10.—ON THE CLASSIFICATION OF THE MYXOSPORIDIA, A GROUP OF PROTOZOAN PARASITES INFESTING FISHES.

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Up to the present time very little attention has been given to the diseases of fishes and to their parasites from the standpoint of the effect produced upon the host; yet there can be no doubt that a knowledge of such diseases would be of great practical value. Anyone who considers the proportions that fish epidemics sometimes attain will hardly be inclined to question the utility of searching investigation in this direction. Thus, to take a single instance, Prof. Forbes states* that in the epidemic of 1884 in Lake Mendota it was estimated that fully 300 tons had died. On August 7 the Madison Transcript reported that 200 tons of fish had been hauled away by the city authorities during the four weeks preceding and that the fishes were still dying. Epidemics of similar extent have been reported in Europe, for several of which (that of the barbel certainly, and that of the crayfish probably) the *Myxosporidia* are responsible.

The important results in the way of prevention of epidemics among domesticated animals and cultivated plants, obtained as the result of scientific investigation, afford ground for the hope that similar results may be obtained here. Obviously the first step in work of this kind is the collection of facts, especially those bearing upon the parasite, its nature, life history, intermediate hosts, enemies, and its connection (whether causal or otherwise) with diseases or other morbid processes in its host. Such data are a necessary preliminary to preventive or curative measures.

The present paper and a more extended one now in preparation are intended as contributions to the objects indicated. In the latter paper the practical bearings of the subject will be fully discussed, and all the data as to epidemics of myxosporidiosis will be given. At present it is desired mainly to discuss the classification of the subclass *Myxosporidia* Bütschli and to record such genera and species as a study of the literature and of such material as was available has led me to recognize. These forms will all be fully described and figured in the second paper. The present only includes such true *Myxosporidia* as have received or appear entitled to receive binomial names, and only such synonymy as is needed for their identification.

*Bull. U. S. Fish Com. 1888, VIII, p. 482.

CLASSIFICATION OF THE SUBCLASS.

The only classification ever proposed is that of Thélohan.* This author enunciates three taxonomic principles:

1. The habitat furnishes no sound basis for specific distinctions.†
2. The myxosporidium affords no taxonomic criteria.
3. The spores alone offer (at least in the present state of our knowledge) characters suitable to serve as a basis for classification. He says:

> By noting the differences of form and size of these elements, the number of their polar capsules, by taking account of the presence or absence of a vacuole in the plasma, of their number in the [pan]sporoblasts‡, one can, I believe, succeed in obtaining elements sufficient for an attempt of this kind.

Thélohan further states that he regards the classification only as a provisional one, and that it is the result of a desire to obviate the great confusion arising from the habit of designating forms by their habitats.

The following is Thélohan's primary classification:

MYXOSPORIDIANS.

Spores	Pyriform; capsule 1, at pointed extremity; vacuole 1, aniodinophile, at large extremity.			I. *Glugeidians.*
	Form variable	No vacuole; capsules 2 or 4.	Capsules 2	II. *Myxidians.*
			Capsules 4	III. *Chloromyxans.*
		Vacuole 1, iodinophile.	Capsules 1–2	IV. *Myxobolans.*

The three principles mentioned, which form the basis of Thélohan's classification, are unquestionably sound as far as they go, but to obtain a satisfactory arrangement it will sometimes be necessary to employ additional characters and to arrange them in a different order of rank. Especially will it be necessary in the *Phænocystes* to refer constantly to the symmetry and topography of the spore.

Further, while there can be no question as to the propriety of drawing a sharp line between the "Glugeidians" of the above table and the remaining *Myxosporidia*,

*Bull. Soc. philomat. Paris, 1892, IV, pp. 165–178.

† While as a general principle this is beyond question, indications are not wanting to show that in some cases the seat and, to a somewhat less extent, the host, bear some relations to generic lines. One of the most significant facts of organal and zoölogical distribution is the following:

Forms.	Total number of species.	Gall and urinary bladders, bile ducts and urinary tubules.	Remaining organs.
Non-vacuolous	9	8	1
Vacuolous	Very many ...	*Ad plur* 2 (3 *f*)	All but 2 (or 3).

‡ *Pansporoblast:* The transparent plasma-sphere formed by the condensation of a portion of the plasma around one of the numerous nuclei of the endoplasm of the myxosporidium; in distinction from the sporoblasts which result from the segmentation of the pansporoblast.

the division certainly can not rest upon such a comparatively unimportant character as the shape of the spore. I have regarded this division as of ordinal value and define the two orders thus:

I. *Cryptocystes* ord. nov. *Myxosporidia* in which the pansporoblast produces many (at the fewest 8) spores; the last minute, without distinct symmetry, with a single capsule; type (and only) family, *Glugeidæ* fam. nov.

Etymology: κρυπτός, concealed; κύστις, capsule.

II. *Phænocystes* ord. nov. *Myxosporidia* in which the pansporoblast produces few (at the most 2) spores;* the last relatively large, with distinct symmetry and 2 or more capsules;† type family, *Myxobolidæ* fam. nov.

Etymology: φαίνω, I appear; κύστις, capsule.

