SUPPLEMENT

TO THE

47th ANNUAL REPORT OF THE DEPARTMENT OF MARINE AND FISHERIES, FISHERIES BRANCH

CONTRIBUTIONS

TO

CANADIAN BIOLOGY

BEING STUDIES FROM THE

BIOLOGICAL STATIONS OF CANADA

1911-1914

FASCICULUS I.—MARINE BIOLOGY

OTTAWA
PRINTED BY J. DE L. TACHE, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1915

[No. 39b—1915]

III.

STUDIES ON THE SPOROZOA OF THE FISHES OF THE ST. ANDREW'S REGION.

By J. W. Mavor, B.A., Ph.D., etc.

Instructor in Zoology, University of Wisconsin, Madison, U.S.A.

(Curator of the Biological Station of the Canadian Government on the Georgian Bay, Canada.)

(Plate IV.)

INTRODUCTION.

The only papers published on the Myxosporidia of American fishes are two by Gurley ('93 and '94) and a short one by Tyzzer ('00). During the twenty years since Gurley's papers our knowledge of the Sporozoa has greatly increased. Only comparatively recently however has special attention been directed to the Myxosporidia. The researches of Doflein, Mercier, Schroeder, Awerinzew, and others have shown this group to be one of great interest, and to-day there is perhaps no group of the protozoa which offers so many interesting features and about the life-cycle of which there is so much doubt.

The writer was of opinion that a study of the Myxosporidia living in the gall bladders of fishes from the Eastern coast of America would lead to interesting results, not only with regard to the distribution of these parasites, but also, it was hoped, with regard to some of the disputed points of their life-history. The present paper deals with the first of these subjects. Another paper to be published later deals with the life-history of one of the parasites found, Ceratomyxa acadiensis n. sp.

While searching for myxosporidian parasites two other parasites were found, a Coccidian and a Haemosporidian, which seem of sufficient interest to be included in this list.

MATERIAL AND METHODS.

The material for the present investigation was collected in Passamaquoddy Bay at or near the mouth of the St. Croix river while the author was at the Marine Biological Station at St. Andrews, New Brunswick, Canada. The fish were brought

(1) The writer wishes to acknowledge his indebtedness to the Board of Directors of the Marine Biological Station at St. Andrews, New Brunswick, Canada for the privilege of working at the station during the summer of 1912.

in a "car" to the laboratory, where they were kept alive either in the car or in tanks supplied with running water. The study of the living parasites was made during the months of July, August and September, 1912, and all the preserved material was collected during the same period.

In searching for parasites of the gall bladder, the bile duct of the fish was ligatured and the gall bladder removed to a carefully cleaned watch glass where it was cut open. Into a pipette freshly made from new glass tubing a small quantity of the bile was drawn. If a fresh preparation was desired this was dropped on a slide and covered with a coverglass. Both slides and coverglasses were prepared as follows: After being cleaned in a mixture of one part bichromate of potash and one part concentrated sulphuric acid to ten parts water they were washed first in tap water and then in distilled water and stored in 95% alcohol. When required for use, the alcohol was burned from them by passing them through the flame of an alcohol lamp. If fixed and stained smear preparations were desired the bile was dropped from the pipette on a coverglass and then sucked back again so that only a very thin film of bile remained on the coverglass. The coverglass was then inverted and allowed to drop on the fixing fluid in such a way that it was supported by the surface tension of the liquid. In this manner the preparations were given no opportunity to dry. This is practically the method of Doflein ('98), with the exception that in all cases no blood was added to the gall. The fixing fluids were Schandinn's fluid, consisting of two parts saturated aqueous solution of corrosive sublimate to one part absolute alcohol used either hot or cold and Hermann's fluid consisting of 75 cc. of 1% platinic chloride, 4 cc. of 2% osmic acid and 1 cc. of glacial acetic acid. These fluids were allowed to act for from five to ten minutes and the coverglasses were then transferred (after Schandinn's fluid) to 60% alcohol containing iodine, or (after Hermann's fluid) to distilled water. The stains used were Giemsa's azar-eosin or Dalafield's haematoxylin. Both were diluted before use to one or two per cent and allowed to act for from twenty-four to forty-eight hours. After staining in Giemsa's mixture the smears were washed in tap water and destained in a mixture containing 95% acetone and 5% xylol. When sufficiently destained they were passed in succession through the following mixtures: (1) acetone 70% and xylol 30%; (2) acetone 50% and xylol 50%; (3) pure xylol, and were finally mounted in Canada balsam. For the details of this method of using Giemsa's stain, Kisskalt and Hartmann ('10, p. 14) may be consulted. After staining in Dalafield's haematoxylin, smears were either first destained in acid alcohol or mounted directly in Canada balsam.

