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## The family Koellikeriadae (Didymozoidae Mont.).

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With Plate 1—3.

The genus *Didymozoon* was created by TASCHENBERG, 1878, 1879 to comprise "worms elongated, sometimes kidney shaped or grown together in a ring with demarcated, often thread-like neck; without suckers. Pharynx spherical or oval, intestine present or absent. Testes forming a tube in numerous convolutions. Egg bearing canal extending in coils with the latter throughout the body. Genital orifice at the anterior body end. Vitellarium absent. The small oval eggs with chitinous shell present in millions in the uterus." The genus *Nematobothrium* later ranged with *Didymozoon* in this family by MONTICELLI and BRAUN is not concisely defined by VAN BENEDEN. BRAUN describes them as very much elongated Didymozoidae without intestine but with mouth opening and with genital pore at the head end.

These two genera make up the family Didymozoidae (MONTICELLI, 1888) defined by BRAUN as follows: Digenetic trematodes living always in pairs in cysts without separation of sexes. Anterior part of body narrowed into a neck, posterior part cylindrical or swollen into kidney shape; sometimes two individuals are grown together. Mouth sucker alone present; pharynx rudimentary or absent; intestine present or absent. Genital pore in front of mouth, terminal. Testis

a much convoluted tube accompanied by windings of the uterus. Eggs very numerous without filaments. Living on the outer surface of the body or in the mouth, branchial cavity or in the body of marine fishes.

As will be seen by anyone who reads the descriptions of the various worms which go to make up this family together with those of a number of other forms which have been given places among the Distomidae or Monostomidae, there still reigns the greatest confusion and it seems almost impossible to set the matter straight because in so many cases names have been assigned after only the most meager study of the worm and even without a single word of description. It is clear that some of the species belong not to the genus *Didymozoon* but to *Nematobothrium* while other genera have been established (*Koellikeria*, *Wedlia* by COBBOLD) to receive forms which had previously been named *Monostomum* or *Distomum*. Of these genera which were proposed long before *Didymozoon*, BRAUN rejects *Wedlia* and retains *Koellikeria*. Both evidently contain forms which correspond with those described as *Didymozoon* and strict adherence to the rules of nomenclature should force us to use one of these names instead of *Didymozoon*.

COBBOLD in 1860 described the genus *Koellikeria* as follows: „Sexus discretus. Corpus maris filiforme antrorsum clavatum, retrorsum sensim attenuatum. Os acetabuliforme orbiculare. Acetabulum ventrale sessile. Apertura genitalis inter os et acetabulum. Corpus feminae antrorsum filiforme clavatum, retrorsum subito increscens, reniforme. Apertura genitalis inter os et acetabulum. *K. filicollis* COBB. = *D. okenii* KOELL., *D. filicolle* VAN BENEDEN, *Monost. filicolle* RUD.

The same author described the genus *Wedlia* as follows, the description showing that it is like *Koellikeria* except in having only one sucker.

*Wedlia*: Corpus inerme, reniforme, lobatum; aliquando antrorsum attenuatum, apice incrassatum clavatum, retrorsum subito increscens. Os terminale acetabuliforme. Acetabulum ventrae mullum. Androgyna (?) apertura genitale infra os. Oviparum, ovulis non operculatis, avium incola et in cavo branchiarum piscium marinarum gemmatim in folliculis inclusum.

*Wedlia bipartita* COBB.

*Wedlia faba* COBB. = *Monost. faba* BREMSER.

Probably none of these descriptions is absolutely exact since, as we shall see, the presence or absence of suckers seems to be a variable feature in these forms and rudimentary suckers or fading remnants of an atrophying and disappearing sucker make it difficult to decide whether there are two, or only one, or none. This appears to be the result of their perfectly inactive life in a cyst and although it is probable that they all originally had two suckers, these organs are now found in various stages of retrogression and their number can scarcely be used as the basis for separating genera.

With regard to the genital apparatus, close examination shows that while in one of the pair the female organs are highly developed and the male obsolescent, in the other the reverse is the case although in both there is a fading hermaphroditism. The outer form of the bodies corresponds with the predominance of the respective sex development.

Therefore specifications as to these points in the description of the genus have not the same decisive importance that they have in other genera and it seems on that basis that COBBOLD'S description of *Koellikeria* is about as accurate as the later ones and therefore by the rules of nomenclature since it is the first generic name which distinguishes these peculiar forms it should be accepted. There is nothing in the description given by TASCHEBERG for the genus *Didymozoon* which would justify the abandonment of the earlier genus, and his statement that there are no suckers is even less accurate than COBBOLD'S division of the group into *Koellikeria* with two suckers and *Wedlia* with one.

There is no good reason why *Wedlia* should not be used as the generic name except perhaps that *Koellikeria* appears first in the same paper.

It is therefore proposed to substitute the name *Koellikeria* for *Didymozoon* throughout and the genus may be briefly redescribed as follows:

*Koellikeria* (COBBOLD, 1860).

Digenetic trematodes living in pairs in cysts. Hermaphrodite but sexually distinguishable by the outer form and by the predominance in each of the genital organs of one sex with obsolescence

of the others. Anterior part of body narrow, posterior part cylindrical or swollen into kidney shape: sometimes two individuals are grown together. Suckers rudimentary or very feebly developed. Both may be present or one or both may be absent: pharynx and intestine may be rudimentary or absent. Genital opening near mouth. Ovary and yolk gland long convoluted tubes meeting in a shell gland at beginning of a long tubular uterus. Eggs yellow and rounded. Testes saccular or tubular with long convoluted vas deferens. No muscular cirrus. Many forms are supplied with a nutritive vascular film from the host.

The situation may be presented most clearly by giving a brief summary of the descriptions of the forms which appear to belong in each of the long accepted genera *Didymozoon* and *Nematobothrium*.

Genus *Koellikeria* COBB. (*Didymozoon* TASCHEBERG).

*K. (D.) thynni* TASCHEBERG. (*Monostomum bipartitum* WEDL, WAGENER etc.)

WEDL's description follows: Cysts 3—4 mm in size found on the gills of *Thynnus vulgaris* contain one or two peculiar monostomes. There is a pyriform head and reniform body connected by a long strand. Head measures  $1,4 \times 0,6$  mm, the abdominal part 2 mm, the neck  $2 \times 0,8$  mm. The smaller of the two worms which seems sexually immature has a much smaller abdominal part. Anterior sucker obliquely perforated, behind it the opening of the uterus which runs back into the abdomen. Thin grey cords seen there represent the ovary. Eggs yellow, brown, reniform  $0,026 \times 0,005$  mm.

