Journal of Fish Diseases 1980, **3**, 11–19.

Renal sphaerosporosis in the common carp *Cyprinus carpio* L.

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Abstract. *Sphaerospora angulata* Fujita, 1912, has been identified as a frequent renal parasite of cultured carp populations in Hungary. Its prevalence ranged from 10 to 50% in the pond farms surveyed. The youngest carp infected were 2½–3 months old. Infections were not common in one-summer fish and tended to become less frequent with increasing age of the host.

The developing stages of *S. angulata* are found in the contorted tubules of the trunk-kidney but never invade the parenchymal tissue of the trunk or head-kidneys. The pansporoblasts developing in the wide proximal segment of the renal tubules, and the spores arising from the pansporoblasts are typically coelozoic parasites, for they apparently do not damage the tubular lining epithelium, nor its brush border. The main adverse effect of *S. angulata* is probably depression of resistance owing partly to deprivation of the host of nutrients secreted by the glomeruli and partly to mechanical obstruction of the distal tubular segments.

Introduction

Impression smears from the kidneys of cultured carp *Cyprinus carpio* L. often revealed the presence in the tubular lumen of a mass of amorphous plasmodia containing luminescent granules. The parasites were initially regarded as the developmental stages of an unknown protozoan, but on closer examination, mature spores, identified as *Sphaerospora angulata* Fujita, 1912, were occasionally found together with the developmental stages.

Most *Sphaerospora* spp. parasitize the renal tubules of fish. Shulman (1966) identified 15 such species in the USSR. Some species are, however, known to establish themselves in the gill and intestinal epithelium, gallbladder or in lymphoid tissues of the head kidney.

Of the many known *Sphaerospora* spp. only the histozoic species *S. carassii*, *S. tincae* and *S. reichenowi* have hitherto been regarded as pathogenic (Kashkovskij, Razmashkin & Skriptsenko 1974; Hámory & Molnár 1972; Molnár 1979; Plehn 1932; Leger 1930; Jacob 1953). Information has been scarce on the pathogenicity of coelozoic parasites, of which little is known apart from their prevalence.

Of the *Sphaerospora* spp. parasitic in carp, only *S. carassii* has been shown to infect indigenous European hosts (Hámory & Molnár 1972; Lom, Golemansky &

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0140-7775/80/0100-0011 $02.00

Grupcheva 1976; Molnár 1979), while *S. cyprini* and *S. angulata* were originally found only in far eastern habitats (Fujita 1912; Shulman 1966). Recently Razmashkin & Skriptsenko (1976) reported the occurrence of *S. cyprini* in western Siberia, and Osmanov (1971) that of *S. angulata* in Central Asia.

The prevalence and pathogenicity of *S. angulata* in indigenous Hungarian carp populations are described in this paper.

Materials and methods

Carp populations from nine Hungarian pond farms were regularly screened for renal sphaerosporosis from 1976 to 1978. For the most part one- and two-summer carp were examined, but occasionally older carp and other fish species from the canal system of the farms, were also included in the study. During 1977–78 fry and one-summer hosts, 20 of each from May to November 1977, and 10 of each from November 1977 to May 1978, were taken at bi-weekly intervals for parasitological examination from the two most heavily infected farms, in which fry rearing was also carried out. Older carp and other fish species were occasionally examined along with the regular sample.

Impression smears of the visceral organs, especially the kidneys, were examined microscopically and two infected kidneys from each sample were examined histologically.

Pieces of head-kidney and oral, median and caudal portions of the trunk kidney were fixed in 10% formalin or Bouin's solution, embedded in paraffin wax and stained with haematoxylin and eosin (H & E), Farkas-Mallory or Gömöri's trichrome technique.

Results

Sphaerospora angulata spores and developmental stages were detected in the kidney of several hosts in each farm under survey, but the percentage occurrence of the parasite differed between farms, ranging from 10–15 to more than 50%.

The kidneys of hosts with sphaerosporosis showed no gross changes compared to non-infected controls.

Microscopic examination of impression smears revealed the presence of *S. angulata* stages in all tubular regions of the kidney. Thus parasites were equally present in the oral, median and caudal portions of the trunk-kidney, but none was found in the lymphoid tissue of the head kidney, glandular adrenal tissue and Stannius' organ. Spores and developmental stages were equally localized in the tubular lumina, without invading the tubular epithelium and renal parenchyma.