For the study of attached stages, the wall of the gall bladder was sectioned. Pieces of the bladder, opened in a watch glass as described above, were fixed in Schandinn's fluid, imbedded in paraffine, and cut into sections from four to seven microns in thickness. The sections were stained in Giemsa's mixture or in Dalafield's haematoxylin, diluted as for the smear preparations, or in Heidenhain's iron haematoxylin. In the case of Giemsa's stain the best results were obtained by washing in water rapidly, for twenty seconds or so, and then destaining in a mixture of acteone 95 cc. and xylol 5 cc. for eight to ten minutes.

TABLE OF FISHES SEARCHED WITH THE SPOROZOAN PARASITES FOUND IN THEM.

Host and Organ	Parasite	Number examined	Number Infected
Clupea harengus			
Testis	None	12	0
Gall Bladder	None	1	0
Cryptacanthodes maculatus.			
Gall bladder	None	1	0
Hemitripterus americanus.			
Gall Bladder	Ceratomyxa sp?	1	1
Myxocephalus octodecemspinous.			
Gall bladder	None	1	0
Myxocephalus groenlandicus.			
Gall bladder	None	4	0
Melanogrammus aeglefinus.			
Gall bladder	Myxidium beregense	1	1
Air bladder	Gaussia gadi	1	1
Osmerus mordax.			
Viscera	No cysts	22	0
Pseudopleuronectes americanus.			
Gall bladder	Ceratomyxa acadiensis	25	25
Gall bladder	Myxidium sp?	25	few
Viscera	No cysts	82	0
Raja ocellatus.			
Gall bladder	None	1	0
Urophycis chuss.			
Gall bladder	Ceratomyxa acadiensis	10	9
Gall bladder	Myxosporidian sp?		
Blood	Haemogregarina sp.	1	1
Zoarces angularis			
Gall bladder	Ceratomyxa acadiensis	8	8

LIST OF SPOROZOAN SPECIES.

1. *Ceratomyxa acadiensis* n. sp.

The *Myxosporidium* (Pl. IV Figs. 1-5, 10-13) is typically club-shaped with a long tail, often many times the length of the thicker part of the body (Pl. IV, Fig. 10). Large individuals may be irregularly stellate (Pl. IV, Fig. 12). The pseudododia often show a rigidity as if possessed of a rigid endoplasmic axis. The protoplasm of certain of the pseudopodia may be collected into clumps, the clumps being connected together by thin hyaline filaments of ectoplasm. A division into ectoplasm and endoplasm though not always clear is often to be seen in the anterior rigion. In the parasite of Urophycis chuss the mxyosporidia were very often found attached to the myxosporidium of an undetermined species (Pl. IV, Fig. 7 and 8) described in the fourth part of this section. An examin-

ation of freed individuals showed the attachment to be brought about by short pseudopodia at the anterior end. In the parasite of Zoarces angularis the attachment is probably to the epithelium of the gall bladdeer, since the fine pseudopodia are found and the myxosporidium found in U. chuss seems to be absent. In the parasite of Pseudopleuronectes americanus no attachment has been seen. The dimensions of a typical myxosporidium are:—

Length, excluding tail.....12–25 μ
Width.....10–20 μ
Tail.....up to 60 μ

In studying the structure of the *spores* of the Myxosporidia it is convenient to use the method of orientation employed by Thélohan ('95, p. 250-251) and generally adopted by subsequent writers. Where there is a single polar capsule or two (cps. pol. Fig. 1) or more close together the part of the spore in which the capsules lie is called anterior (a Fig. 1). The plane (pa Fig. 1) passing through the suture separating the two valves is called the sutural plane. The spore is

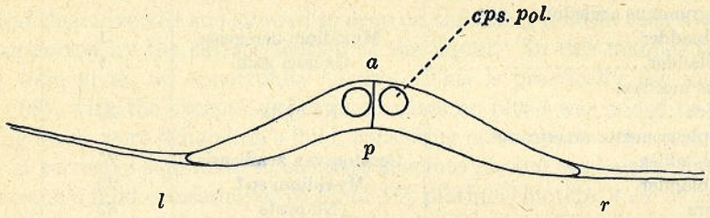

Fig. 1

Fig. 1. Spore of Ceratomyxa acadiensis n. sp. drawn to show method of orientation and nomenclature. Explanation in text. × 2000.

orientated by placing it with the polar capsules in front and the sutural plane vertical (Fig. 1). Then the front is anterior and the part behind is posterior (p Fig. 1), the upper surface dorsal and the lower surface ventral, the right side the right and the left side the left. The sutural diameter (Thélohan '95, p. 251) is the greatest diameter in the sutural plane. The bivalve axis (l r, Fig. 1) is the line which measures the greatest distance between the two valves perpendicular to the sutural plane.

