereoscan 250.

RESULTS

Optical and scanning electron micrographs of paired *S. hippopotami* are shown in Fig. 1 & 2. Of particular interest is the large oral and ventral suckers of the male. In the female these structures were minute when compared to those of the male. The male is also longer than the female.

The oral sucker is illustrated in Fig. 3 and the ventral sucker or acetabulum in Fig. 4. They are spotted with fibrin fibrils and leukocytes. From the outside to the inside the acetabulum exhibited a spined rim, a less spined region, a densely spined region and a less spined centre with sensory receptors. Fig. 5 is a close-up view of the densely spined region revealing radial folds in the tegument.

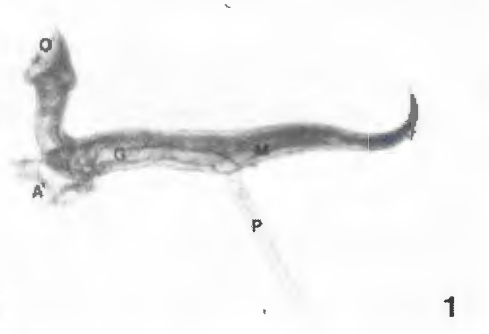

FIG. 1 Optical micrograph of paired *Schistosoma hippopotami* (A = ventral sucker or acetabulum of male: G= anterior half of female within the gynaecophoric canal of the male: M= male: O= oral sucker of male: P= posterior half of female protruding from the gynaecophoric canal)

FIG. 2 Scanning electron micrograph of paired *S. hippopotami* (legend as for Fig. 1)

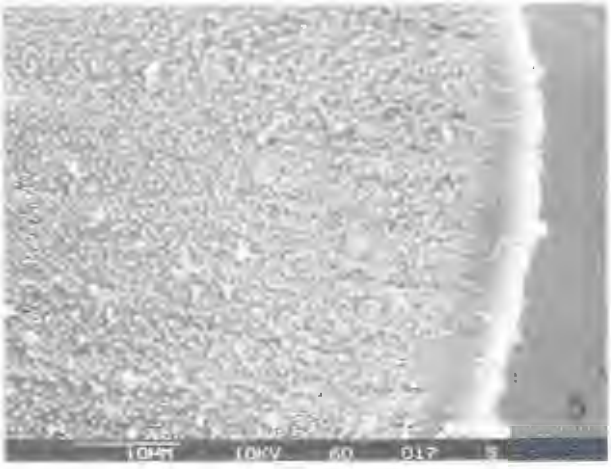

FIG. 5 Densely spined region of acetabulum revealing radial folds

FIG. 3 Male oral sucker spotted with fibrin fibrils and leukocytes

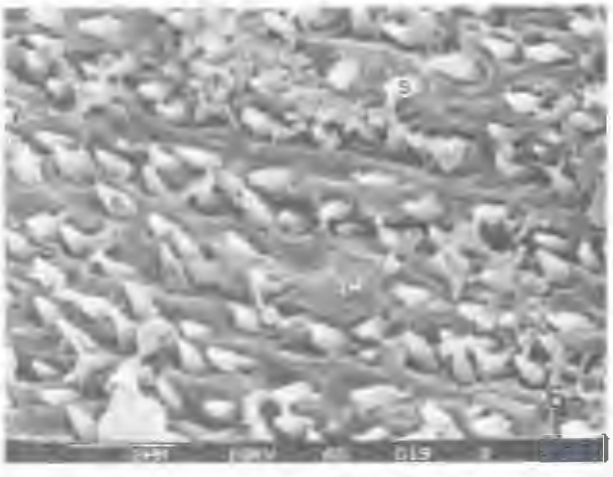

FIG. 6 Interior of gynaecophoric canal (C= ciliated sensory receptor: F= fibrin fibrils: S= spines)

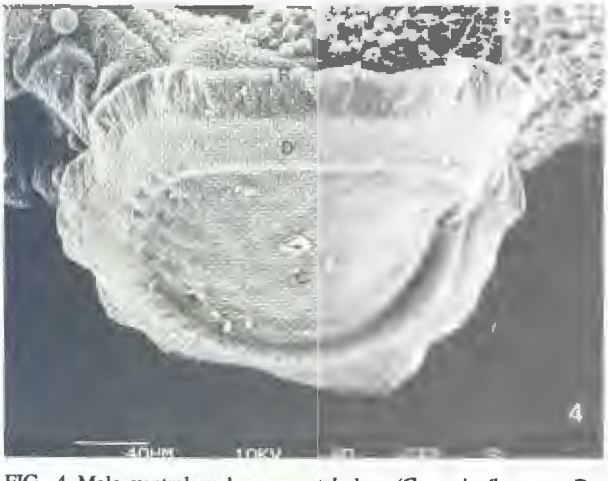

FIG. 4 Male ventral sucker or acetabulum (C= spined centre: D= densely spined region: L= less spined region: R= spined rim