TASCHEBERG adds, pharynx oval, intestine present. The two individuals of one cyst grow together into a roundish structure with two heads. Length  $6 \text{ mm} \times 4,5 \text{ mm}$ .

Many others have described this worm, WAGENER mentioning 3 types and ARIOLA separating 3 species which he assigns to 2 new genera *Didymocystis* and *Didymostoma* as follows:

*Didymocystis reniformis* (WAGENER's second form).

Animals in each cyst similar to one another. The two regions of body sharply demarcated, posterior sac like, anterior filiform 3—4 mm long and enlarged anteriorly. Mouth small, terminal with double muscular pharynx but no sucker, short oesophagus and two

simple intestinal coeca. Genital opening below bifurcation, with genital canal. Parallel to this canal runs the uterus which opens near the mouth. Eggs bean shaped  $16 \times 10 \mu$ . Animal  $10 \times 6$  mm.

*Didymostoma bipartitum* (WEDL, 1855), (WAGENER'S first form).

Identical with *Didymozoon micropterygis* of RICHIARDI. Cysts with two dissimilar individuals, one large as a pea with two regions, filiform and globular; the other minute without posterior swelling. Mouth sucker present, but no pharynx; short oesophagus bifurcates in two simple intestinal coeca. Uterine opening near mouth. Eggs  $21 \times 11,6 \mu$ . Small individual has mouth sucker and larger and longer neck. Measures  $3,5 \times 2$  mm. The smaller is 2,5 mm in length.

*Didymocystis wedli* (WAGENER'S third form).

Cysts on gills contain two equal individuals with elongated body, the abdominal region of which is divided into two parts, a caudal recurved cylindroid and a larger anterior part indented by a groove from which the head emerges. No swelling of cephalic end, no mouth sucker, double pharynx. Oesophagus divides into two intestinal coeca. Genitalia as in other forms.

Apparently then at least three different species have been known by the same name but it seems doubtful that new generic names should be established on such slender basis as stated in ARIOLA'S descriptions and I prefer to class all three as *Koellikeria*, especially since other species of this genus possess mouth suckers.

*Koellikeria (Didymozoon) scombr* TASCHEBERG.

Body elongated, rounded at both ends, neck only slightly narrower than the body. Pharynx spherical, intestine present. Opening of uterus on a little papilla et anterior end of animal. Length 18 mm. Cysts on the gill covers of *Scomber colias*.

*K. (D.) pelamydis* TASCHEBERG.

Body very long, slightly narrowed posteriorly and sharply pointed; neck thin, head widened, spoon shaped. Pharynx spherical. Intestine lacking. Length 30 mm. Cysts between gill leaflets of *Pelamys sarda*.

*K. (D.) sphyraenae* TASCHEBERG.

Body short, compressed, rounded posteriorly. Neck sharply marked off from body; head very little broadened. Pharynx oval,

intestine present. Length 15 mm, breadth 1,5 mm. Cyst under the mucosa of the mouth of *Sphyraena vulgaris*.

*K. (D.) auxis* TASCHEBERG.

Body long and slender, nearly rectangular, sometimes folded at the margins. Neck very sharply marked out from the body, thread-like. Pharynx oval. Intestine lacking. The two individuals in a cyst grow together sometimes through the union of anterior and posterior body ends into a ring. Length 12 mm. In cysts on the outside of the gill leaflets of *Auxis rochei*.

*K. (D.) serrani* MONTICELLI.

"This new species was found on the gills of a *Serranus fimbriatus* from Madeira; the same undescribed species I have frequently found attached to the gills of *Serranus gigas* of the Gulf of Naples. At present I give only a figure of this new species to ensure its recognition. The detailed description with anatomical remarks will be given in a forthcoming paper. The lengths of the cysts of this new species are 6—10 mm."

*D. serrani* is the first species of this genus found in fish of the family *Percidae*, the other known species inhabiting fishes of the families "*Scombridae* and *Sphyraenidae*".<sup>1)</sup>

*K. (D.) pretiosus* ARIOLA.

A single cyst found on the gills of *Thynnus vulgaris* contained two equal individuals. Abdomen long flattened and ribbon-like, as in *D. sphyraenae* and *pelamydis*. There is a quadrilateral expansion at the union of neck with the body. Mouth sucker lacking. Length 11 mm of which 8 mm belong to the abdomen.

*K. (D.) micropterygi* RICHIARDI.

This paper was inaccessible to me but ARIOLA states that the form is identical with his *Didymostoma bipartitum*.

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1) Such characteristic descriptions form the source of the confusion referred to above. No further description has appeared to my knowledge and we know nothing of this worm — not even whether it merits a separate specific name or not.

*K. (D.) exocoeti* PARONA et PERUGIA.

This paper is also inaccessible but the form is the same as *Monostomum filum* DUJ. and lives in the liver and in the eye of *Exocoetus exiliens*. It possesses a long thread-like body attached to the cyst wall, a mouth sucker and pharynx.

*K. (D.) benedenii* MONTICELLI.

A new and interesting species of *Didymozoon* found on the gills of *Orthogoriscus* probably same as that found by VAN BENEDEN but given this name. Nothing can be determined of the nature of this worm, especially since MACLAREN who thought it identical with his properly described *Nematobothrium molae* was persuaded by MONTICELLI that it was a different worm. At any rate it is probably a *Nematobothrium*.

*K. (D.) filicolle* RUD., 1819. VAN BENEDEN, 1858.

Syn. for *Distomum filicolle* VAN BENEDEN, *Monost. filicolle* RUD., *D. okenii* KÖLL., 1849, *Köllikeria filicolle*.

Two different individuals in each cyst in the gills of *Brama raja*. The sac is not really a cyst as it opens into the branchial cavity. One individual is full of eggs, the other thin and delicate. The anterior part of body is narrow, slightly swollen anteriorly. Rest of body very large and rolls on itself. Buccal and abdominal suckers easily recognized. Intestine bifurcated — between the coeca a canal which opens behind the buccal bulb. This is the uterus partly filled with eggs and convoluted in posterior part of body. There are other tubes not yellow but milk white all belonging to the female apparatus. The other individual is like this in the anterior part but the body narrows behind and is elongated. There is a long tube beside the intestine but no eggs. Probably the male organs atrophy in one, the female in the other. WAGENER has seen spermatozoa and eggs in the same individual and two of this kind in a cyst. There are worms which are more or less female or more or less male (VAN BENEDEN).

*K. (D.) tenuicolle* RUDOLPHI, 1819.