The general shape of the spore of Ceratomyxa acadiensis n. sp. (Fig. 1) may be described as that of a spindle, of which the longitudinal axis has been bent into an arc of a circle. The chord of this arc is the bivalve axis, and may be called the width of the spore. The convex side of the arc is anterior, the concave side posterior and the opposite ends right and left. The sutural axis extends in the antero-posterior direction and is equivalent to the length of the spore. The two valves are cone-shaped, the pointed ends being directed one to the right and the other to the left and the bases meeting in the plane of suture. The spore is slightly compressed dorso-ventrally. A slight variation in the form and dimensions of opposite valves of the same spore was often noticed. The lateral filaments, extending outward from the tips of the valves on either side, are very long and thin.

Their exact length in the spore of the parasite from Urophcxis chuss was not measured. Their extreme fineness and great length make this very difficult except in very favorable preparations. This was, however, done in the case of the parasite of Zoarces angularis (Pl. IV, Fig. 9) where they were found to measure 250-300 μ or about six times the width of the spore exclusive of the filaments. The cavity of the valves does not appear to extend into the filaments. The length of these filaments is greater both relatively to the width of the spore and absolutely, than the length recorded for the lateral filaments of any other species of Ceratomyxa. Long filaments are most common in the two genera Ceratomyxa and Henneguya. It is generally believed that the filamentous appendages of Myxosporidian spores function in aiding the distribution of the spores by retarding the rate at which they sink and by rendering them more easily carried by currents.

The polar capsules (Fig. 1, cps. pol.) are almost spherical and lie close together at the anterior end of the spore. They are so oriented that the polar filaments when extruded cross each other (Pl. IV, Fig. 14). The extrusion of the polar filaments was effected by concentrated sulphuric acid but was not brought about by a solution of iodine in potassic iodide or by ammonia water. The failure of these two reagents may have been due to the spores not having been ripe. When extruded the filaments appear as very fine threads of uniform thickness.

The sporoplasm as seen in fixed and stained preparations is eccentrically placed, being in one valve, and contains, in all the spores examined from the gall bladder two compact darkly staining nuclei.

The dimensions of a typical spore are:

Length = sutural axis..... 7–8 μ
Width = bivalve axis..... 40–50 μ
Diameter of polar capsule..... 3–4 μ
Length of lateral filaments.....205–300 μ
Length of extruded polar filaments..... 70 μ

Triradiate spores are of frequent occurrence. These spores may show a fairly regular radial symmetry, both as regards the valves and the polar capsules (Pl. IV, Fig. 16) or one of the valves may be smaller than the other two while the three polar capsules are of equal size and symmetrically arranged (Pl. IV, Fig. 15). Cases where a triradiate spore and a normal spore were developing in the same myxosporidium were found (Pl. IV, Fig. 12) as were also cases where two triradiate spores were developing together.

Ceratomyxa acadiensis has been found in three hosts and perhaps in a fourth from the coast of New Brunswick, Canada. In the gall bladder of Urophycis chuss, the hake, it is usually found attached to an undetermined parasite, probably a species of Myxidium or Chloromyxum which is itself attached to the gall bladder. Nine out of ten U. chuss examined for the parasite were found to be infected. In the gall bladder of Zoarces angularis, the eel pout, C. acadiensis was not found attached although the modification of the anterior end for attachment was found. Each of the eight Zoarces angularis examined for the parasite was found to be infected. In the gall bladder of Pseudopleuronectes americanus, the winter flounder, no evidence of attachment was seen, vegetative forms were found relatively abun-

dantly, spores only rarely. Twenty-five flounders examined all contained the parasite. In Hemitripterus americanus myxosporidia resembling closely the myxosporidia of Ceratomyxa acadiensis were found. As no spores were found it was not possible to make a complete identification of this parasite.