The parasite mass, to which the nuclei of the pansporoblasts and early spores gave a granular appearance, was easily visible in the tubular lumen. The pansporoblasts were round or ellipsoid bodies 12–15 μm in width, with 8–14 conspicuous nuclei.

Figure 1. Tubular lumen packed with sphaerospores (H & E, ×200).

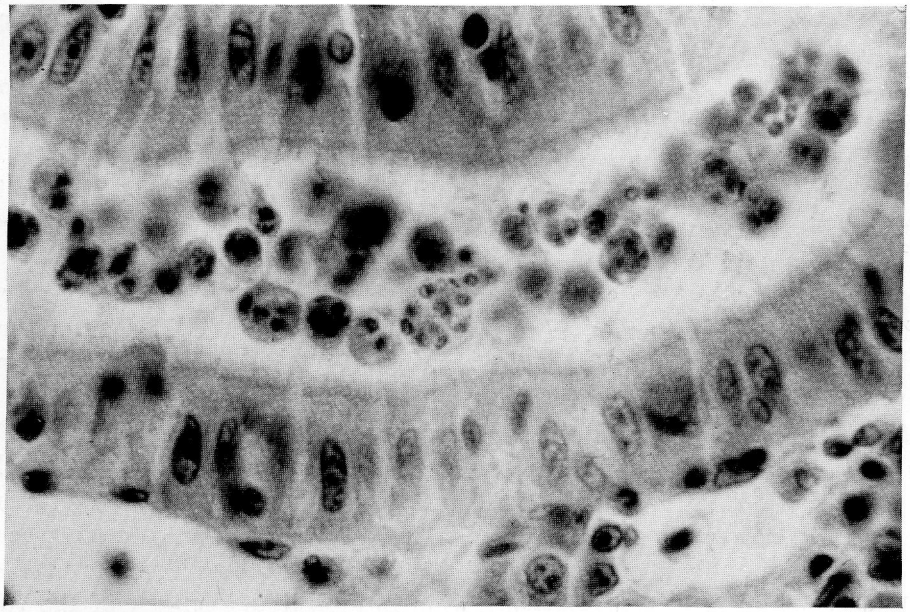

Figure 2. Proximal segment of renal tubule with *Sphaerospora* pansporoblasts (H & E, ×700).

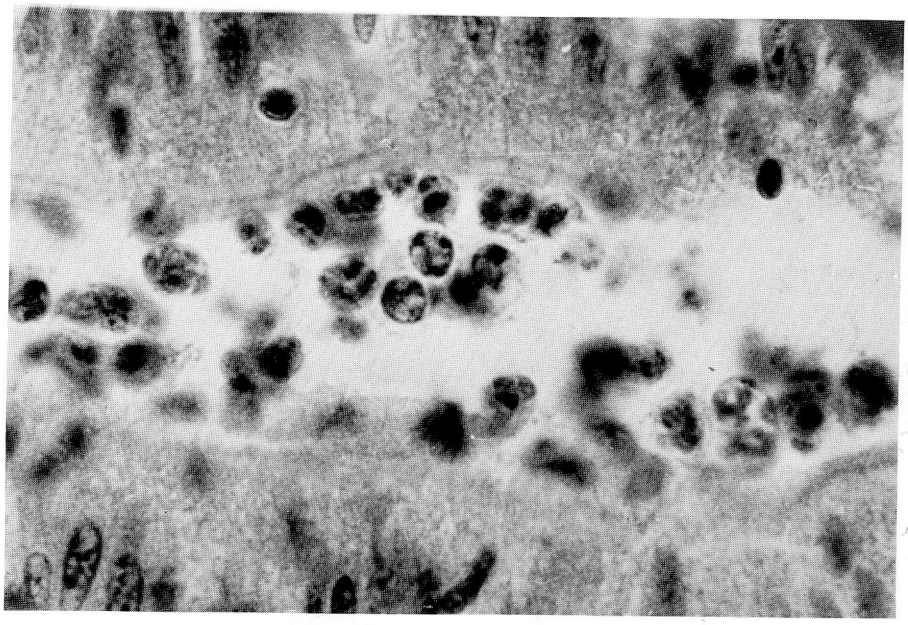

Figure 3. *Sphaerospora* spores arising in pairs within the pansporoblasts located in the tubular lumen (H & E, ×700).