Syn. *Monost. tenuicolle* RUD. *Dist. affine* DIES. *Dist. decorynum* DIES. and probably *Didymozoon lampridis* LÖNNBERG. Worm encysted

in flesh of *Lampris guttatus* measuring  $20 \times 30$  lines. Neck narrow. Abdomen full of vessels of three kinds two of which are brown. The drawings which R. gives make it clear that this is a characteristic *Didymozoon*.

*K. (D.) lampridis* LÖNNBERG.

From cysts in gills of *Lampris guttatus*. Worm 30—35 mm long paired in cysts but not united. There is a mouth sucker instead of a pharynx with radiate and circular muscle. No intestine present, the loss of intestine and weak development of musculature connected with the mode of life in cyst (BRAUN).

It will be seen that in no single instance is the anatomy of these worms at all completely understood but the external characters are such that it seems entirely justifiable to range them in one genus — *Koellikeria*. The following descriptions of other species recently met with may throw a little light on the finer structure and the relation of the worms to the allied genus *Nematobothrium*.

*Koellikeria xiphiados n. sp.*

In cutting up a sword fish (*Xiphias gladius*) a fisherman at Woods Hole came upon several cysts embedded in the muscles behind the gill cavity and containing large rounded masses which could be easily shelled out. He shelled out all of them and mutilated all but two so that the relations were much obscured, but in the material which he brought to the laboratory the U.S. Fish Commission, it could be seen that the cysts were thick walled and lined with a smooth white tissue. They measured  $31 \times 36 \times 50$  mm and two of them which lay close together had a common partition wall. They were situated just under the skin of the host the most distant one being 70 mm from the branchial cavity. From each there ran toward the gill cavity a cord made up of blood vessels which extended into the cyst and into relationship with the enclosed parasite in a peculiar way. There was no evident opening in the cyst wall through which communication with the outside could be established. The contents of the cysts were rounded or ovoid masses covered with a very thin, white wrinkled or smooth velvety membrane which ruptured at the slightest touch showing the parasite to be made up of irregularly triangular or wedge shaped lobules connected at the center by their apices. Into this mass there penetrated in every direction the vas-

cular film supplied with the arterial blood of the host through the cord described and drained by the vein of the same cord. This arrangement is almost like the vascular stroma of a tumor or like the circulation supplied to the foetus inasmuch as it evidently maintains the nourishment of the parasite.

The ovoid worms measured  $24 \times 28 \times 40$  m. There were in all five of them although one was reduced to a hardened brown shrunken mass which proved later to contain many recognisable eggs although the rest of the body was shrunken into a sort of mummified form. Otherwise they were all alike in form. Whether they lay two in a cyst or alone cannot be stated with certainty. On attempting to make out something of the structure of the animal it was found almost impossible to avoid tearing the fragile skin which formed the smooth outer surface and thus allowing the segments to pull apart. However, as will appear, these segments are not all of the same size and are not all continuously connected in the interior of the worm. Instead the vascular membrane entering between them at one point spreads out from the middle to lie in crevices among them in every possible direction. Any section of the mass shows these spaces containing a filmy connective tissue carrying the blood capillaries of the host.

At about that central point one may discover, by separating the segments, a small pointed white teat-like projection not more than 5 mm in length which proves to be the head. Ordinarily it is quite hidden down among the voluminous masses of the body, and whether it can stretch out so as to appear outside the sphere is difficult to say.

Little could be made out of the structure of the worm except by means of serial sections since the tissues were so excessively delicate and at the least touch ruptured to flood everything with eggs which appeared like yellow paint, so fine and so adherent they are.

A whole worm was embedded in celloidin and cut into thick serial sections which gave the topography of the internal organs. From another thin sections were made in various situations and the head was separated and cut into serial sections. From all these it was determined that the following conditions exist:

The pointed head and neck measure  $5 \times 1,4$  mm and therefore do not form an elongated filiform structure such as has been described in other forms. At the base this neck spreads out into the lobu-

lations of the body which rise up all round it so as to hide it from view.

At the extreme point there can be seen an indefinite rounded mass which shows some muscle fibers and which is apparently the representative of a mouth sucker or pharynx. No distinct opening can be seen and no definite vestige of an oesophagus or intestinal tract can be traced away from it. Somewhat lower in the neck there is a faint outline of a tube which bifurcates and which in its turn may be the remnant of a digestive tract but no connections could be shown.

On the other hand, the uterus and vas deferens are extremely prominent and open together at a point beside the muscular mass.

The uterus is thickwalled and muscular and somewhat coiled even in the neck — it continues back into the root of the neck and disappears into one of the lobes of a body where, becoming wider and thinner walled it extends continuously through all the lobes to its origin in a small isolated lobule situated rather near the neck at the junction of the lobes.

Throughout part of the lobulations, although apparently not all of them, there runs the long tubular ovary. Careful study has been made to determine whether this tube branches into any of the lobes or runs continuously as one tube. In one place near the entrance into the uterus it seemed that it was joined by a branch but this is uncertain. Everywhere it has the appearance of being a single continuous tube. The same things are true of the narrow tubular vitellarium which takes little of the blue nuclear stain but has its own brown color. This courses through many lobes but is probably one continuous tube. It meets the ovary and gives rise to a single tube which after several convolutions during which it is thickly surrounded by the shell gland becomes the beginning of the uterus. There is no evident receptaculum seminis. The shell gland forms a relatively large mass of radially arranged cells and from it the uterus runs back to enter one of the general lobes. The lobule in which the shell gland lies and in which this junction of the various canals occurs contains no other organs and is rather separated from the rest although continuous with them at either end. Its skin is very much corrugated. The uterus in its main portion is thin walled and distended with huge numbers of eggs which are yellow and rounded and measure 0,06 mm in diameter.

The vas deferens which opens at the termination of the pointed

head without any special muscular reinforcement is convoluted and rather bulbous in this part; posteriorly it divides into two branches which extend into two of the lobes and expand into plicated sacs — the testes. Not all the lobes contain testicular material and in the two which do the organ is evidently a continuous tubular sac. Spermatogenesis may be observed very clearly in all stages.

No excretory system could be clearly traced although there are many thin walled spaces and canals which doubtless have this function. Practically no musculature is found anywhere in the body except in the walls of the uterus. The whole mass is composed of a soft watery parenchyma of large cells and large spaces condensed into a firmer sort of connective tissue in the central mass where the lobules are held together. The skin is delicate and unarmed but provided with the usual cuticular cells.

It is most difficult of all to understand how the body acquired this peculiar shape and indeed to learn precisely what the relation of the parts is.