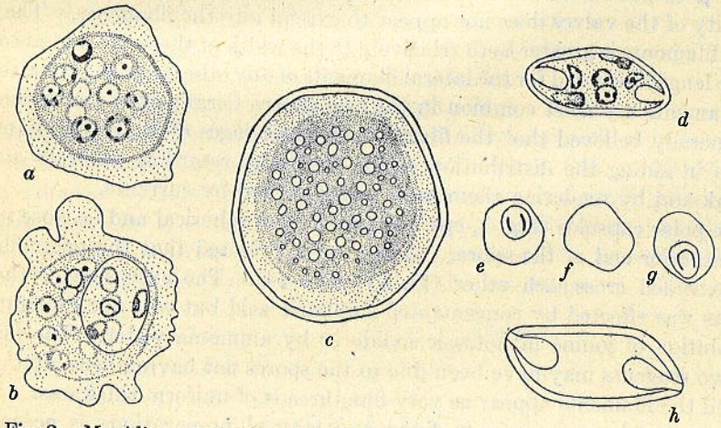

Fig. 2. Myxidium bergense Auerbach. *a*, myxosporidium containing eleven nuclei in the endoplasm and showing the intermediate zone and the ectoplasm; from a preparation stained with Delafield's haematoxylin. *b*, a similar myxosporidium containing a sporoblast with six nuclei and ten other nuclei in the endoplasm; from a preparation stained with Grenacher's borax carmine. *c*, myxosporidium showing outer resistant membrane (indicated by the clear area between the two contour lines) and numerous green granules; from a fresh preparation. *d*, spore showing the two polar capsules and the six nuclei; the two germ-nuclei lie one over the other near the centre, the two polar nuclei lie against the polar capsules and the valve-nuclei are more faintly stained and lie against the valves of the spore; from a preparation stained with Delafield's haematoxylin. *e*, *f*, *g*, optical cross sections of a spore; *e* and *g*, at either end and *f* at about the middle. *h*, spore showing shell and polar capsules and placed so as to correspond in position to the sections *e*, *f*, *g*. Figures *e*-*h* from fresh preparations. × 1900.

The spores of Ceratomyxa acadiensis resemble in size most closely those of C. appendiculata Thél. (Thélohan '95). As Thélohan does not give a figure of the spore and the only measurements given are those of the length and width it is impossible to carry the comparison further. The myxosporidium differs from that of C. appendiculata in being found attached. The spore resembles in form that of C. drepanopsettae Awer. (Awerinzew, '09) but differs from it in size.

Some interesting stages in the life history of this parasite have been worked out and will form the subject of a separate paper.

2. *Myxidium bergense* Auerbach.

The *Myxosporidium* is spheroidal, 25-35 μ in diameter or elongated up to 50 μ in length. There is a clear differentiation into ectoplasm, an intermediate zone resembling that described in M. lieberkuhni, Butschli, by Cohn ('96) and

endoplasm. In the living parasite the ectoplasm is hyaline, the intermediate zone very finely granular and slightly less transparent than the ectoplasm while the endoplasm is filled with yellowish green granules (Fig. 2, *c*). In stained preparations this differentiation of the protoplasm becomes more apparent, the intermediate zone being more deeply stained than either the ectoplasm or endoplasm (Fig. 2, *a* and *b*). The nuclei are confined to the endoplasm. The pseudopodia may be of two forms:—lobose, relatively large and rounded (upper and left side of Figure 2, *b*) or fine and short in which case they are usually numerous and arranged so as to give the part of the surface where they occur a villate appearance (right of Fig. 2, *b*). The latter attach the myxosporidium to the epithelium of the gall bladder. Under certain conditions the myxosporidium may become surrounded by a distinct doubly contoured membrane (Fig. 2, *c*) giving the whole the appearance of a cyst. At times the protoplasm may be seen in fresh preparations to be shrunken within this membrane leaving a clear space between the membrane and the ectoplasm. The sporoblasts are formed without the previous formation of pansporoblasts. One to six sporoblasts may be found in a myxosporidium. The sporoblasts are usually not arranged in pairs but are scattered in the myxosporidium. Figure 2, *b*, shows a myxosporidium with one sporoblast. The sporoblast shows the usual six nuclei:—the two nuclei of the valve cells, the two of the capsulogenous cells, and the two germ nuclei. The two nuclei of the valve cells will be seen each to have adherent to the periphery at one point a dark body. This dark body seems to be of frequent or constant appearance at this point. Its significance is not clear to the writer. A later stage where the polar capsules are forming is shown in Figure 2, *d*. Here also there are two germ nuclei. In every spore examined from the gall bladder there were two germ nuclei.