I. CRYPTOCYSTES ord. nov.

GLUGEIDÆ fam. nov.

Glugeidées Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173–174.

Definition (provisional as regards negative characters): *Cryptocystes* destitute of a bivalve shell; with the capsule at the anterior extremity and with an aniodinophile vacuole; type genus, *Glugea* Thélohan.

This family contains three genera,‡ whose relations are shown in the following table:

Myxosporidium.	Spores formed in pansporoblast.	Pansporoblast membrane.	Genera.
Present	Inconstant, numerous	Not subpersistent	*Glugea* Thélohan.
Absent	Inconstant, numerous	Subpersistent	*Pleistophora* gen. nov.
Absent	Constant, 8	*Subpersistent*	*Thélohania* Henneguy.

GLUGEA Thélohan, 1891.

Compt. Rend. hebdom. Soc. Biol. Paris, III, p. 29; *ib.* Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p 174.

Definition: *Glugeidæ* possessing a myxosporidium, and in which the pansporoblast produces an inconstant but large number (always more than 8) of spores; pansporoblast membrane not subpersistent; type, *G. microspora* Thél. (synonym for *G. anomala* Moniez).

Glugea anomala Moniez, 1887.

Nosema anomala, Compt. Rend. Acad. Sci. Paris, CIV, p. 1312; *Glugea microspora*, Thélohan, 1891, Compt. Rend. hebdom. Soc. Biol. Paris, III, p. 29.

Glugea destruens Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, pp. 165, 174 (footnote).

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* Three asserted in one species (Leydig, Müller's Archiv., 1851, p. 229).

† Except (at most) two *Myxobolus* species (one of them perhaps inconstantly), which have suffered reduction to one.

‡ Thélohan recognizes only 2 genera, the distinctions between which are mainly based upon the three characters noted. If (as both he and I believe) these characters are sufficient to determine genera at all, a third genus must be recognized, as *Pleistophora typicalis* sp. nov. could not (as the above table shows) well be forced into either of the existing ones.

PLEISTOPHORA* gen. nov.

Definition (provisional as regards negative characters): *Glugeidae* destitute of a myxosporidium and in which the pansporoblast produces an inconstant but large number (always more than 8) of spores; pansporoblast membrane subpersistent (as a polysporophorous vesicle); type (and only) species, *P. typicalis* sp. nov.

Pleistophora typicalis sp. nov.

(Corpuscles of *Cottus scorpio* Thélohan, 1890, Annal. de Microgr. Paris, II, pp. 203, 212; *ib.* Thélohan, 1891, Compt. Rend. hebdom. Soc. Biol. Paris, III, pp. 27–8; *ib.* Henneguy and Thélohan, 1892, Annal. de Microgr., IV, pp. 618–619, 622, 631, 636.)

Pansporoblast: Spherical, diameter 15 to 18 μ.

Spore: Ovoid; length 3 μ; breadth 1.5 to 2.0 μ; chromatophile granules *ad plur.* 4.

Habitat: Interior of fibrillæ of muscles of *Cottus scorpio;* diseased mass forming white streaks 5 to 6 by 3 mm.; not leading to muscle degeneration.

THÉLOHANIA Henneguy, 1892.

In Thélohan, Bull. Soc. philomat. Paris, IV, p. 174 (footnote); *ib.* Henneguy and Thélohan, 1892, Annal. de Microgr., IV, p. 639.

Definition (provisional as regards negative characters): *Glugeidae* destitute of a myxosporidium and in which the pansporoblast produces constantly 8 spores; pansporoblast membrane subpersistent (as an octosporophorous vesicle); type, *T. giardi* Henneguy.†

Thélohania contejeani Henneguy, 1892.

In Thélohan, Bull. Soc. philomat. Paris, IV, p. 174 (footnote).

Thélohania octospora Henneguy, 1892.

In Thélohan, Bull. Soc. philomat. Paris, IV, p. 174 (footnote).

Thélohania giardi Henneguy, 1892.

In Thélohan, Bull. Soc. philomat. Paris, IV, p. 174 (footnote).

Thélohania macrocystis sp. nov.

(Sarcosporidian of *Palæmonetes varians* Garbini, 1891, Atti Reale Accad. Lincei Roma, VII, Sem. 1, pp. 151–152, with figs.; myxosporidian of *ibid.* Thélohan and Henneguy, 1892, Compt. Rend. hebdom. Soc. Biol. Paris, IV, p. 586).

Sporophorous vesicle (subpersistent pansporoblast) elongate-fusiform.

Habitat: Muscles of *Palæmonetes varians* from the Mincio, near Verona.

II. PHÆNOCYSTES ord. nov.

It is in the classification of this order that the criteria furnished by Thélohan most need to be supplemented by considerations drawn from the *symmetry* of the spore. Considering the taxonomic importance of symmetry throughout the animal kingdom, it is strange that no attention has yet been paid to it in the *Myxosporidia.* But a little study of it shows that, whereas in all fusiform spores the pointed extremities have heretofore been loosely lumped together as "ends," those of *Myxidium lieberkühnii* Bütschli are not ends (*sens strict.*;=anterior and posterior), but sides; for the

*Etymology: πλεῖστος, very many; φέρειν, to carry.