It was stated that the outer surface looked smooth and relatively white but that it readily cracked and fell apart revealing lobules. In section it is seen that the outer covering is not continuous over a smooth surface but that while it covers several lobulations it dips down between the main ones. Then, too, a quite similar cuticular covering is found upon lesser lobulations which are hidden in the main mass and upon the inner side of the various parts which go to make up the main lobulations. It is as though there were many folds or lobules which had fused in groups wherever they presented externally so that while over their outer surface, skin and parenchyma became continuous the inner parts remained discrete each covered there with skin so that a whole series of little crevices or caverns arose between these lobules roofed over by the fused outer part. It is into these crevices everywhere that the vascular film from the host finds its way and brings nutriment and oxygenation.

But all the lobules seem to fuse together at the centre into a sort of common core of denser tissue into which the vasa deferentia and the uterus run to enter the neck. The mass which contains the shell gland and the connection of ovary, vitellarium and uterus lies in this central part and indirectly connected with the central core.

It will be seen from this necessarily imperfect description that this worm differs in several respects from those already described.

It is lodged in cysts embedded deep in the muscles and not, as in most other cases in relation with the gills. It is definitely hermaphrodite both male and female organs being well developed. Whether two worms or only one live in each cyst we cannot state with absolute certainty since all were turned out of the cysts by the fisherman who could give no precise information about it. From measurements it would seem, however, that two of the worms might have been accommodated in each cyst.

The neck is remarkably short and practically no trace of suckers nor of digestive tract remains. The peculiar invasion of all the interlobular crevices by a vascular film from the host is similar to that seen in the form of *Nematobothrium* to be described and in another form of *Koellikeria*. It probably occurs generally although it is rarely mentioned. Similarly the reniform or bean shaped body so commonly found might prove to show lobulations such as are seen here, if carefully studied. From the arrangement of the uterus, ovary, vitellarium etc. it seems probable that this curious form is in this case at least not due to the mere swelling of the posterior end of the body but rather to the complicated coiling into a compact mass of what was originally a greatly elongated body with secondary fusions such as to consolidate the whole into a compact mass and even weld together the outlying parts into a smooth surface. The form next to be described from *Haemulon* presents a similar process in a simpler stage.

How the eggs escape from these cysts to the outer world is a problem which we cannot solve with the facts at our disposal. From somewhere near the branchial cavity a cord-like band was traced through the muscles to each cyst and this cord was found on section to contain a large artery and several veins which supply blood to the film described as penetrating the crevices of the worm. The suggestion has been made that some channel might exist along this cord through which the neck of the worm could extend to discharge eggs or through which the eggs themselves might pass into the branchial cavity, but no such canal was demonstrated. One specimen was found dried up into a mummified mass in which eggs were recognisable and this has also been observed in another form. It seems possible, therefore, that sometimes the eggs may never escape unless the host dies and disintegrates, when they may pass into some intermediate host.

Diagnosis: *Koellikeria xiphiados*. Large worms found encysted

in muscles of *Xiphias gladius*. Neck short, suckers, pharynx and digestive tract practically absent. Uterus and vas deferens open together at cephalic extremity. Body forms a lobulated mass with extensive fusion of lobules. Nutritive vascular film from host extending everywhere among these lobules. Eggs innumerable round and yellow. Shell gland bulky. No receptaculum seminis. Dimensions  $40 \times 28 \times 24$  mm.

*Koellikeria scomberomori n. sp.*

On October 1, 1911 there were found in the stomach of the Spanish Mackerel (*Scomberomorus maculatus*) 5 worms 4 of which were loose while 1 lay in a cavity or cyst in the wall of the stomach from which it could be pulled out. These were kidney shaped and measured  $1,75 \times 1,08$  mm with a slender neck which protruded 0,12 mm. No exact study could be made since none of the worms were cut into sections, but coils of the uterus full of eggs, the tubular ovary and vas deferens could be seen shining through the body wall. The ova measure  $0,014 \times 0,01$  mm.

In the very delicate neck the uterus and the vas deferens can be seen extending quite to the tip of the cephalic extremity. There is a small muscular mouth sucker and a very definite muscular pharynx there but no alimentary tract could be definitely made out.

Further study of this parasite will be necessary when better material is obtained before its systematic position can be more definitely established but there seems no question of its belonging to this genus and its size and shape and the form of the neck, which shows no cephalic enlargement, seem sufficient to distinguish it from any of the described forms.

In the same fish there were found on another occasion, August 15, 1912, four small pear shaped cysts of a bluish or lead color firmly attached to the gill filaments. They measured  $5 \times 3$  mm and at the center of the larger end there could be seen a small dark spot which seemed to be an opening. On teasing out the contents of one cyst it was found to contain two worms of an orange color with much black material in several parts of the body. Serial sections showed the cysts to be very thick walled and the contents to be almost entirely necrotic and loaded with black pigment. Many eggs of oval form measuring 0,01 mm could be seen but no outlines of the organs remained visible. In this case we venture nothing further but await more material for a more satisfactory study. The

parasite is probably a different form from that which we have named *K. scomberomori*.

*Koellikeria haemuli* n. sp.

On the pseudobranchs of *Haemulon flavolineatum* (Yellow Grunt) there were found (New York Aquarium) two reddish prominent masses which measured about  $6 \times 4 \times 2$  mm and which were intimately attached to the underlying bony tissues. In removing them they were unfortunately somewhat torn so that certain imperfections appeared later in the serial sections. Surrounded tightly by a fibrous capsule the enclosed worm was not to be everted but seemed rather to be embedded in a meshwork of fibrous partitions. Many elliptical yellow eggs were sifted off from the torn surface and these were found to measure  $0,2 \times 0,15$  mm. Since it was impossible to isolate the worms one cannot give an accurate impression of their external form but from a reconstruction of the serial sections it appears as though a very much elongated cylindrical worm, or more probably two, were coiled together in loops and irregular twists, invested everywhere with the tissues of the host and in many places adherent or even partly fused together. This idea although not absolutely proven is supported by the fact that each loop or fold in every section contains one cross section of each canal represented and further by the fact that one may trace any canal such as the uterus through fold after fold in succession.

Two of the encapsulated masses were found and cut into serial sections. They differ somewhat in structure but are unquestionably of the same species. The difference in structure depends upon the fact that in one mass the female organs of reproduction are most conspicuous while in the other the male organs overshadow the female. Elements of both, however, are present in each case.

In such a complex tangle it was essential to determine first whether two worms were concerned in each mass or only one, and even now after the most painstaking study of these two series we are not absolutely certain, chiefly on account of the imperfection of the specimens but partly on account of the extreme intimacy of adhesion of the folds which obscures the outlines.