The spores are spindle shaped with the axis of the spindle slightly bent in the form of an enlongated S, the two ends of which have been bent at right angles to the plane of the letter and in opposite directions. Corresponding to this curving of the axis of the spindle, the polar capsules are placed with their axes approximately tangent to the curve described, i.e., their axes make angles (of about 20°) on opposite sides of the line joining their points of contact with the spore shell. The polar filaments are visible within the capsules in the fresh state but the number of coils of the spiral in one capsule could not be counted. The filaments were not extruded when treated with a solution of iodine in potassic iodide. The dimensions of a typical spore are:

Length	16–18 μ.
Width	6–7 μ.
Length of polar capsule	4 μ.
Width of polar capsule	2·5–3 μ.

This description will be found to agree with that of Auerbach ('09, '09[a] p. 61, and '12, pl. 2), in all particulars with the exception of the cyst-like condition described in the present paper. The presence of this cyst may however be due to some exceptional condition of the parasite.

3. *Myxidium* Sp.?

The myxosporidium of this rare parasite was not seen in fresh preparations of the bile. In stained smears there occurred a large spheroidal myxosporidium containing twenty-two nuclei, and having numerous long lobose pseudopodia on one side. The general arrangement of the pseudopodia suggested that they served for the attachment of the myxosporidium to the gall bladder. It contained no spores.

The pansporoblasts are spherical 15-16 μ. in diameter.

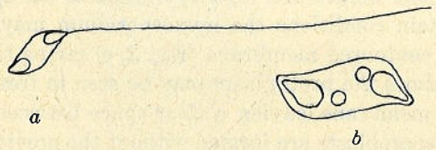

Fig. 3

Fig. 3. Spores of Myxidium sp. from Pseudopleuronectes americanus. *a*, with polar filament extruded by ammonia water. × 660 *b* × 1320.

The spores (Fig. 3) are spindle shaped with the long axis slightly bent in the form of an S. The polar capsules are pear-shaped and situated at either end of the spindle. The polar filaments were visible in the fresh state within the capsule. The polar filaments were extruded in ammonia water (Fig. 3, a).

The dimensions of a typical spore are:

Length	14–15 μ.
Width	6–7.5 μ.
Length of polar capsule	4 μ.
Width of Polar capsule	2.5 μ.
Length of extruded polar filament	90–95 μ.

This species of Myxidium was found in the gall bladder of Pseudopleuronectes americanus on the coast of New Brunswick, Canada.

The spores found resemble most closely those of M. bergense Auerbach (:09, p. 74 and '09[a]. p. 61) but differ from these by their small size and longer polar filaments. They resemble also the spores of M. sphericum Thél. but differ in the relatively smaller polar capsules (Thél. '95, Pl. 7, Fig. 28) and the longer polar filaments.

4. *Myxosporidium* of an undetermined species.

Attached, usually in large numbers, to the epithelium of the gall bladder in Urophycis chuss, occurs a spherical or ellipsoidal myxosporidium which in stained preparations is found to contain numerous nuclei (Pl. IV, Figs. 6-8). The examination of a large number of these myxosporidia has not revealed the presence of any developing spores in them. Very often clusters of C. acadiensis are found

adhering to the free surface of the myxosporidium (Pl. IV, Figs. 7 and 8) i.e. the surface not in contact with the epithelium. In fresh preparations the appearance is that of budding from a parent organism (Pl. IV, Figs 7-8). For a time this was thought possibly to be the case for some of the adherent individuals. An examination of sections has shown a sharp division between the myxosporidium and C. acadiensis. No other spores than those of C. acadiensis were found in the gall bladder of U. chuss.

5. *Goussia gadi* Fiebiger.

The haddock in which this parasite was found was caught on the sixth of August. The abdominal organs were cut out and the fish was put on ice. Next day when the fish was being prepared for the table it was proclaimed unfit for cooking on account of a creamy exudation in the dorsal part of the body cavity. It was at this time that the fish was brought to the notice of the writer. On examination a creamy mass, yellowish white in color was found adherent to the inner surface of the air bladder. This had the appearance of being due to the breaking down of the lining membrane. The kidneys and surrounding muscular tissue appeared quite normal. A microscopic examination revealed the presence of numerous ellipsoidal spores arranged in groups of four in the creamy mass. "Wet" smears were fixed in Schandinn's sublimate-alcohol mixture and in Hermann's platinic chloride-osmium-acetic mixture. They were subsequently stained in Grenacher's borax carmin and in Delafield's haematoxylin. The preservation proved to be not all that could have been desired but seems sufficient to determine the systematic position of the parasite.