†I propose *T. giardi* Henneguy as the type of the genus.

spore is symmetrical on either (right or left) side of the vertical plane,* but it is asymmetric on either (anterior and posterior) side of the transverse plane. On the other hand, if, as seems probable, the generic reference of *O.? diploxys* sp. nov. be correct, then "ends" in *Cystodiscus* are ends, properly speaking. It is needless to emphasize the taxonomic import of these results, for we are thus enabled to orient the spore and the results of such orientation may be summed up as follows:

1. Within this order the most important characters are the *position* and *grouping* of the capsules. Compared to this the mere *number* of these bodies is a character of minor importance; for not only has *Myxobolus* 1 or 2 and *Cystodiscus* 2 or 4, but the number even varies in the same species, *Myxidium lieberkühnii* Bütschli having 2 or 4.† But whether 1 to 2 or 2 to 4, the topographic relations are never varied. Thus in *Myxobolus* they are always in one group at the anterior end; in *Cystodiscus* in two groups, *anterior* and *posterior;* and in *Myxidium* in 2 groups, *right* and *left.*

Similar results are obtained with relation to the position of the valves, or, in other words, to the orientation of their plane of junction.

The following table shows the relations of these points to generic lines:

Comparison of generic characters in the Phænocystes.

[×=present; 0=absent; ( )=less usual; —=condition not known.]

	Symmetry.		Capsules.				Shell.			Vacuole.	Tail.
	Antero-posterior.	Bilateral; perfect.	Number.	In one group (at the anterior end.)	In two groups.		Bivalve.	Inclination of plane of junction of valves to longitudinal plane.			
					At the (anterior and posterior) ends.	In the (right and left) wings.		0°.	90°.		
Cystodiscus Lutz	×	×	2 (or 4)	.....	×	.....	×	.....	×	—	0
Myxobolus Bütschli *sens. strict*	0	×	2 (or 1)	×	.....	.....	×	×	.....	×	0
Henneguya Thélohan	0	×	2	×	.....	.....	×	×	.....	×	×
Chloromyxum Mingazzini	0	×	4	×	.....	.....	×	—	(?)	0	0
Mixosoma Thélohan	0	×	2	×	.....	.....	—[2]	—	—	0	0
Sphærospora Thélohan	0	×	2	×	.....	.....	×	—	—	0	0
Ceratomyxa Thélohan	0	(1)	2	×	.....	.....	×	.....	×	0	0
Myxidium Bütschli	0	×	2 (or 4)	.....	.....	×	0	.....	.....	0	0

[1] Imperfect. Shell and capsules symmetrical; sporoplasm unilateral.

[2] From analogy and general similarity of appearance, this genus can hardly be other than bivalve.

*The three planes to which symmetry may be referred may be thus defined:

Vertical plane: Median, longitudinal and intercapsular in position.

Transverse plane: Vertical, transverse and (in *Myxobolus*) postcapsular in position.

Longitudinal plane: Horizontal, longitudinal and percapsular in position.

† Balbiani, 1883, Journ. de Microgr. Paris, VII, p. 274, fig. 64 *g*.

From this table we may conclude that—

1. *Cystodiscus* Lutz is certainly entitled to separate family rank.

2. *Henneguya* Thélohan agrees with *Myxobolus* in every respect but one, the presence of a tail.

3. Thélohan's groups, "*Myxidiées*" and "*Chloromyxées*" must undergo rearrangement (see table below); for clearly *Chloromyxum* Mingaz, *Mixosoma* Thél., and *Sphærospora* Thél. form a compact group, with which *Myxidium* has no character of consequence in common except the absence of a vacuole.

4. *Sphærospora* and *Mixosoma* do not differ at all in the characters given (the distinction between these unispecific genera resting solely upon the shape of the spore), and the two taken together present only a single character in contrast to *Chloromyxum*, viz, the *number* of the capsules.

5. *Ceratomyxa* agrees sufficiently closely with *Chloromyxum* to permit its reference to the *Chloromyxidæ*.

6. *Myxidium* must form the type of a separate family.

The following table shows the relations of Thélohan's classification to the one now proposed:

Thélohan's classification.			Proposed classification.		
GROUP.			GENUS.	FAMILY.	CHARACTERS.
No vacuole, 2 or 4 capsules.	2 capsules. (II. Myxidians.)	Fusiform, 1 capsule at each extremity. *Myxidium* Bütschli.	*Myxidium* Bütschli.	*Myxidiidæ*.....	Bilateral but not antero-posterior symmetry; capsules in 2 groups right and left; no bivalve shell; no vacuole.
	Spores.	Elongated; shell, formed of 2 hollow-cone valves soldered along their bases. *Ceratomyxa* Thél.	*Ceratomyxa* Thél ..	*Chloromyxidæ*.	Bilateral but not antero-posterior symmetry; capsules in 1 group (at the anterior end); a bivalve shell, with the valve-junction plane perpendicular (?) to the longitudinal plane; no vacuole.
		Flattened-ovoid, more or less elongate. *Myxosoma* Thél.	*Chloromyxum* Mingaz, et sub-gen. *Sphærospora*.		
		Spherical. *Sphærospora* Thél.			
	4 capsules. (III. Chloromyxans.)	*Chloromyxum* Mingaz.			
One iodinophile vacuole; 1 or 2 capsules.	IV. Myxobolans. Spore-shell.	Destitute of a tail; capsules 1 or 2. *Myxobolus* Bütschli.	*Myxobolus* Bütschli.	*Myxobolidæ*....	Bilateral but not antero-posterior symmetry; capsules in 1 group (at the anterior end); a bivalve shell with the valve-junction plane parallel to the longitudinal plane, an iodinophile vacuole.
		With a tail; capsules 2. *Henneguya* Thél.			
			Cystodiscus Lutz.	*Cystodiscidæ* ..	Bilateral and antero-posterior symmetry; capsules in 2 groups, anterior and posterior; a bivalve shell with the valve-junction plane perpendicular to the longitudinal plane; condition of sporoplasm unknown.

As a result of this analysis, the order *Phænocystes* may be divided into the following families:

CYSTODISCIDÆ fam. nov.

Definition: *Phænocystes* whose spores possess antero-posterior and bilateral symmetry; capsules in 2 groups, situated at the (anterior and posterior) ends; a bivalve shell, the plane of junction of whose valves is perpendicular to the longitudinal plane: condition of sporoplasm* unknown; type (and only) genus *Cystodiscus* Lutz.

CYSTODISCUS Lutz, 1889.

Centralbl. f. Bakt. u. Parasitenkde., v, p. 88.

Definition: Characters those of the family; type, *C. immersus* Lutz.

Cystodiscus immersus Lutz, 1889.

Centralbl. f. Bakt. u. Parasitenkde., v, pp. 84–88; figs. separately and subsequently.

Cystodiscus ? diploxys sp. nov.

(Psorosperms of *Pyralis viridana* Balbiani 1867, Journ. Anat. et Physiol. Paris, p. 335 (footnote), t. 12, f. 10–12.)

Spore: Parallel-sided fusiform; ends symmetrically double convex-curved pointed; plane of junction of valves coincident with the vertical plane; capsules 2 at each end, of equal size.

Habitat: *Tortrix viridana.*

MYXOBOLIDÆ fam. nov.

(*Myxosporidieæ*† Perugia, 1891, Boll. Scientif. Pavia, XIII, p. 23; "Myxobolées" Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 176.)

Definition: *Phænocystes* whose spores are destitute of antero-posterior, but possess bilateral, symmetry;‡ capsules in 1 group at the anterior end; a bivalve shell, the plane of junction of whose valve is parallel to the longitudinal plane; an iodinophile vacuole; type (and only) genus, *Myxobolus* Bütschli.

MYXOBOLUS Bütschli, 1882.

Bronn's Thier-Reich, I, t. 38, f. 6–10; *Myxosporidium* § Perugia, 1891, Boll. Scientif. Pavia, XIII, p. 23; *Myxobolus* et *Myxosporidium* Weltner, 1892, Sitzgsber. d. Gesellsch. Naturf. Freunde Berlin, pp. 34–35; *Myxobolus* et *Henneguya*‖ Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 176, 177.

Definition: Characters those of the family; type *M. müllerí* Bütschli.

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* *Sporoplasm.* Protoplasm of the spore.

† I propose *Myxosporidium* Perugia (synonym for *Myxobolus* Bütschli) as the type genus of the Fam. *Myxosporidieæ* Perugia.

‡ Except species which have suffered reduction of characters (*Myxobolus unicapsulatus* sp. nov., *M. piriformis* Thél.).

§ I propose *M. merlucii* Per. as the type species of this genus.

‖ I propose *H. psorospermica* Thél. as the generic type. No valid generic distinction seems possible between the untailed and the tailed forms, for which latter Thélohan proposed *Henneguya.* Apart from the absence or presence of a tail (both of which conditions may, according to good observers, occur in the same species; cf. Weltner, Sitzgsber. Ges. Naturf. Freunde Berlin, 1892, pp. 28–36) the only character relied upon for their separation is the constancy of 2 capsules in the tailed forms, but this is also the typical number for *Myxobolus* and the presence of two exceptional species does not militate against the rule.

Myxobolus unicapsulatus sp. nov.

(Psorosperm of *Labeo niloticus* Müller, Müller's Archiv., 1841, p. 487, t. 16, f. 5 *a–d*.)

Spore: Of the form and size of *Chloromyxum dujardini* Thél.; capsule only 1, obliquely directed.

Habitat: *Labeo niloticus*, from the Nile.

Myxobolus piriformis Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, p. 177.

Myxobolus inequalis sp. nov.

(Psorosperms of *Pimelodus blochii* (Valenc.) Müller, Müller's Archiv., 1841, p. 487, t. 16, f. 6 *a*, *b*.)

Spore: Length 11 μ; breadth, 7 μ; capsules 2 of *unequal* size.

Habitat: On *Pimelodus clarias* Bloch (=*Silurus clarias* Valenc.), from Guiana and Surinam.