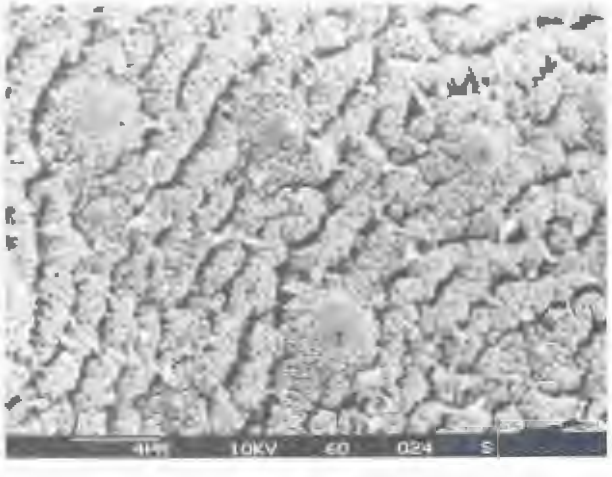

FIG. 7 Pitted dorsal tegument of the male (C= ciliated sensory receptors: T= tubercles)

The interior of the gynaecophoric canal with dense spines interspersed with ciliated sensory receptors is shown in Fig. 6. Host fibrin fibrils, clotted to the spines, are also visible.

The slightly tuberculated, spineless, pitted dorsal tegument of the male with ciliated sensory receptors is revealed in Fig. 7. The intricately folded tegument of the female is shown in Fig. 8.

Ciliated sensory receptors, which were observed on males as well as females and which are common to all schistosome species are depicted in Fig. 9.

DISCUSSION

Hockley & McLaren (1977) recognized 3 basic types of male dorsal tegument, namely, tuberculate with spines, tuberculate without spines, and non-tuberculate.

FIG. 8 Intricately folded tegument of the female

FIG. 9 Ciliated sensory receptors

S. hippopotami falls in the 2nd class. However, the tubercles are considerably smaller than those of all other African mammalian schistosomes described in the literature.

A literature study of the teguments of all the *Schistosoma* species on which SEM was conducted revealed that, although minor ultrastructural differences exist between the females of the different species, their topography at low magnification seems to be similar, i.e. it consists of a series of successive annular folds. The intricately folded tegument of female *S. hippopotami* would seem to be unique and specific to this species.

Thurston (1971) considered the large size of the male acetabulum of *S. hippopotami* to be a morphological feature by which this species may be distinguished from *S. edwardiense*. The micrographs presented here clearly illustrate the enormous size of this structure. This feature is characteristic of *S. hippopotami* only, as no other schistosome species has a similar sized male acetabulum or, for that matter, oral sucker. However, the spined ventral surface of the acetabulum, which is in contact with the endothelium of the host, is similar to those of other species of the genus *Schistosoma*. The acetabulum of the female seems to be normal in size but the oral sucker is larger in comparison with that of the females of other species.

The larger sizes of the male oral sucker and acetabulum are probably adaptations to the pulmonary arterial circulation of the host. The sites from which the schistosomes were recovered, namely the right atrium, right ventricle and pulmonary arteries are subjected to fluctuating arterial blood pressures and velocities and probably also to turbulence. Other schistosome species infect the mesenteric and vesicular veins of their hosts and therefore do not have to cope with these factors, hence the smaller suckers. If *S. hippopotami* is synonymous with *S. mansoni*, as suggested by Pitchford & Visser (1981), the considerably larger suckers of the parasite have to be attributed to phenotypic plasticity.

The relatively small suckers of the female suggest that they cannot maintain themselves as individuals in the same arterial environment as the males, and thus have to be paired. The intricately folded tegument of the female is probably an adaptation which ensures improved clasping by the male. The spines of the male gynaecophoric canal will closely interlock with these folds. An additional adaptation of the female to the arterial environment seems to be that she is shorter than the male and in this respect differs from the schistosomes which occur in the veins of their host. In fact, the male is also shorter and more stream-lined that those of the other *Schistosoma spp.*

In view of the above observations we accept *S. hippopotami* as a valid species and suggest that it is adapted to pulmonary arterial blood flow. Whether or not the hippopotamus is the parasite's primary host is still unknown. We are currently investigating the possibility that *S. hippopotami* discharges eggs via the airways of the hippopotamus.

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