The macerated condition of the cells of the air bladder both when examined fresh and in preserved preparations has made it impossible to determine any of the schizogonic or syngamic stages. There can however be no doubt that the form is tetrasporous from the almost constant occurrence of the spores in groups of four usually surrounded by a structure which appears membranous in the preparations.

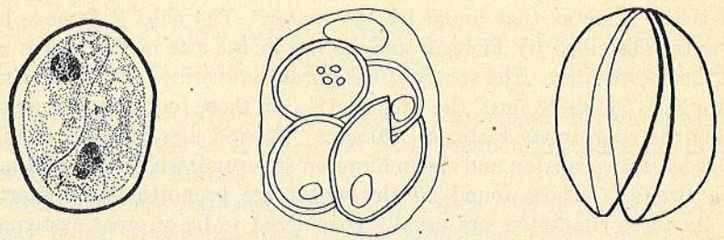

Fig. 4. Goussia gadi Fiebiger. *a*, spore stained with Delafield's haematoxylin showing the two sporozoites with their nuclei, × 1900. *b*, tetrad of spores inclosed in mass which is probably remains of host cell; drawn from fresh preparation, × 970. *c*, two valves of spore cell drawn from preparation fixed in Hermann's fluid, × 1900.

Figure 4, *b* drawn from a fresh preparation of the creamy mass in the air bladder shows the arrangement of the oval spores in tetrads. In this the tetrad is inclosed in what may have been one of the cells of the air bladder.

In fresh preparations the spores measure 16 μ in length by 12 μ in width. A spore stained with Delafield's haematoxylin is drawn in Figure 4, *a*. The two sporozoites are seen filling the spore. Each has a nucleus situated near one end. The nucleus of a sporozoite is usually, though not always, situated at one end and the nuclei of the two sporozoites in a spore are usually at opposite ends of the spore. There is no residual protoplasm in the spore.

The shell of the spore is ellipsoidal. The line of suture of the two valves does not lie in a focal plane of the ellipsoid but is shaped so as to give each valve somewhat the form of a spoon. In fresh preparations the spore shell could be seen to consist of two layers, an outer yellowish layer and an inner dark green layer. Figure 4, *c* drawn from a preparation preserved in Hermann's fluid shows the shape of the valves of the spore shell.

From the above description there can be no doubt that the organism we are concerned with belongs to the order Coccidiida. Following the classification of Labbé ('99) since the number of archispores (sporoblasts) is limited to four we have:—

Order Coccidiida
Sub-order Oligoplastina
Tribe Tetrasporea,

and since the spores are oval and bivalve the parasite is to be placed in the genus Goussia, Labbé ('96). Fiebiger ('08) has described under the name of Goussia gadi a species of Goussia infecting the air-bladder of Gadus morrhu and Gadus virens and has identified it with the parasite found by J. Müller in the air-bladder of Gadus callarias. Auerbach ('09, p. 74, 81) has also described briefly a parasite from the air-bladder of Gadus aeglefinus which he identifies as a species of Goussia. The writer is of opinion that in the present stage of our knowledge these parasites are to be regarded as all belonging to the same species and that the parasite found by him is probably also of this species.

The microscopic appearance of the diseased air bladder as described by these authors is the same as that found by the writer. The chief difference between the parasites described by Fiebiger and he are in the size of the spores and the form of the sporozoites. The spores of the parasite described by Fiebiger measure only 11 $\mu \times 7{\cdot}5\ \mu$ as against the 16 $\mu \times 12\ \mu$ of those found by the writer. In describing the sporozoites Fiebiger ('08) says "Es sind dies schlanke Gebilde mit einem vorderen zugespizten und einem hinteren abgerundeten Ende von 10μ Lange und 4 μ Breite." Those found by the writer are proportionately shorter and wider. As these characters are usually considered to be of great systematic importance considerable doubt may be expressed as to the two parasites being of the same species. However, the writer considers that other similiarities make it possible that the variations in size may be due to the different environments of the hosts and the difference in the form of the sporozoites, to his not having seen

the final stage in their development or to defective preservation. It is worthy of note that Fiebiger found also such sporozoites in his preparations ('08, Fig. s).

6. *Hæmogregarina* sp?