Myxobolus mugilis Perugia, 1891.

Myxosporidium mugilis, Boll. Scientif. Pavia, XIII, pp. 23–4; *Myxobolus mugilis* Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 166.

Myxobolus oviformis Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, p. 177.

Myxobolus mülleri Bütschli, 1882.

Bronn's Thier-Reich, I, t. 38, f. 6–10.

Myxobolus oblongus sp. nov.

(Psorosperms of *Catostomus tuberculatus* Müller, Müller's Archiv., 1841, pp. 487–90, t. 16, f. 7–9.)

Cyst: Round or elliptic, 1 mm. or less.

Spore: Spatular or round-oblong; length, 14 to 17 μ; greatest breadth and greatest thickness at about the junction of the anterior and second fourth of the length; breadth, 8.5 μ; thickness, 5 to 6 μ; width of ridge nearly equal to one-third of thickness; capsules, 2; nuclei 2, and perhaps* more; vacuole not seen.

Habitat: Subcutaneous on head of *Erimyzon sucetta* Lac. (= *Catostomus tuberculatus* Le Sueur).

Myxobolus ellipsoides Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, p. 177.

Myxobolus bicostatus sp. nov.

(Myxosporidian sporeof branchiæ of *Tinca vulgaris* Bütschli, 1882; Bronn's Thier-Reich, I, t. 38, f. 19.)

Spore: Shell with 2 oblique ribs over the longitudinal axes of the capsules; capsular index 0.50.†

Habitat: Branchiæ of *Tinca tinca* L.

Myxobolus lintoni sp. nov.

(Psorosperms of *Cyprinodon variegatus* Linton, 1891, Bull. U. S. Fish Com. for 1889, IX, pp. 99–102, t. 35, f. 1–16.)

Spore: Ovate; length, 13.9 μ; breadth, 11 μ; thickness about 8 μ; shell, valves separating rapidly in sulphuric acid (cold, concentrated); capsules, 2, equal; filaments extruded under influence of sulphuric acid and of iodine water; nuclei *ad plur.* 4, 2 of which are the pericornual;‡ vacuole present.

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*The condition of the material being such as not to exclude the possibility of sporoplasmic degeneration, these results are not entirely decisive.

† *Capsular index.* The ratio of the length of the capsule to the antero-posterior diameter of the shell cavity.

‡ *Pericornual nuclei.* The 2 nuclei ("granules" "globules") situated at the antero-lateral angles (*cornua*) of the sporoplasm or on the posterior extremities of the capsules.

Habitat: Subcutaneous, on *Cyprinodon variegatus*, from the Atlantic at Woods Holl, Mass., August 20, 1889.

Myxobolus obesus, sp. nov.

(Psorosperm of the "Ablette," Balbiani, 1883, Journ de Microgr., VII, p. 203, fig. 43.)

Spore: Very broadly ovate.

Habitat: On *Alburnus alburnus* L.

Myxobolus cycloides, sp. nov.

(Psorosperms of *Cyprinus rutilus* (*pars*) Müller, Müller's Archiv., 1841, pp. 481, 486, t. 16, f. 4 *d–g*.)

Spore: Subcircular-ovate to broadly rounded-elliptic.

Habitat: Opercle and pseudobranchiæ of *Leuciscus rutilus* L., from German rivers, May and June.

Myxobolus spheralis sp. nov.

(Psorosperms of *Coregonus fera* Claparède, 1874, in Lunel's Hist. Nat. d. Poissons du bassin du Léman, Geneva, pp. 113-4.)

Spore: Untailed; perfectly spherical; diameter, 9 μ; containing a single spherical very strongly refringent "nucleus" [? vacuole].

Habitat: Cysts imbedded by thousands in the branchial mucosa of *Coregonus fera* Jur.

Myxobolus globosus, sp. nov.

Cyst: Elongate-elliptic or rod-shaped; length *ad max.*, 0.50 mm.

Spore: Globose; length, 7 or 8 μ; breadth, 6 μ; thickness, 5 μ; ridge very wide, one-third of thickness; capsular index somewhat more than 0.50.

Habitat: Branchial lamellæ of *Erimyzon sucetta* Lac. (= *Catostomus tuberculatus* Le Sueur), from Kinston, N. C., Columbia, S. C., and from the tributaries of the Fox River, Miss. (collections U. S. National Museum).

Myxobolus transovalis, sp. nov.

Spore: Transversely elliptic; length, usually 6, occasionally 7 μ; breadth, 8 μ; valves separating in sulphuric acid; ridge narrow; capsules 2, equal; capsular index, 0.50; filaments extruded under the influence of glycerine and of sulphuric acid; nuclei, 2, rarely only 1, pericornual nuclei apparently absent; vacuole probably present.

Habitat: In hollow of under surface of scales of *Phoxinus funduloides* from Four mile Run (tributary of Potomac River), Carlins, Va., June 29, 1892.

Myxobolus merlucii Perugia, 1891.

Myxosporidium merlucii, Boll. Scientif. Pavia, XIII, pp. 22, 24, f. 9–14.

Myxobolus perlatus, sp. nov.