The characteristic angular shape of the spores is an important differentiating feature from other *Sphaerospora* spp. of the common carp.

In the fry renal sphaerosporosis was first demonstrable at $2\frac{1}{2}$–3 months of age i.e. in August, while in the older age groups infected hosts were encountered all the year round. Nevertheless, only a few individuals from more than two-summer old populations contained spores.

Confirming the findings from unstained impression smears, histological examination also showed that the parasites localize exclusively in the tubular lumen, without invading the lining epithelium or parenchyma. Occasionally 80% of the tubules were filled by *S. angulata* stages (Fig. 1). In mild infections the parasites established themselves chiefly in the proximal segment of the tubules, whilst in massive infections they also appeared in the intermediate and distal segments.

The earliest stages of *S. angulata* were found mainly in the proximal segment of the tubule, where the lumen is wide, and the brush border of the lining epithelium dense. The development of pansporoblasts with their 14 nuclei (Fig. 2) and appearance within these of pairs of spores (Fig. 3) could be easily followed in these locations. The life cycle of *S. angulata* does not seem to be synchronized, for fully developed spores not infrequently appeared among granular early stages. Despite the large numbers of sections examined, we failed to detect pre-sporoblastic stages inside tubules. The mature spores moved gradually to the deeper tubular segments, leaving only reticular residual pansporoblasts (Fig. 4). Debris of the residual parasite tissue tended to accumulate in the relatively wide intermediate segment of the tubule, lined by cuboidal epithelium, and some mature spores not infrequently got caught in

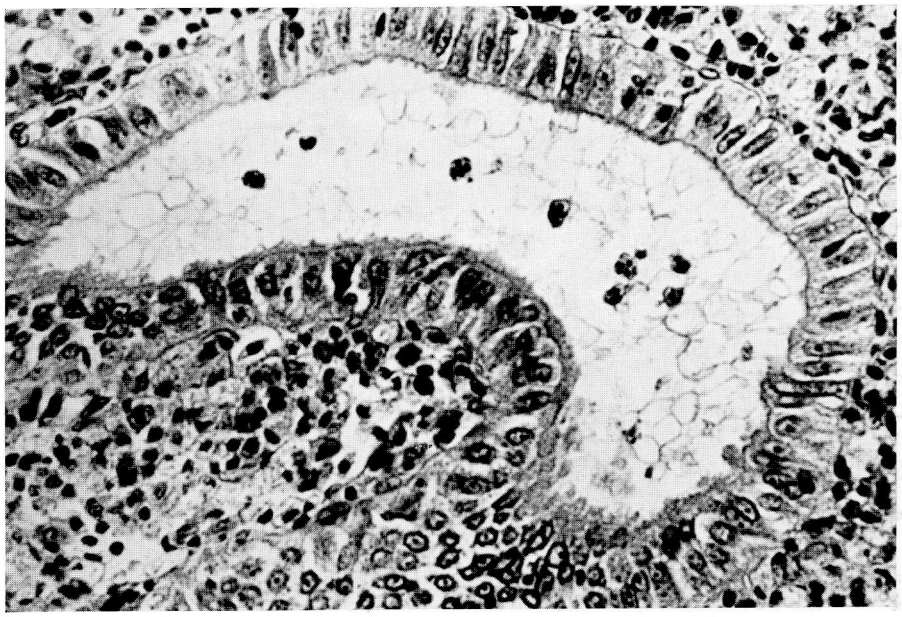

Figure 4. Residues of reticular pansporoblastic tissue in the proximal segment of a renal tubule after release of the spores (H & E, ×200).

