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Myxosporidia are highly successful sporozoan parasites of fishes. Although a few species have been described from other cold-blooded vertebrates, fishes are the characteristic hosts and harbor over 90% of the known species. In all localities in which a survey has been undertaken the Myxosporidia have proved to be common. This is equally true of fresh water and marine habitats. Although each species inhabits a particular host organ, the group as a whole have been recovered from the lumina or the tissues of nearly every organ in the body cavity, as well as the muscular, skeletal and nervous tissues and the gills, fins and integument. They may be divided into two categories, the histozoic species which dwell in the tissues of the host, and the coelozoic species, which live in the lumina of various hollow organs. They are never intracellular, and have not been found in the lumen of the alimentary tract.

This report is a comparison of two studies which were undertaken some time ago. One, dealing with Myxosporidia from Illinois fishes, was reported in the Journal of Parasitology in 1937. This paper records the observations which resulted from the microscopic examination of the tissues of 200 fishes belonging to 36 species, in all. The other study was made at the U. S. Bureau of Fisheries station at Beaufort, N. C. just before the war. Unavoidable circumstances forced a postponement of the completion of the study, and after the war it was discovered that many of the specimens had deteriorated. Some of the species which were obtained have been described, but no overall report of the findings has been made. In all a total of 348 fishes were examined, representing 46 different species.

Exactly the same methods were employed in both studies. The same organs were prepared for microscopic examination in the same sequence, and in all respects the results should be comparable. It may be assumed that about the same proportion of light infections were caught and missed in both cases.

The results of the Beaufort study are given in the table below. The results of the Illinois investigation are incorporated in a similar chart (Journal of Parasitology, 23:467).

The recapitulation of the two surveys are given in Table 2. It is evident at once that the marine fishes exhibited a somewhat higher incidence of infection, and, moreover, contained a more varied

Table 1

Recapitulation of Infections with Myxosporidia in Fishes from Beaufort, N. C.

Fishes Examined	No. Inf.	Organ Inf.	Myxosporidian
Achirus fasciatus	1	0	
Anchoviella epsetus	6	0	
Ancylopsetta quadrocellatus	1	1 Gall Bladder	Ceratomyxa undulata
		1 Urinary Bladder	Sphaeromyxa sp.
		1 Urinary Bladder	Sinuolinea sp.
Archosargus probatocephalus	2	1 Kidney	Henneguya sp.
		1 Kidney	Leptotheca sp.
Bairdiella chrysura	25	3 Urinary Bladder	Chloromyxum granulosum
		5 Urinary Bladder	Myxoproteus cornutus
		1 Urinary Bladder	Sphaerospora sp.
		3 Kidney	Myxosoma sp.
		4 Gall Bladder	Ceratomyxa sp.
Balistes carolinensis	2	1 Gall Bladder	Immature
Brevoortia tyrannus	19	2 Muscles	Kudoa clupeidae
Caranx latus	2	0	
Carcharius littoralis	1	0	
Chaetodipterus faber	6	3 Urinary Bladder	Myxoproteus cordiformis
		1 Gall Bladder	Ceratomyxa streptospora
		1 Gall Bladder	Myxidium sp.
Cynoscion nebulosus	3	2 Gall Bladder	Myxidium glutinosum
		1 Urinary Bladder	Myxoproteus sp.
Cynoscion regalis	18	5 Gall Bladder	Myxidium glutinosum
		2 Gall Bladder	Chloromyxum sp.
		6 Urinary Bladder	Sinuolinea dimorpha
		5 Kidney	Leptotheca sp.
Dasyatus centrura	3	1 Gall Bladder	Myxidium sp.
		1 Gall Bladder	Immature
Diplodus holbrooki	6	0	
Etropus crossotus	3	0	
Felichthyes felis	10	0	
Fundulus majalis	12	1 Gall Bladder	Myxosoma sp.
		8 Gall Bladder	Myxidium incurvatum
		2 Kidney	Chloromyxum renalis
		1 Urinary Bladder	Chloromyxum renalis
		2 Urinary Bladder	Myxosoma sp.
		1 Kidney	Myxosoma sp.
		4 Gills	Myxosoma sp.
Fundulus sp. (majalis x ocellaria?)	1	1 Mesenteries	Myxosoma subtecalis
Galeichthyes milberti	5	2 Gall Bladder	Thelohanellus sp.
Lagocephalus laevigatus	1	0	
Lagodon rhomboides	5	4 Kidney	Leptotheca sp.
		1 Gall Bladder	Ceratomyxa sp.
Larimus fasciatus	3	2 Urinary Bladder	Sinuolinea sp.
Leiostomus xanthurus	10	1 Gall Bladder	Ceratomyxa aggregata