(Psorosperms of *Acerina cernua* Balbiani, 1883, Journ. de Microgr. Paris, VII, pp. 201, 204, fig. 44.)

Spore: Wider than long.

Habitat: On *Gymnocephalus cernua* L.

Myxobolus?? zschokkei, sp. nov.*

(Psorosperms of *Coregonus fera* Zschokke, 1884, Archiv. de Biol. v, pp. 234–5, t. 10, f. 16.)

Cyst: Oval, pea to nut size; multiple (up to 30).

Spore: Body lenticular or oval, a little wider in front than behind; often bearing in front a blunt prolongation; posteriorly one distinguishes two "tails" (*queues*) 6 to 8 times longer than the body, attenuating posteriorly, curved and undulating; the number of two "tails" is constant; at the pole opposite to the "tails" are 2 oval, transparent anteriorly converging vesicles; one sometimes sees, however, an extremely fine canal extending from the posterior end of each vesicle to the base of the corresponding "tail"; the vesicles then probably play here also the rôle of receptacles for the "tails"; round refractile globules are also seen at the bases of the vesicles; the remainder of the body is filled by a homogeneous plasmic mass which frequently contracts to the center of the body cavity, forming a clearly distinct round or oval mass.

Habitat: Subcutaneous and superficial intermuscular tissue of *Coregonus fera* Jur.; April and May.

Myxobolus brevis Thélohan, 1892.

Henneguya brevis, Bull. Soc. philomat. Paris, iv, p. 177.

Myxobolus medius Thélohan, 1892.

Henneguya media Bull. Soc. philomat. Paris, iv, p. 176.

Myxobolus monurus, sp. nov.

(Psorosperms of *Aphredoderus sayanus* Ryder, 1880, Amer. Nat. xiv, pp. 211–212, figs. 1, 2.)

Cyst: Lenticular, large, about 20 in number.

Spore: Tailed; body lenticular or slightly obovate; tail undivided, thick at origin, gradually attenuating, more or less curved, 2 to 3 times as long as body; capsules 2, equal, subparallel.

Habitat: Subcutaneous intermuscular tissue of *A. sayanus* from near Woodbury, N. J.

Myxobolus macrurus, sp. nov.

Cyst: 15 to 20 or more, the size of a pinhead.

Spore: Plainly dorso-ventrally asymmetric; tailed; body round-elliptic; 10 or 11 μ long; 6 to 8 μ broad; 4 μ thick. Shell insoluble in sulphuric acid (cold, concentrated); superior valve more convex than inferior; tail somewhat less transparent than shell, completely dissolved by cold concentrated sulphuric acid; almost or entirely invisible in balsam; length 30 to 40 μ, usually much less, the attenuate posterior portion being easily, and consequently frequently, broken off; tail separated entirely from shell by iodine water. Capsules 2, equal; nuclei *ad plur.* 4, 2 of them being the pericornual; vacuole present.

Habitat: Cysts invariably† embedded in the subcutaneous tissue of some part of the head (especially the under surface of the lower jaw) of *Hybognathus nuchalis* Ag., from the Neches River, 14 miles east of Palestine, Texas, November 24, 1891.

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* Dedicated to Dr. F. Zschokke, of Basel.

† Among several hundred cysts, one was seen at the base of the pectoral fin, say 3 mm. behind the head.

Myxobolus strongylurus, sp. nov.

(Psorosperms of *Synodontis schal*, Müller, Müller's Archiv., 1841, pp. 480–481, t. 16, f. 2.)

Spore: Body anteriorly blunter than in *M. schizurus;* length of body 9 μ; breadth 5.4 μ; tail single, undivided, very peculiar in being constantly oblique in the longitudinal plane.

Habitat: Encysted in skin of head of *S. schal* from the Nile.

Myxobolus kolesnikovi,* sp. nov.

(Psorosperms of *Coregonus fera* Kolesnikoff, 1886, Veter. Vestnik Kharkoff., v, pp. 242–248, f. 1–3.)

Cysts: Numerous (up to 80), spherical or oval, 10 to 30 mm. long by 7 to 20 mm. broad.

Spore: Round or oval with a sharp anterior end; tail single or double, thick at its origin, attenuating gradually.

Habitat: Interstitial connective tissue of the thoracic muscles of *Coregonus fera* Jur.

Kolesnikoff's figures show the "double" tail to be merely the separated (laterally shifted) halves of the really single tail. To this species should probably be approximated one of Claparède's 3 forms, † viz, the tailed form habitant in the muscles of *C. fera.*

Myxobolus linearis, sp. nov.

(Psorosperms of *Pimelodus sebæ* and of *Platystoma fasciatum* Müller, Müller's Archiv., 1841, p. 489, t. 16, f. 10).

Spore: Body lanceolate-linear; length 3 to 4 times breadth; capsules 2, equal, entirely parallel-appressed; tail single, occasionally double.

Habitat: Cysts in membrane lining branchial cavity of *Rhamdia sebæ* Cuv. & Val., and in branchial lamellæ of *Pseudoplatystoma fasciatum* L., both from South American rivers.