In the first series only one head has been found with terminal pharyngeal bulb, oesophagus and uterine orifice. In the second

series a quite similar narrow prolongation was found with uterus, intestinal coeca etc. but the end was broken off before the actual head was reached. Nevertheless the structure was so similar to that of the head in the other series that there seems no doubt that this is the head of one worm. In this second series another head was found with pharyngeal bulb, oesophagus and a strongly developed vas deferens filled with spermatozoa. Two worms exist, therefore, in the second series: possibly only one in the first. The series will be described separately.

The first series: The head and neck are extremely slender and tapered anteriorly. Where the neck passes into the general tangle of folds of the body it becomes much wider and quite dense in structure. The mouth is terminal, guarded by no sucker but opening directly into an elliptical pharyngeal bulb. From this the oesophagus runs a short way and bifurcates into narrow, very thinwalled intestinal coeca which run far back into the body of the worm but do not branch again. The uterus, which is extremely narrow at its termination, opens just behind the pharynx. In the neck it is very muscular and this thick wall can be traced far back into the body. No trace of the vas deferens can be seen there. A short way behind the bifurcation of the intestine there is a minute but quite distinct ventral sucker. This is almost embedded in the parenchyma but does not open on the surface. It is extremely weak and small and is rather indistinctly outlined.

The nervous system is visible in its coarser features in the form of the usual pair of ganglia about the oesophagus. The excretory system in the form of one or two thinwalled tubes appears in the neck and courses through the rest of the body.

The main bulk of the worm is occupied by the female organs of generation which are arranged as follows. Extending back from the anterior orifice the uterus widens and courses along through every fold, twisting and turning so that in some places it is cut two or three times, in others only once. It runs back through the whole body once as a rather straight tube exactly as in *Nematobothrium sardae* and then in coils comes forward again. At one point in the body all the uterine coils are pushed aside by the great mass of the shell gland and within this there takes place the union of the portions of the reproductive system. The ovary which is long and cord-like lies in the anterior, part of the body. The vitellarium, also long and cord-like or tubular, extends through the posterior part.

They meet almost at a point in a thickwalled tube in the midst of the shell gland from which starts the narrow uterus. No receptaculum seminis nor LAURER'S Canal could be found. At first the eggs in the uterus take a bluish stain and this continues for some distance finally giving place to the more mature ones with thick yellow shell. It may be remarked that in this worm the large mass of radiating cells which forms the shell gland occupies the whole width of one loop of the worm and is very conspicuous. It is traversed also by one strand of the mid portion of the uterus and by a canal which seems to belong to the excretory system. It is curious that the portion of the body just behind this through which the beginning of the uterus courses from the shell gland contains in addition only the straight strand of the uterus and one of the vitellarium. It leaves the general mass of loops and after a little returns again and enters into their midst.

In the more anterior part of the body there are masses of testicular substance but their outline is very indefinite and difficult to trace. No vas deferens can be found and although there are certain loops whose content seems to be chiefly testicular tissue, which project from the inner surface of the mass it is impossible to reconstruct these organs clearly. Since little slender masses containing this tissue alone project sometimes from the edge of the section one gains the impression that they may be part of another worm with essentially male characters but no attempts to trace these were successful in anything more than losing them in the general mass — nor was a second head discoverable.

On the whole, then, in this mass was found a tangled coiled worm with highly developed female organs of reproduction opening near the mouth and ill defined testicular structures without recognisable connections. No second worm could be definitely made out.

In the second series the general appearance is at first sight the same. Abundant coils are seen to contain wide uterine canals filled with eggs and strands of the ovary and vitellarium but even the most careful search fails to reveal the mass of the shell gland which is so conspicuous a feature of the contents of the other mass. On the other hand the testicle is extremely well developed and sharply outlined and the vas deferens with its connection becomes very conspicuous.

Beginning in the mass of coils most distal from the broad attachment of the cyst is a distinct head closely resembling that

seen in the first mass in that the mouth opening is terminal guarded by a pharyngeal bulb and extending into a short oesophagus which quickly bifurcates. The nervous ganglia are very distinct and at their level just behind the pharynx is the opening of the vas deferens which is not provided with any especially muscular cirrus. Traced back through the neck of the worm the vas deferens continues as a thickwalled tube and is spirally twisted. No uterine canal is visible. No abdominal sucker is found although an indefinite pink staining mass with numerous scattered nuclei is visible at about the point where it was found in the other worm. After a quite long course during which it passes back into the central part of the tangled coils without showing any evidence of the presence of an accompanying uterus, there appears a lateral pear shaped sac which is filled with spermatozoa and which from its connection with the vas deferens must be regarded as a seminal vesicle or reservoir. From that point the vas deferens becomes connected with the abundantly folded and convoluted testis. It has not been possible to make out with certainty whether in each worm all these testicular masses are connected. In the other cyst there were numerous disconnected masses. In this one those connected with the vas deferens appear to be continuous but other separate testicular masses appear in the field of the microscope in other coils and probably belong to the second worm entangled in this mass.

At the other edge of the section, that is in the area of attachment where the worm was somewhat torn there is a neck-like elongated structure containing the muscular uterus and two intestinal canals. This was broken before the extremity was reached but it corresponds exactly with the neck found in the first cyst and must be regarded as belonging to a second head. The uterus is muscular and can be traced back as a thickwalled tube through coil after coil in the main mass. It is full of eggs. No vas deferens is found in this prolongation nor any ventral sucker. Probably, however, this latter would have been in the part which was broken off. The rest of the coils which seem to belong to this head contain the large uterus with many eggs, ovaries and vitellarian cord but as mentioned before no definite shell gland nor any place at which these canals form a conspicuous union could be found although the whole series was searched carefully. Such a connection must be present but it must be very different from that seen in the other mass for otherwise it could not possibly escape attention.

From all this it is seen that peculiar conditions prevail in this species. The worm is a cylindrical elongated form which is coiled abundantly in a meshwork of connective tissue. In one specimen there is a pair, in the other as far as we can see only one individual. The single individual is a well developed female with obsolescent male organs. In the pair there is one with very distinct and highly developed male characters and obsolete if any female characters, and another with rather poorly developed female characters and obsolescent testicular masses without any trace of vas deferens.

The name *Koellikeria* is retained for this transitional form, although apparently the worm is even more closely allied to the genus *Nematobothrium* than to the genus *Koellikeria* if one may judge from its body form and from the arrangement of its organs which is precisely that of the *Nematobothrium*. It furnishes an especially brilliant example of the degeneration and disappearance of organs under peculiar conditions of life and possibly represents a transition toward the monoecious state.

How cross fertilization has occurred in these specimens it is difficult to surmise for the efficient male is enclosed in a cyst at a distance from the efficient female and has only a rudimentary female in the same cyst to fertilize while the female is isolated except for its own rudimentary male apparatus.