Table 1 (Continued)

Fishes Examined	No. Inf.	Organ Inf.	Myxosporidian
Menidia beryllina	40	0	.....
Menticirrhus americanus	3	0	.....
Menticirrhus saxatilis	1	1 Urinary Bladder	Leptotheca sp.
Micropogon undulatus	9	2 Gall Bladder	Ceratomyxa aggregata
Mugil cephala	1	1 Gall Bladder	Immature
		1 Kidney	Myxosoma sp.
Mugil curema	7	2 Gall Bladder	Myxidium incurvatum
		1 Urinary Bladder	Myxosoma sp.
		2 Kidney	Myxosoma sp.
Opisthonema oglinum	4	0	.....
Opsanus tau	6	3 Urinary Bladder	Sphaerospora polymorpha
		1 Urinary Bladder	Leptotheca sp.
Orthopristus chrysopterus	7	1 Kidney	Leptotheca sp.
		1 Kidney	Henneguya sp.
		1 Urinary Bladder	Leptotheca sp.
Paralichthyes dentatus	30	2 Gall Bladder	Ceratomyxa drepanopsettae
		1 Urinary Bladder	Leptotheca glomerulosa
		3 Urinary Bladder	Leptotheca lobosa
		4 Urinary Bladder	Leptotheca sp.
		1 Urinary Bladder	Sinuolinea brachiophora
		1 Urinary Bladder	Sinuolinea capsularis
		4 Urinary Bladder	Sinuolinea sp.
		5 Urinary Bladder	Ceratomyxa navicularia
Peprilus alepidotus	18	4 Gall Bladder	Ceratomyxa monospora
Pomotomus saltatrix	8	2 Kidney	Leptotheca sp.
Porontus triacanthus	4	0	.....
Prionotus evolans	14	5 Gall Bladder	Myxidium sp.
		2 Urinary Bladder	Sinuolinea sp.
		2 Gall Bladder	Sphaerospora sp.
Pteroplatea micrura	4	1 Gall Bladder	Immature
Scomberomorus maculatus	4	1 Gall Bladder	Immature
Selene vomer	8	0	.....
Sphaeroides maculatus	4	3 Urinary Bladder	Ceratomyxa navicularia
		3 Gall Bladder	Ceratomyxa sp.
		1 Urinary Bladder	Zschokkella sp.
Sphyrna tiburo	1	1 Gall Bladder	Ceratomyxa mesospora?
		1 Gall Bladder	Leptotheca fusiformis?
Synodus foetans	8	4 Gall Bladder	Ceratomyxa amorpha
		1 Urinary Bladder	Leptotheca sp.
		1 Urinary Bladder	Zschokkella sp.
Tautoga onitis	7	2 Gall Bladder	Sphaeromyxa sp.
		2 Kidney	Henneguya sp.
Trachinotus carolinus	3	1 Gall Bladder	Henneguya sp.
		1 Urinary Bladder	Henneguya sp.
		1 Kidney	Henneguya sp.
		2 Gall Bladder	Myxidium sp.
		1 Urinary Bladder	Myxosoma sp.
Trichiurus lepturus	10	0	.....

Table 2

Comparison of Infection Rates in Marine and Fresh Water Fishes

Habitat	Fishes Examined		Infections		Number Myxosporidian species	Ratio of fish species to parasitic species
	No.	Species	No.	%		
Fresh Water	200	36	61	33.8	18	2.0
Marine	348	46	164	47.1	59	0.7

Table 3

Comparison of Histozoic and Coelozoic Infections in Marine and Fresh Water Fishes

Habitat	Fishes Examined		Number Coelozoic Inf.	Number Coelozoic Species	Number Histozoic Inf.	Number Histozoic Species
	No.	Species				
Fresh Water	200	36	50	10	9	6
Marine	348	46	127	45	6	3

Table 4

Infection Rates of Urinary and Biliary Myxosporidia in marine and Fresh Water Fishes

Habitat	Fishes Exam.	Infections in						Number of Myxosporidian species		
		Gall Blad.		Urin. Blad.		Kidney				
		No.	%	No.	%	No.	%	Gall Blad.	Urin. Blad.	Kidney
Fresh Water	200	51	25.5	0	0.0	1	0.5	10	0	1
Marine	348	67	19.2	60	17.2	27	7.8	24	21	11

myxosporidian fauna. The ratio of fish species examined to parasite species found is markedly different, despite the fact that on the average about the same number of examples were studied (Av. number of each species studied about 7 at Beaufort and 6 in Illinois).