In order to insure against the confusion of elements of the blood with stages in the life-history of the parasites of the gall-bladder of Urophycis chuss, smears of the blood were made. In these smears a hæmogregarine (Fig. 5) was found. The infection was a rather abundant one, some hundred or so individuals being found in a single smear and at times two in one field of the oil-immersion objective. All the individuals found had the characteristic sausage shape of the merozoite of hæmogregarines. Usually one side of a red corpuscle was completely filled by the parasite and often the nucleus of the corpuscle was forced to one side (Fig. 5).

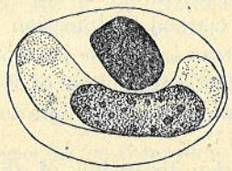

Fig. 5. Hæmogregarina sp.? from the blood of Urophycis chuss. × 3000.

The nucleus of the haemogregarine was usually about half as long as the individual and filled its complete thickness; it was usually situated nearer one side. In the nucleus could usually be distinguished a number of deeply staining granules. Sometimes the merozoits were bent upon themselves. In such cases, however, the corpuscles were shorter than usual and the curling of the parasite was probably due to the drying of the smear.

The host of the hæmogregarine, Urophycis chuss, occurs on the coast of North America from the banks of Newfoundland to Cape Hatteras (Jordan and Evermann 1898; III, p. 2555). The writer is not aware of the description of any hæmogregarines from the fishes of these waters.

ON THE GEOGRAPHICAL DISTRIBUTION OF THE PARASITES FOUND.

Certain of the parasites found in the fishes of Passamaquoddy Bay are believed by the writer to be of the same species as parasites found in the same fishes occurring on the coast of Europe.

Myxidium bergense has been found by Auerbach ('12) in Sebastes viviparus, Anarrhichas lupus, Gadus callarias, Gadus aeglefinus, Gadus merlangus and Pleuronectes platessa, caught at points on the coast of Norway extending from Christiania in the South to Vardö in the North, and by the writer in Gadus aeglefinus from the eastern coast of Canada.

Goussia gadi has been found by Fiebiger ('08) in Gadus morrhua and Gadus virens from the coast of Iceland but not in Gadus aeglefinus from the same region

which he also searched for the parasite. Fiebiger attributes his failure to find the parasite in the latter species to his not having examined a sufficient number of fish. Assuming that the parasite described by Auerbach ('09, p. 74, 81) is Goussia gadi, as seems probable, it has been found in Gadus aeglefinus on the coast of Norway at Bergen. The coccidian described by J. Müller ('42) from Gadus callarias is identified by Fiebiger ('08) as Goussia gadi. The parasite found by the writer is also identified as Goussia gadi. The distribution of Goussia gadi is therefore from the Cattegat to the North of Norway, Iceland and Eastern Canada.

There can be no doubt that the parasites in question, Myxidium bergense and Goussia gadi complete their life cycle in the host fish, in other words there is no intermediate host. Hence their spread occurs only from fish to fish, and a fish becomes infected only by coming into such relations to an infected fish that the spores of the parasite are carried to it from the latter by water currents. This probably means the fairly close proximity of the two fish. The investigation of infectious diseases, where the method of infection is contaminative, has shown that their spread over large areas is almost invariably due to the migration of diseased animals. It is possible that the spread of Myxidium bergense and Goussia gadi over the North Atlantic is due to the migrations of the host fishes in these waters.

The places mentioned in the discussion of the distribution of Myxidium bergense and Goussia gadi are shown on the map (Fig. 6).

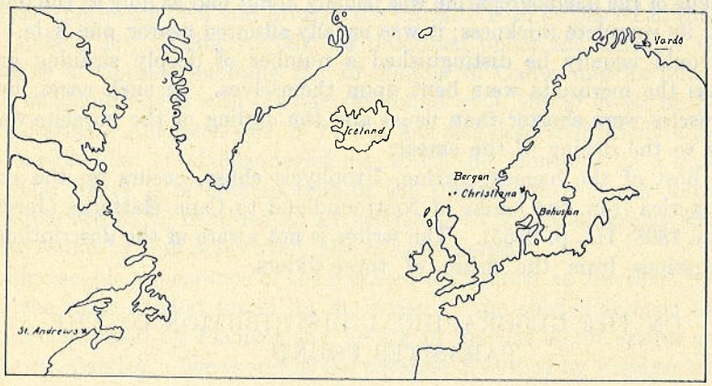

Fig. 6. Map on Mercator's projection showing places mentioned in the section upon geographical distribution.