The wall of the cyst is more fibrous and less vascular than that of the *Nematobothrium sardae*; nevertheless there are bands and filaments of highly vascular character which run between the coils and doubtless supply them with nourishment. No distinct opening for egress of eggs etc. could be made out, but this point must be restudied when fresh material is found and sectioned without tearing of the attachment. Still the head bearing the opening of the vas deferens lies just under the perfectly intact outer wall of the capsule as though at least its projection through any external opening was unnecessary and further the fact that the opposite side of the mass where both the heads containing the uterine openings lie is the side of firm attachment to the bone so that it seems extremely unlikely that any opening occurred there. The escape of eggs to the outer world must therefore in all probability be through rupture of the cyst or its digestion after the death of the fish by some intermediate host.

Genus *Nematobothrium* VAN BENEDEN 1858.

The genus *Nematobothrium* established by VAN BENEDEN contains up to the present only 3 species if we except the forms *benedenii* and *taenioides* of MONTICELLI which have been referred to *Didymozoon*. These latter worms are merely mentioned and nowhere described in detail so that it is impossible to determine their exact position. STOSSICH who has studied *D. taenioides* describes it as follows: body very long, cylindrical, tapering toward the anterior part. The pharynx is small, subglobose and provided with a very long narrow oesophagus which divides into two narrow intestinal coeca. The uterus opens anteriorly at the extremity of a little prominence near the cephalic end of the body and contains thousands of very small eggs with thick smooth shell of a deep yellow color. It forms cysts, sometimes quite voluminous, in the muscles of *Orthogoriscus mola*. The figure shows no ventral sucker. This description seems to apply rather better to a member of the genus *Nematobothrium* than to a *Didymozoon* even though MONTICELLI definitely decides upon the latter designation.

The 3 species which are rather more clearly described are *N. filarina* VAN BENEDEN, *N. guernei* MONIEZ and *N. molae* of MACLAREN but these descriptions too leave much to be desired.

*Nematobothrium filarina* found lodged in cysts in the thickness of the skin of the branchial cavity at the shoulder girdle in *Sciaena aquila* is described by VAN BENEDEN as a worm 1 metre long. It lives in pairs tangled together in the cavity of the cyst which has no connection with the outside. The body is long, round, soft and folded with no segmentation. It is not free in the cyst but lodged in a mantle which clings tightly. At one end there is an excavation which is not a sucker; at the other end, which is more truncated, there is also an excavation of different form. There is no ventral sucker. No trace of intestinal canal could be found, but it is thought that it may have existed before the great development of the genitalia and disappeared as in *Filaria medinensis*, *Gordius* and *Distomum filicolle*. Generally there are two worms enlaced, recalling *Distomum filicolle*, the thickest being rolled round the slender one which has less numerous eggs which are not yellow like the eggs of the larger one. There is a large tube with contractile walls ending blindly and disappearing in contraction. It must be the excretory canal and permits one to distinguish the posterior end.

The anterior end is pointed and very mobile. No buccal orifice is recognisable. Another tortuous canal is filled with eggs. The ovary oviduct or uterus is, a single long tube making four or five turns through the body, all full of eggs which distend the body in part of its length. Eggs very small, oval, yellow and extremely numerous. They often contain an embryo bent on itself.

*N. guernei* was found by MONIEZ attached by one or both extremities in the muscles of the inferior maxilla of *Thynnus alalunga* the rest of the body being free. In another case they were free in the intestine or caught in the mucosa, and in still others encysted in pairs on the gills in cysts about the size of a pea or bean. Those in the muscles measured 30—50 cm in length, the body elongated, striated almost as though segmented, sometimes round, sometimes flattened. There is a large tube opening posteriorly and stretching through the whole body and seeming to open anteriorly in the mouth with walls like those of the digestive tube of a nematode. Anteriorly there are two distinct sexual orifices superposed, a "poche péniale" prolonged by a spermiduct which separates into two immense testicular tubes. From the vaginal orifice goes an extremely long folded oviduct which prolongs itself into an ovary of the same general character. The water vascular system opens at the posterior extremity and is prolonged as a thick walled tube without ramifications to the anterior part of the body. No other organs were discoverable. MONIEZ thinks it possible that the smaller worms (3—15 cm) which were found in the intestine, the encysted and the intramuscular forms may represent alternations of generations.

*N. mola* is described by MACLAREN from the gills of *Orthogoriscus mola* where it occurs encysted in pairs. It resembles *N. filarina* closely except in the possession of a small ventral sucker. The worm is 7 cm long by 2 mm in thickness, soft irregular in form with a threadlike anterior portion and a blunter posterior end. The mouth at the anterior end opens directly into the pharynx without a sucker. The genital opening lies on a prominent ventral papilla about 0,6 mm from the mouth. The body is enveloped in a thin sheath. There is a rather long oesophagus which divides into two short intestinal coeca lined with peculiar amoeboid cells. The excretory canal is a single irregular canal opening posteriorly and bifurcating anteriorly at the level of the ventral sucker. There are two testes of long tortuous tubular form stretching through the body which taper into vasa deferentia and unite into a bul-

bous seminal reservoir. There is no definite penis although the end portion of the canal may be everted. The long tubular ovary twists through the whole body. Its connection with the uterus was not seen. The uterus is a roomy canal which runs in loops through the hinder part of the body turning forward to open directly behind the male opening. Enormous numbers of eggs are found in it. The ripe eggs measure  $0,02 \times 0,015$  mm and are without filament. Two tubular vitellaria accompany the testes and uterus in their windings.

MACLAREN restates the diagnosis of the genus *Nematobothrium* VAN BENEDEN as follows: much elongated distomidae with small pear shaped pharynx, no mouth sucker. Mouth at anterior point: small ventral sucker not far from mouth; simply bifurcated intestine: excretory canal bifurcated at anterior end but without anastomosis over pharynx; Hermaphrodites: ovary long tubular; 2 long tubular vitellaria; eggs without filament; 2 long tubular testes without special penis; Genital canals open separately on a papilla somewhat behind the mouth; LAURER'S canal? The animals live in pairs encapsulated on the gills or in the flesh of sea fish.

#### *N. sardae n. sp.*

On the gills of the Bonito (*Sarda sarda*) I found (July 8, 1913) in the Laboratory the U. S. Fish Commission of Wood's Hole a few yellow cysts which were lodged between the layers of the gills. They were flattened and measured  $9 \times 4,50 \times 1,50$  mm and were found to contain two worms which although tangled together are quite separate and unattached to one another. When disentangled and laid out straight these worms measure about  $34 \times 1$  mm and are quite yellow. The mouth at the anterior end is provided with a fairly strong sucker but no abdominal sucker could be found after the examination of four or five worms mounted in toto and the serial sections of two pairs.