In cysts at the base of the dorsal fin of *Ameiurus melas* Raf., from Storm Lake, Iowa, a spore occurs which I strongly suspect to be identical with this species, as it answers in every respect to the above (rather meager) diagnosis. It is peculiarly interesting, as the tail is composed of a dorsal and a ventral half, and is insoluble in sulphuric acid (cf. *M. macrurus*).

Myxobolus schizurus, sp. nov.

(Psorosperms of *Esox lucius* Müller, Müller's Archiv., 1841, pp. 477–478, t. 16, f. 1.)

Cyst: 0.44 to 1.09 mm. in diameter.

Spore: Body oval, length 12 μ; breadth 6 μ; thickness one-half the breadth; tail stout at origin, 3 to 4 times length of body, very frequently (probably as a rule) more or less bifurcate; capsules 2, equal, diverging posteriorly.

Habitat: In cellular tissue of the eye muscles, in that of the sclerotic, and in that between the sclerotic and choroid of *Esox lucius* in May and June. Müller failed to find it in North American pikes.

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* Dedicated to N. F. Kolesnikoff, who first figured this form.

† Claparede in Lunel's Hist. Nat. d. Poissons du bassin du Léman, pp. 113.

Myxobolus creplini,* sp. nov.

(Psorosperms of *Acerina vulgaris* Creplin., 1842, Wiegm. Archiv. f. Naturgesch, I, pp. 61–63, t. 1, f. 1 *a-e*; cf. Weltner, 1892, Sitzungs.-Ber. Ges. Naturf. Freunde Berlin, pp. 29–31, 34).

Spore: Body elongate ventricose-elliptic; length 17.3 μ; breadth 5.8 μ; tail simple, as long as or a little longer than the body; capsules 2, equal.

Habitat: On *Gymnocephalus cernua* L., collected March 14, 1837.

Weltner believes the form observed by him in the ovary of *Esox lucius* to be identical with this form. Weltner's species was sometimes tailed and sometimes untailed.

Myxobolus psorospermica Thélohan, 1892.

Henneguya psorospermica, Bull. Soc. philomat. Paris, IV, pp. 167, 176.

Myxobolus diplurus, sp. nov.

(Psorosperms of kidney of *Lota vulgaris* Bütschli, 1882, Bronn's Thier-Reich, I, t. 38, f. 21.)

Description (from figure).

Spore: Capsules 2, equal, posteriorly situated; tail double from base, the 2 halves adnate.

Habitat: Kidney of *Lota lota* L.

CHLOROMYXIDÆ fam. nov.

("Chloromyxées" *et* "Myxidiées" (*pars*) Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 176.)

Definition: *Phænocystes* destitute of antero-posterior, but possessing bilateral, symmetry;† capsules in 1 group at the anterior end; a bivalve shell, the plane of junction of whose valves is perpendicular (?) to the longitudinal; no vacuole; type genus *Chloromyxum* Ming.

CHLOROMYXUM Mingazzini, 1890.

Bull. Soc. Nat. Napoli, IV, p. 160; *ib.*, *Sphærospora*, *Myxosoma et Mixosoma*‡ Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 175–6.

Definition: *Chloromyxidæ* with subspherical or ovate spores, whose breadth does not exceed their length; valves hemispherical; sporoplasm bilaterally and symmetrically situated; type *C. leydigii*.

CHLOROMYXUM *sens. strict.*

Definition: Quadricapsulate Chloromyxa; type *C. leydigii*.

Chloromyxum fluviatile Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, pp. 173, 176, fig. 2.

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* Dedicated to the discoverer, J. C. L. Creplin.

† Imperfect from unilateral position of sporoplasm in *Ceratomyxa*.

‡ See subgenus *Sphærospora*, p. 419. The table on p. 411 shows that *Sphærospora* and *Mixosoma* differ from *Chloromyxum* by only a single character, viz: the *number* of the capsules. As shown on p. 411, this character is a subordinate one compared to the *grouping* and *position* of the capsules, in which latter all the three genera agree. They may, therefore, all be grouped under one genus.

The two unispecific genera *Sphærospora* and *Mixosoma* have (at least as far as the record now shows) absolutely no distinctive character but the *shape of the spore*. They are therefore fused. Provisionally (but with some hesitation) I have recognized *Sphærospora* (including *Mixosoma*) as a subgenus. Its sole claim to such distinction rests on 2 capsules as against 4 in *Chloromyxum* proper. It is also worthy of note that the possibility of transitions are by this definition arbitrarily excluded, inasmuch as all our experience shows that increase of capsule number is by *duplication* and not by *addition*. So that the possibility of its ultimate entire fusion with *Chloromyxum* seems by no means remote.

Chloromyxum mucronatum sp. nov.

(Psorosperms of *Gadus lota* Lieberkühn, Müller's Archiv., 1854, pp. 352–3, 368, t. 14, f. 5, 6.)

Myxosporidium: Measuring 75 μ or less; spherical or ellipsoidal, rarely irregular.

Spore: Broadly rounded-oval; concave pointed anteriorly; length *ad max.*, 8 μ.

Habitat: Free in urinary bladder of *Lota lota* L.

Chloromyxum leydigii Mingaz., 1890.