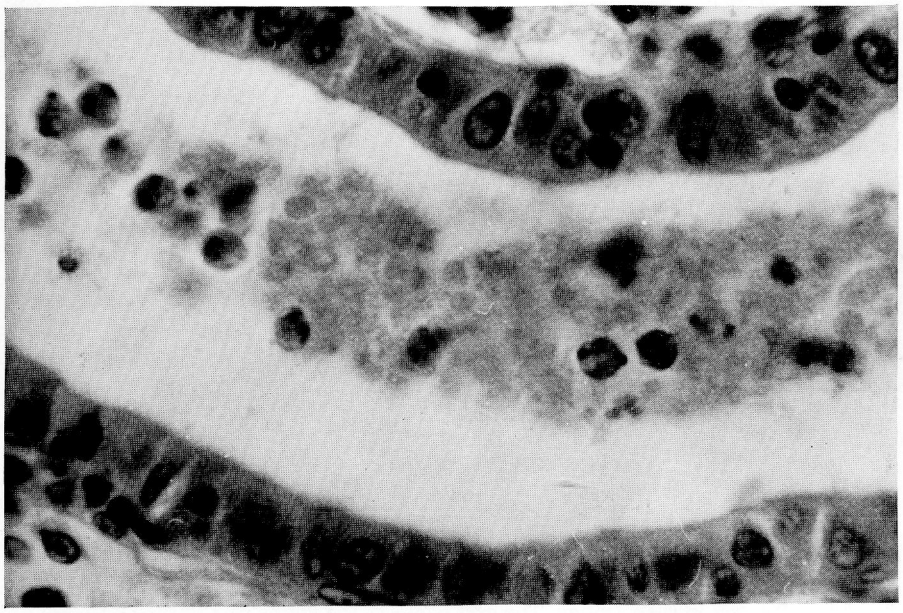

Figure 5. Accumulation of tissue and parasite residues together with a few intact spores in the intermediate tubular segment (H & E, ×700).

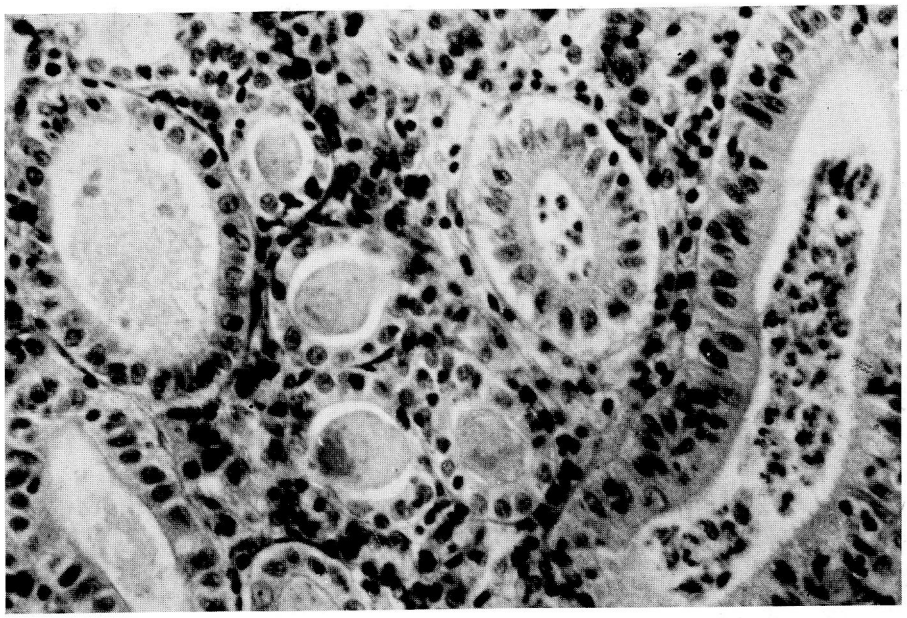

Figure 6. Segments of renal tubule. Right: proximal segment, lined by columnar epithelium and packed with sphaerospores. Left: intermediate segment, lined by cuboidal cells, with a mass of tissue debris in its wide lumen. Centre: narrow distal segment filled out by condensed tissue debris (H & E, ×200).