The anterior part of the body is rather suddenly narrowed from the rest but is flattened out somewhat for a short distance behind the head and widened accordingly. The terminal mouth sucker is quite strong and muscular. It opens directly through the more feebly muscular pharynx into the oesophagus. This after a very short course passes into a most curious single intestinal canal, which is surrounded by a thick bushy mass of cells so as to be a very conspicuous object. Running almost straight at first it soon

assumes a very wavy or zigzag course, the surrounding cells becoming more compactly and closely applied about it. Even where the mantle of cells is thickest the lumen can be seen shining through as an empty tube. It extends back only a short way, not more than four or five millimeters to a point about midway along the stretch of the testes where it becomes invisible. In the section it is seen, however, that it does not end here but passes into an extremely thinwalled tube. In spite of our best efforts we have not succeeded in tracing this continuation backward nor determining absolutely whether it divides or not. This is partly because its wall loses any distinctive character and becomes exactly like that of the wide and tortuous excretory canals which are present everywhere throughout the length of the body.

The anterior or mouth sucker is terminal and surrounded by no lip or prolongation. It is quite strong being provided with an inner and outer layer of circular as well as the main mass of radial fibers. Numerous large cells are embedded in this muscle and there is a fairly thick cuticular lining which passes on into the pharynx. This has a wall made up of a loose network of radial fibers and also shows large cells embedded in it. The oesophagus is a thin walled tube lined by a smooth membrane. Possibly the whole succeeding tube should be regarded as the oesophagus if it should ever prove that the thin walled sac at its end is bifurcated or that it represents the definite intestine. The lining membrane gradually thickens as we pass into this convoluted tube and becomes closely set with cilia but no lining epithelial cells are to be seen. Outside this membrane, however, the cells are ranged in radial strands closely packed about the canal but fraying out a little externally. They are narrow elongated cells with very definite nucleus and are at least ten or twelve deep all round the canal. It is hard to know exactly how to explain their presence and what function to ascribe to them. At the lower end these cells fade away and the ciliated lining disappears. — There is left only the most delicate membrane in which cellular structure cannot be made out clearly.

The nervous system consists of a pair of ganglia with commissural connection just behind the pharynx and several rather stout nerve trunks which run to the anterior end of the body and backward.

The excretory system appears to be composed of two large thin walled tubes which run from one end of the body to the other.

They twist about among the uterine coils so that in every section they appear repeatedly, cut in various directions and containing a faint granular coagulum. In spite of protracted effort, however, we could not determine where the orifice is situated.

Almost the whole body of the worm is occupied by closely twisted coils of the extremely long and wide uterus which is filled with yellow eggs. This gives the general yellow color which shines through the wall of the cyst. Among these coils one even wider straight length of the tube can be seen to stretch forward to the anterior end of the body. Among them, too, especially throughout the posterior portion there are mingled many coils of a narrower tube which is of a deeper brown color and in the more anterior part similar coils of another tube which appears rather white in the unstained worm but takes a bright nuclear stain which makes it conspicuous in the stained specimen. This proves to be the ovary, the brown tube in the posterior part the vitellarium. At the junction of the anterior and middle thirds of the body there is a space among all these coils in which one can make out a pear shaped seminal reservoir, a voluminous shell gland and the junction of all the tubes. The ovary lies in front of this space, the vitellarium behind it. The uterus opens abruptly in an almost unguarded slit just behind the mouth sucker at a point immediately behind and adjacent to the opening of the vas deferens. Studied in serial sections the following relations are found to prevail. The ovary is a practically solid cord of great length and making many folds — it is tubular only in the sense that the central cells are less compactly placed than the outer ones. It reaches the point mentioned above without narrowing appreciably and joins a narrow rather thickwalled canal which receives at the same point the neck of the seminal reservoir and the narrowed channel from the vitellarium. There is no LAURER'S canal. The seminal reservoir is a rounded sac bent on itself and tapering into a rather long neck. It is always found closely packed with bundles of stiff looking spermatozoa. The vitellarium seems to be a single convoluted tube which extends back with the uterus to the extreme posterior end of the body. It is lined with cubical or pyramidal cells which contain many highly refractive brown granules and the smaller cells which fall off into its central part constitute the yolk. They are indeed extremely small. These three ducts join at a point where they are surrounded and imbedded deep in a large conspicuous mass of cells radially arranged which one

must regard as the shell gland. This gland is developed to a very great extent probably because of its task of furnishing shell material to the myriads of eggs which collect in the uterus. The combined channel twists about as a very narrow canal through a great deal more of the shell gland and finally emerges toward the posterior end as a gradually widening tube filled with eggs which are at first small and polygonal and do not show perfectly their completed form nor their finished shell. It is only after many coils that the eggs assume their definitive appearance. The course of the uterus after this has been described. In this species it nowhere becomes so bulky as to distort the cylindrical form as described by MACLAREN for *N. mola*. It opens on a little hillock just behind the mouth sucker and the terminal portion though surrounded by a few nucleated cells resembling those of the skin is not provided with any special musculature. The testis is single though much folded and twisted in its posterior part. It begins anteriorly as a sausage-shaped structure at about the point where the neck of the worm begins to widen out into the body and runs backward for a distance of only about two or three millimeters. Anteriorly it gives off a convoluted vas deferens which runs beside the uterus to practically the same point just behind the mouth sucker. There it dilates a little into a bulbous extremity which then narrows to pass into a pear shaped sac which opens again on the apex of a little hillock. This sac has at most a delicate layer of circular muscle fibres surrounded by a number of closely arranged deeply staining cells, but it is lined by a layer of stiff recurved hairs. It can probably be everted to act as a penis. The testis shows a compact outer layer of cells but in the interior the cells are grouped in clusters separated here and there by sheaves of straight rigid spermatozoa.

There seems to be some indication of a separation of the sexes in this form, for although each worm possesses both male and female organs in full development as far as can be seen from study of the testis, ovary, shell gland etc. the terminal portion of the uterus with the uterine outlet is well developed and conspicuous in one of the pair but scarcely traceable in the other. On the other hand the vas deferens with its bulbous seminal reservoir and the sac which serves as a penis is very striking in the other worm of the pair while in the first one in which the uterine opening is so evident no such sac can be found nor can the vas deferens be definitely traced to an outlet. It is quite empty of spermatozoa in its cephalic

portion and escapes from view before it reaches its point of outlet. Better sections might still reveal these fading terminations but in the two pairs studied in series the contrast was very striking. It may conceivably be the result of the functioning of one worm as a male and the other as a female during which the remaining sexual function of each was held in abeyance. It reminds one of the statement of VAN BENEDEN in regard to *N. filarina* that the smaller worm of the pair has less numerous eggs than the larger and that these are not yellow as they are in the large one.