Boll. Soc. Nat. Napoli., IV, pp. 160–4 (see also the next species).

Chloromyxum incisum sp. nov.

(Psorosperms of *Raja batis* Leydig, Müller's Archiv., 1851, pp. 225–226, 234, t. 8, f. 4*a–f.*)

Myxosporidium: Biliary yellow, roundish or somewhat elongate, 29 to 88 μ in diameter, without or with 1 to 4 pansporoblasts.

Spore: Sharply cuneate-oval, *posterior border radiate-incised*, resembling a radiate-ribbed Lamellibranch shell.

Habitat: Free in gall-bladder of *Raja batis* L.

In face of the striking difference between this spore-form and *C. leydigii*, the present evidence (which consists of Mingazzini's opinion* without any detailed evidence, Perugia's opinion,† too little explicit, and the probably not independent opinion of Thélohan ‡) is insufficient to warrant the fusion of the two forms, especially as it does not appear that either Mingazzini or Perugia examined the gall-bladder of *Raja batis*.

Chloromyxum ? ? congri Perugia, 1891.

Myxosporidium congri, Boll. Scientif. Pavia, XIII, pp. 24–5, f. 15–20.

Habitat: Gall-bladder of *Leptocephalus conger* collected in August, 1890.

Subgenus SPHÆROSPORA Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, p. 175; *Mixosoma*§ *et Myxosoma ibid.*, p. 175.

Definition: Bicapsulate Chloromyxa; type *Chloromyxum* (*S.*) *elegans* Thél.

Chloromyxum elegans Thélohan, 1892.

Sphærospora elegans, Bull. Soc. philomat. Paris, IV, pp. 167, 175.

Chloromyxum dujardini Thélohan, 1892.

(Psorosperms of *Cyprinus rutilus* (*pars*) Müller, Müller's Archiv., 1841, pp. 481, 486, t. 16, f. 4 *b*, *c*; psorosperm of *Cyprinus erythrophthalmus* Dujardin, 1845, Hist. Nat. des Helminthes, p. 644, t. 12, f. 12 N_1, 12 N_2.)

Mixosoma dujardini, Bull. Soc. philomat. Paris, IV, p. 175.

Myxosporidium: 1.25 to 1.50 mm. long.

Spore: Ovate, pointed anteriorly, broadly rounded posteriorly; length 10 to 12 μ; capsules 2, of equal size.

Habitat: Branchial lamellæ of *Leuciscus* (*Scardinius*) *erythrophthalmus* from the Vilaine, at Rennes, France; pseudobranchiæ of *Leuciscus rutilus*, from German rivers.

Concerning the form observed by him, Müller says:

Once there was found on the pseudobranchiæ (*Nebenkiemen*) a mass of small yellow cysts. The size of this mass was 4 lines. This time all the cysts contained elongate capsules with pointed anterior and bluntly rounded posterior ends (f. 4 *b*). On the flat border the convex surfaces were exactly equal and the two diverging vesicles were attached interiorly at their points.

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* Boll. Soc. Nat. Napoli, 1890, IV, pp. 160–161.

† Boll. Scientif. Pavia, 1890, XII, p. 138.

‡ Bull. Soc. philomat. Paris, 1892, IV, p. 176.

§ Type *Chloromyxum* (*Mixosoma*) *dujardini*.

Thus this form was never found coexisting in the same cyst with *Myxobolus cycloides* sp. nov. Considering the great frequency of occurrence of the latter species such coexistence would be expected if they were merely different forms of one species. Their persistent non-association thus strongly reënforces the argument in favor of their specific distinctness, drawn from their different characters.

The synonymy is on the authority of Thélohan (letter to the author, 1893). He has found *Mixosoma dujardini* upon both of the fishes named above and believes that Müller's and Dujardin's figures represent the same species.

CERATOMYXA Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, pp. 169, 175.

Definition (provisional): *Chloromyxidæ* with bilaterally symmetrical, transversely extended, sub-isosceles-triangular spores, whose breadth greatly exceeds the length; valves hollow-conical with solid tips; sporoplasm unilaterally and asymmetrically situated; type *C. sphærulosa* Thél.

Ceratomyxa sphærulosa Thélohan, 1892.

Bull. Soc. philomat. Paris, IV, pp. 171–3, 175, fig. 1.

MYXIDIIDÆ fam. nov.

("Myxidiées" (*pars*) Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 175.)

Definition (provisional, as regards negative characters): *Phænocystes* destitute of antero-posterior, but possessing bilateral symmetry; capsules in 2 groups in the (right and left) wings; no bivalve shell; no vacuole; type (and only) genus *Myxidium* Bütschli.

MYXIDIUM Bütschli, 1882.

Bronn's Thier-Reich, I, t. 38.

Definition: Characters those of the family; type *M. lieberkühnii* Bütschli.

Myxidium lieberkühnii Bütschli, 1882.

Bronn's Thier-Reich, I, t. 38, f. 12–15.

Probably a second species is Leydig's "psorosperm" of the bile-ducts of *Raja batis*, Müller's Archiv, 1851, pp. 226, 234, t. 8, f. 4*g*.