The fact that no cysts of Sporozoa were found in the 82 specimens of Pseudopleuronectes americanus is interesting. The writer found fifty per cent of the fish of this species caught in the Wood's Hole region in the summer and winter of 1910 infected with Glugea stephani Hagenmüller. At this time he also found Osmerus mordax from Wood's Hole frequently infected with a microsporidian, apparently Glugea stephani. The twenty-two examples of Smelt Osmerus mordax examined from the St. Andrews region contained no microsporidian cysts.

BIBLIOGRAPHY.

Auerbach, M.: '09. Bemerkungen über Myxosporidien. Zool. Anz. Bd. 34, p. 65-82.

'09*a*. Biologische und Morphologische Bemerkungen über Myxosporidien. Zool. Anz. Bd. 35, p. 57-63.

'12. Studien über die Myxosporidien der norwegischen Seefische und ihre Verbreitung. Zool. Jahr. Abt f. Systematik. Bd. 34, p. 1-50, pl. 1-5.

Awerinzew, S. '09. Studien über parasitische Protozœn. I. Die Sporenbildung bei Ceratomyxa drepanopsettae mihi. Arch. f. Protist Bd. 14, p. 74-112.

Cohn, L. '96. Uber die Myxosporidien von Esox lucius und Perca fluviatilis. Zool. Jahrb., Abt. f. Morph. Bd. 9, p. 227-272.

Fiebiger, J. '08. Uber Coccidien in der Schwimmblase von Gadus-Arten, Vorläufige Mitteilung. Annalen des K. K. Naturhistorischen Hofmuseums Wien. Bd. XXII, Nr. 2-3. 1907-08., p. 124-128.

Gurley, R. '93. On the Classification of the Myxosporidia. Bull. U. S. Fish. Comm. for 1891, Vol. II., p. 407-420.

'94. The Myxosporidia or Psorosperms of Fishes and the Epidemics produced by them. Report U. S. Comm. Fish and Fisheries. Pt. 18, p. 65-304.

Jordan, D. S. and Evermann, B. W. '96-'00. The Fishes of North and Middle America. U. S. National Museum, Bull. No. 47, 4 pts., Washington.

Kiskalt, K. and Hartmann, M. '10. Praktikum der Bakteriologie und Protozoologie. Teil II., Protozoologie, Jena.

Labbé, A. '96. Recherches zoologiques, cytologiques et biologiques sur les Coccidies. Arch. Zool. Exp. Ser. 3, vol. 4, p. 517-654., pl. 12-18.

'99. Sporozoa in Tierreich Das. Deutsch. zool. ges. 5. Liefg., Berlin.

Müller, J. und Retzius, A. '42. Uber parasitische Bildungen, Müller's Archiv. f. Anat., Physiol. u. wiss. Medizen, p. 193-198.

Thélohan, P. '95. Recherches sur les Myxosporidies. Bull. Scient., France et Belgique, Vol. 26, p. 100-394.

Tyzzer, E. E., '00. Tumors and Sporozoa in Fishes. Journ. Boston Soc. Vol. 5, p. 63-68, Pl. 6.

EXPLANATION OF PLATE.

PLATE IV.

Ceratomyxa acadiensis, n. sp.; myxosporidia and spores drawn from fresh preparations of the bile of the host.

Fig. 1. Young myxosporidium of C. acadiensis from the gall bladder of Urophycis chuss. × 390.

Figs. 2-5. Young myxosporidia of C. acadiensis from the gall bladder of U. chuss. × 830.

Fig. 6. Undetermined myxosporidium from gall bladder of U. chuss. × 600.

Fig. 7. Undetermined myxosporidium from gall bladder of U. chuss with attached C. acadiensis. × 830.

Fig. 8. Same subject as figure 7, drawn three hours later. × 830.

Fig. 9. Spore of C. acadiensis from gall bladder of Zoarces angularis. × 270.

Fig. 10. Myxosporidium of C. acadiensis from gall bladder of Pseudopleuronectes americanus × 830.

Fig. 11. Myxosporidium of C. acadiensis from gall bladder of Pseudopleuronectes americanus. × 830.

Fig. 12. Myxosporidium of C. acadiensis containing two sporoblasts, one forming a normal spore, the other forming a triradiate spore with three polar capsules. From the gall bladder of P. americanus. × 390.

Fig. 13. Myxosporidium of C. acadiensis from the gall bladder of Zoarces angularis. × 830.

Fig. 14. Spore of C. acadiensis from the gall bladder of U. chuss. × 390.

Fig. 15-16. Triradiate spores from the gall bladder of U. chuss. × 390.

All drawings were made with an Abbe camera lucida.

PLATE IV.