The eggs are very small (about 0,01 mm) elliptical; some of them contain stainable material while others seem to be mere empty shells. They are present in enormous numbers.

The skin is delicate and thin, supplied as usual with many secreting cells. The body musculature is extremely poorly developed — indeed except in the anterior end of the body it can hardly be made out at all. Even about the head the longitudinal and oblique fibres are extremely delicate. The parenchyma in the head end is composed of large swollen cells with small nucleus much as described by MACLAREN. In the posterior parts it is scarcely evident.

The worms seem to arrive at complete sexual maturity within the cyst and evidently copulate there. No mode of egress was demonstrated. They are not covered with a sheath such as VAN BENEDEN described but lie quite free in the cyst.

The outer wall of the cyst is composed of a pretty dense fibrous tissue within which there is developed a most highly vascular lining. From this lining there run partitions and films of exceedingly richly vascular tissue among the folds of the worms evidently to supply them with oxygenated blood. In section one sees this membrane as a closely beaded band each bead representing a distended capillary of the host carrying fresh blood. It might be imagined that in that way an adequate supply of nutriment and oxygen could be brought to the worm even if it made no attempt to actually suck blood from this film — an idea which the character of its alimentary tract and its emptiness seem to go far to prove.

This form seems to belong without doubt to the genus *Nematobothrium* although it differs in so many points from *N. molae* which MACLAREN has described and from the forms described by VAN BENEDEN and MONIEZ although their descriptions are rather too meager to allow of accurate comparison.

These are trematode worms resembling the genus *Koellikeria*

in living in pairs enclosed in cysts, a mode of life which brings with it modifications and retrogressions of various organs. They are distinct from *Koellikeria* in the form of the body which is long and cylindrical but similar in the possession of a long cord-like ovary and vitellarium and in the position of the genital opening at the cephalic extremity. I should prefer with BRAUN to regard *Nematobothrium* as a part of the family *Koellikeriadae*, separate from the *Monostomidae* or *Distomidae* and define the genus as follows:

*Nematobothrium* VAN BENEDEN, 1858.

Trematodes of greatly elongated form living in the mature state in pairs in cysts in gills or flesh of sea fish. Digestive tract in various degrees of retrogression. Hermaphrodite but tending to retrogression of one sex in each. Genital openings directly behind mouth at cephalic extremity. Ovary and vitellarium in form of long coiled cords, shell gland and seminal reservoir well developed, uterus forming extremely long coiled tube. Single testis and vas deferens, rudimentary penis.

The forms recognized up to the present are:

<i>N. filarina</i> VAN BENEDEN	<i>Sciaena aquila</i>
— <i>guernei</i> MONIEZ	<i>Thynnus alalonga</i>
— <i>molae</i> MACLAREN	<i>Orthogoriscus mola</i>
— <i>taenioides</i> (?) MONTICELLI	" "
— <i>sardae</i> n. sp.	<i>Sarda sarda</i> .

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We wish to express our gratitude to Dr. B. H. RANSOM of the U. S. Dept. of Agriculture who kindly sent us photographic copies of some of the less accessible literature.

### Explanation of plates.

<i>m. s</i> Mouth sucker	<i>s. g</i> Shell gland
<i>ph</i> Pharynx	<i>ov. d</i> Oviduct
<i>i</i> Intestine	<i>oot</i> Ootype
<i>f. g. p</i> Female genital pore	<i>vit</i> Vitellarium
<i>m. g. p</i> Male genital pore	<i>ov</i> Ovary
<i>v. d</i> Vas deferens	<i>ves. sem</i> Seminal vesicles
<i>g</i> Supraoesophageal ganglion	<i>oes</i> Oesophagus
<i>v. s</i> Ventral sucker	<i>Ex. c</i> Excretory canal
<i>ut</i> Uterus	<i>r. s</i> Receptaculum seminis

### Plate 1.

#### *Koellikeria xiphiados.*

Fig. 1. Portions of cyst in the muscle of the sword fish from which worms have been removed.

Fig. 2. Whole worm. Lobules spread apart to show projecting head.

Fig. 3. Section of portion of one lobe showing coils of uterus, testis and vitellarium. The cuticular covering extends over all lobules and between them is the vascular film from the host.

Fig. 4. Longitudinal section of the head showing muscular pharynx, uterus and vas deferens.

Fig. 5. Transverse section of vascular cord running through muscles of the host to the cyst.

*Koelikeria scomberomori.*

Fig. 6. Sketch of whole worm showing mouth sucker and pharynx and arrangement of organs in body.

## Plate 2.

*Koelikeria haemuli.*

Fig. 7. Section taken through the whole encysted mass showing uterine and ovarian coils as well as some testicular folds. Cyst wall sends septa between the coils of the worm.

Fig. 8. Head showing mouth sucker, pharynx, supraoesophageal ganglia, uterus vas deferens and intestine.

Fig. 9. Section through several lobes showing the shell gland with the projecting junction of oviduct, vitellarium and uterus.

Fig. 10. A coil of the relatively male worm showing testis, vas deferens and seminal vesicles.

*Nematobothrium sardae.*

Fig. 11. Whole worm.

## Plate 3.

Fig. 12. Head and neck showing mantle of cells about intestine.

Fig. 13. Longitudinal section of mouth sucker, pharynx and oesophagus.

Fig. 14. Longitudinal sections of the heads of the worms forming a pair, showing the inequality of development of the sexual apparatus.

Fig. 15. Longitudinal section through cyst wall, three coils of the worm and the vascular film.

Fig. 16. Portion of the whole worm showing junction of ovary, vitellarium, receptaculum seminis and beginning of the uterus in the midst of the shell gland.

Note. Since returning the proof of this paper for publication we have been dismayed to learn that we had overlooked an important paper on the same subject (*Zur Anatomie der Didymozoen* by T. ODHNER which appeared in a volume dedicated to Prof. TULLBERG, *Zoologiska Studier*, Uppsala, 1907).

ODHNER describes *Didymozoon scombri* and *Wedlia bipartita* and proposes to separate as *Didymozoon* those forms with separate sexes while for the hermaphrodite *D. bipartitum* he retains the old name *Wedlia* given by COBBOLD. Although dealing with species different from those which form the subject of this paper he has described in detail most of the internal organs which we thought we were studying for the first time.



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