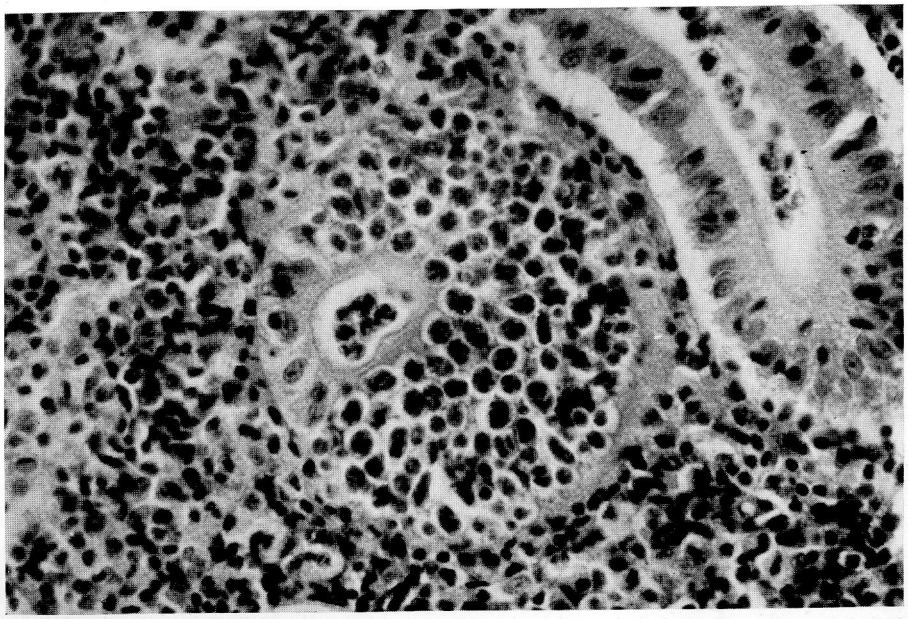

Figure 7. *Myxobolus* cyst in carp kidney. The cyst encloses the major part of the epithelial lining of a tubule which harbours *Sphaerospora* stages in its lumen. Note the conspicuous difference between *Myxobolus* and *Sphaerospora* spore sizes (H & E, ×200).

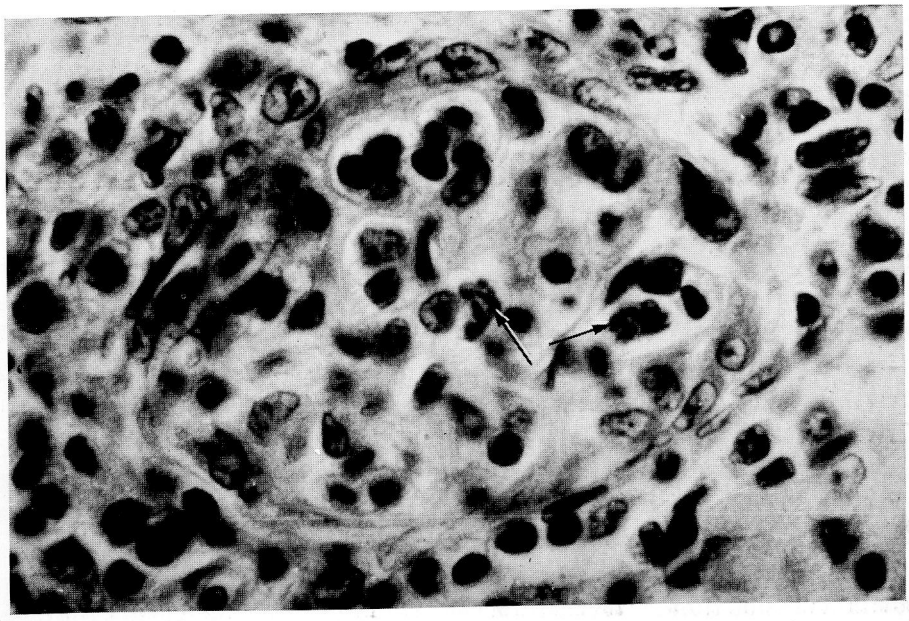

Figure 8. The extracellular sporozoan described by Csaba (1976) localized in glomerular capillary vessels (H & E, ×700).

the residual mass (Fig. 5). Condensation of the latter caused obstruction of the narrow distal tubular segment; this probably explains the development of hyaline cylinders in these locations (Fig. 6). At the light microscope level no close relationship could be detected between the tubular epithelium and the parasite mass filling the lumen. However massive the infection, the tubular lining epithelium and its brush border remained intact, except that it was reduced in height owing to the dilatation of the parasite-packed lumen.