In the following comparison of the incidence of histozoic and coelozoic species, kidney infections have not been included. Some species of Myxosporidia inhabit the lumina of the kidney tubules and must be considered as coelozoic, while others live as true tissue parasites in the kidney. For some of the parasites observed at Beaufort there was not sufficient evidence to determine which of the cases obtained. At least some of the Beaufort Myxosporidia were coelozoic. In the single case of a kidney infection in fresh water fishes the parasite was histozoic. It is probable that the addition of the kidney parasites to the chart would not materially change the proportions found.

Marine fishes are found to exhibit a higher proportion of the coelozoic species. There is some evidence that, on the whole, a smaller number of histozoic species are found. It is tempting to correlate this with the fact that the genera which are exclusively marine include those which are usually thought to be most primitive. It is further suspected that the first Myxosporidia were coelozoic. The preponderance of more primitive coelozoic genera would tend to give results similar to those actually obtained.

An examination of Table 4, however, reveals that there is no dearth of coelozoic biliary parasites among fresh water fishes. If anything, the biliary species tend to occur more commonly. However, no coelozoic parasites of the urinary bladder were encountered from the Illinois fishes, although they were relatively common at Beaufort. The same trend is seen among parasites of the kidney. It would appear that urinary parasites are not common among fresh water fishes, while they are quite common among marine fishes. It should be noted here that fresh water organisms have been known to harbor Myxosporidia in both kidney and urinary bladder. One of the commonest of the Myxosporidia is *Leptotheca ohlmacheri* which occurs in the kidney of *Rana* spp., for example. The fact remains that in the localities which the author has worked, urinary parasites are not particularly common in freshwater fishes, and their absence in the urinary bladder tends to produce the discrepancy between coelozoic and histozoic species. It may be supposed that the differences in the osmotic relationships between marine and fresh water fishes are possibly concerned in some way.

Table 5

Comparison of the Occurrence of Some Genera in Marine and Fresh Water Fishes

Genus	Gall Bladder		Urinary Bladder		Kidney		Other Histozoic	
	Fresh Water	Marine	Fresh Water	Marine	Fresh Water	Marine	Fresh Water	Marine
Ceratomyxa	0	10	0	1	0	1	0	0
Chloromyxum	4	1	0	2	0	1	0	0
Henneguya	1	1	0	0	0	0	3	0
Kudoa	0	0	0	0	0	0	0	1
Leptotheca	0	2	0	6	0	4	0	0
Myxidium	5	6	0	0	1	0	0	0
Myxobolus	0	0	0	0	0	0	2	0
Myxosoma	0	1	0	3	0	3	1	2
Myxoproteus	0	0	0	3	0	0	0	0
Sphaeromyxa	0	0	0	1	0	0	0	0
Sphaerospora	0	2	0	3	0	0	0	0
Thelohanellus	0	1	0	0	0	0	0	0
Zschokkella	0	0	0	2	0	0	0	0

It is also interesting to compare the occurrence of the various genera in the fresh water and marine fishes. Ceratomyxa and Leptotheca are typically parasites of marine or brackish water fishes. Other genera occur about as commonly in marine as in fresh water hosts. Myxidium, for example, is quite common in both habitats, as is Chloromyxum. In the family Myxobolidae, Myxosoma is fairly common in marine fishes, while Myxobolus was found only in the fresh water hosts. Unfortunately there was an insufficient amount of data to permit a careful comparison of the histozoic forms. Nevertheless, belonging to the same Family Myxobolidae, Henneguya is found more or less indiscriminately among the marine and fresh water forms, and it is evident that relationship, as reflected by spore morphology, does not correlate very well with differences in the habitat of the host, except in the case of the Ceratomyxidae which are almost exclusively marine, and were so found in these studies.

There can be little doubt that the myxosporidia, although insulated from the physical factors of their hosts' environment except at the

time of transmission from host to host, are not immune from that environment. The physical character of the environment, directly or indirectly, plays a large part in determining the distribution of species and, in some cases, genera, and is also, in at least one case—that of the urinary system—correlated with a significant difference in choice of host organs.

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