While *S. angulata* was exclusively limited to the tubule lumen, macrophage-surrounded spores of *Myxobolus cyprini* were often found in the parenchyma of the trunk-kidney and in the lymphoid tissue of the head kidney. The pin-head-sized cysts encountered in the trunk-kidney of some hosts probably represented developmental stages of the latter species. The cysts were also found in the tubular region as well as the parenchymal tissue. Inside such cysts some tubules contained *S. angulata*, while externally they were surrounded by stages of *M. cyprini*. Although the pansporoblasts of *M. cyprini* also damaged tubular epithelium cells, they did not interfere with the development of the intraluminally localized stages of *S. angulata* (Fig. 7).

Most of the fry also harboured in their blood an extracellular sporozoan of unknown systematic position, which was recently described by Csaba (1976); this parasite was easily detected in blood smears and histologically also inside glomerular capillaries (Fig. 8). Its histological appearance was reminiscent of the developmental stages of *Sphaerospora* spp.

It should be noted that although a very large amount of material was studied, we

found no indication of the species *Hoferellus cyprini*, described by Plehn (1924) as a frequent parasite of the renal tubules in the common carp.

Among the other fish hosts examined, *Rutilus rutilus* (L.), *Scardinius erythrophthalmus* (L.), *Alburnus alburnus* (L.) and *Hypophthalmichthys molitrix* Valenciennes harboured *Sphaerospora* spp. in the kidney, but these were not identified to species.

Discussion

The present findings indicate that renal sphaerosporosis is a fairly frequent fish parasitosis in Hungary, affecting carp of 3 months old and above. The parasites, which fill the lumen of renal tubules, presumably lead an exclusively coelozoic life, and do not directly affect the tubular epithelium. Of the developmental stages of *S. angulata* only the stages of sporogony could be found in the tubules; in this respect *S. angulata* behaves similarly to *Hoferellus cyprini*, a carp parasite occurring in Germany and the USSR, with the difference that, although all intraluminally localizing stages of the latter species are spores or pansporoblasts, its amoeboid pre-sporoblastic stages are detectable inside tubular epithelium cells (Plehn 1924), which is not the case with *S. angulata*.

Some *Sphaerospora* spp. lead a histozoic existence; of these, *S. carassii* is parasitic in the gills, *S. reichenowi* in the intestinal epithelium and *S. tincae* in the lymphoid tissues of the head-kidney. This has prompted us to investigate in great detail the head-kidney as a probable localization of pre-sporoblastic stages of *S. angulata*, but we never found any in carp. This suggests that the early stages of *S. angulata* probably develop in non-renal localizations. Clarification of the precise role of the protozoon found by Csaba (1976) in the Bowman's capsule could probably throw more light on this problem.

The pathogenicity of *S. angulata* cannot be precisely assessed. It obviously does not inflict direct damage to the renal epithelium but it probably utilizes a considerable part of the excreted, but not yet reabsorbed, nutrients available in the absorptive tubular segment. In addition, mechanical damage by the parasite cannot be ruled out, for the residual mass resulting from spore development obstructs the distal, more narrow segment of the renal tubules, thereby promoting the formation of the so-called hyaline cylinders, the presence of which causes nephrosis.

The observation that sphaerosporosis occurs mostly in fry populations in poor condition and is not infrequently associated with inflammation of the airbladder suggests that sphaerosporosis might affect fish health by lowering resistance, thus increasing their susceptibility to other diseases.

We have shown a high prevalence of sphaerosporosis amongst indigenous carp in Hungary and it seems remarkable that there are no reports of its occurrence in other European countries. This can be explained either by the introduction of *S. angulata* to Hungary by fish imported from the Far East or by a frequent misdiagnosis of sphaerosporosis as hoferellosis in other countries.

The fact that developing *Sphaerospora* stages were easily detected in the kidney

of species other than carp suggests that sphaerosporosis in fishes caused by different *Sphaerospora* spp. is more frequent than is indicated by the literature. The parasites described by Bendele & Klontz (1975) as coelozoic Myxosporidia were in all probability sphaerospores, judging by their great histological similarity to the latter.

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