Four species of Microcotyle, M. pyragraphorus, macroura, eueides and acanthophallus.

By

G. A. MacCallum, M. D. and **W. G. MacCallum**, M. D., New York.

(From the Department of Pathology, Columbia University.)

With 10 figures in the text.

No very satisfactory study of the genus *Microcotyle* has been made so far, the literature on these parasites of the gills of marine fishes being limited to a few publications in which classification has been attempted from different points of view, so that the characters emphasized by one author as of chief specific importance are somewhat neglected by another. Though we add four new specific names to this genus, we do so after having carefully reviewed all of the forms already described, none of which seem to agree at all closely with those in our hands. The analytical table which will serve to give a general survey of all these species has been copied in part from Parona & Perugia [1]) and in part made up from the papers of Goto [2]), Vogt [3]), Lorenz [4]) and Ariola.[5]) It will be seen

1) Parona e Perugia, in: Ann. Mus. civ. Stor. nat. Genova, 1890—1891, Vol. 10, p. 173.

2) Goto, in: Journ. Coll. Sc. Univ. Tokyo, 1894, Vol. 8, p. 1—273; 1899, Vol. 12, p. 263.

3) Vogt, in: Z. wiss. Zool., Vol. 30, Suppl.

4) Lorenz, in: Arb. zool. Inst. Wien, 1878, Vol. 1, p. 405.

5) Ariola, in: Boll. Mus. Zool. Anat. comp. Genova.

that the original papers of Van Beneden & Hesse [1]) were reviewed by Parona & Perugia in their table and to this we have added the description of *M. acanthurum* from another paper by the latter authors. Linton [2]) has described another form *M. incisa* but it is hardly possible from his description to place this species exactly.

In all these papers rather more stress is laid by the authors upon certain external characters than upon the arrangement of the internal organs and perhaps this is desirable, for in the papers of Goto at any rate it is difficult to make out the slightest variation in the arrangement of the female genital organs in the twelve species described and depicted by him. He emphasizes, however, the position of the genital pore with relation to the bifurcation of the intestine, the character of the lateral coeca of the intestine and the number of lobules in the testes while the earlier authors fail in many instances to record this latter point. On the other hand, Parona & Perugia describe very minutely the armature of spines about the genital opening, and base their determination of the species largely upon this distinctive character. None of these authors has described any penis or ejaculatory apparatus in the forms of *Microcotyle*, although, as will be seen from the descriptions and drawings, we have found this organ present in three of our four species, and quite completely developed. Nor has any of the few authors who have concerned themselves with the anatomy of *Microcotyle* paid more than the most cursory attention to the character of the supporting framework of the suckers upon the caudal disc. This, however, is a perfectly constant feature of each species and apparently has a definite specific importance in the distinguishing of the species. We wish especially to emphasize the value of the study of the skeleton of these suckers and hope that it may be possible for someone to restudy those forms which have already been described with this point in view. We should recognize then, as features of value in determining species, the following things:

1. The form of the body and the relation of the caudal disc, especially as to whether it is symmetrically or asymmetrically attached.

2. The number of suckers which it bears and particularly the arrangement of the skeletal framework of these suckers.

1) Van Beneden et Hesse, in: Mem. Acad. Sc. Belg., 1864, Vol. 134.

2) Linton, in: Publ. Carnegie Inst. Washington, No. 133, 1910.

3. The character of the armature of the genital orifices including that of the vagina which in some species is double.

4. The structure of the suckers about the mouth, especially as to whether they are partitioned or armed with teeth.

5. The number, form and size of the eggs.

6. The number and arrangement of the testicles.

Of all these probably the least variable for any given species are the form of the eggs and the character of the framework of the suckers of the caudal disc.

Microcotyle pyragraphorus n. sp.

A few examples of this form were found attached to the gills of the Pompano (*Trachinotus carolinus*).

The worm is quite small measuring 4 to 5,40 mm in length by 0,6 to 1,0 in breadth. Posteriorly, it spreads out into a delicate thin sucker bearing foot which extends gracefully about an equal distance on each side and measures transversely 1,60 to 2,60 mm. It has a double row of spiny suckers along its free margin. These are elevated on pedicels and vary curiously among themselves, for while about forty of them are arranged with long chitinous stalks like a pair of tongs, the rest about sixty-two in number, have no such stalks. These two groups are sharply separated, the stalked ones occupying one side of the foot while the unstalked begin about the middle where they leave off and extend to the other angle of the foot.

Otherwise, the body is smooth and unarmed. It is narrow and elongated and flattened as shown in the drawing and its marginal portions are occupied from the foot nearly to the anterior end by masses of brown vitellarian lobules. Scattered everywhere and even extending into the foot, there are pigmented cells which are very conspicuous.

At the anterior extremity, there is a small unguarded mouth which opens into a mouth cavity provided on each side with a muscular sucker measuring 0,11 × 0,05 mm. These suckers diverge anteriorly but approach one another closely behind being separated by the pharynx. They are elliptical and unperforated and form part of the wall of the mouth cavity. The edges of their orifices are set with a single row of minute chitinous spines, like teeth, and there is an indistinct transverse partition dividing the cavity into two loculi. In section they are composed chiefly of radial

muscle fibres with perhaps a few circular fibres externally. The pharynx which is closely approximated to the mouth cavity is surrounded by a thick connective tissue membrane but is rather cellular in its structure and not powerful. The lumen is laterally flattened. The intestinal coeca which are smooth in outline as far as they can be traced run back laterally to near the level of the foot. They are extremely thin walled and no epithelium is apparent.

The male genitalia consist of a complicated ejaculatory apparatus and a number of testicular lobules. There are about twenty of these lobules situated in the median portion of the body and extending back to about the level of the beginning of the caudal disc. There is a tortuous tubular vas deferens running dorsally from about the region of the ovary forward to enter the hinder end of the cirrus sac. This ejaculatory structure is composed of a long club shaped thick-walled muscular sac the orifice of which lies far anteriorly in the median ventral line a short way behind the pharynx and a considerable distance in front of the opening of the uterus. Within the cirrus sac is the penis proper which consists of a posterior membranous sac, a middle muscular portion and an elongated anterior part which is eversible, and is covered with fine bent spines which when everted point backward.

There is a sort of uterine cloaca opening also in the median line ventrally and posterior to the male genital opening. This is quite deep and at its inner end suddenly narrows like a test tube and connects with a narrow tube which is probably the uterus proper. The peripheral or cloacal portion is lined at its inner end by a thick layer of spicules which are closely packed together and difficult to distinguish separately. They shine through appearing as a rosette when one views the whole worm, and form a most conspicuous feature. Behind this sac there is sometimes another thin-walled sac like a spermatheca. The ovary is a coiled tubular organ giving off an oviduct which is joined by the common yolk duct after which it enters the posterior end of the straight uterus. The yolk ducts are plainly seen running far forward. We can make out no vagina.

A special note may be devoted to the clinging organs of the posterior foot since they are most characteristic. As stated above, about half of them occupying one side of the foot are like tongs in their form with long rods of chitin corresponding to the handles of the tongs. Jointed to the ends of these are broad flattened blades

(Fig. Ba) which have a framework very much like that of the more rounded suckers which move about upon the end of a muscular stalk only. The disposition of the skeleton can be seen clearly in

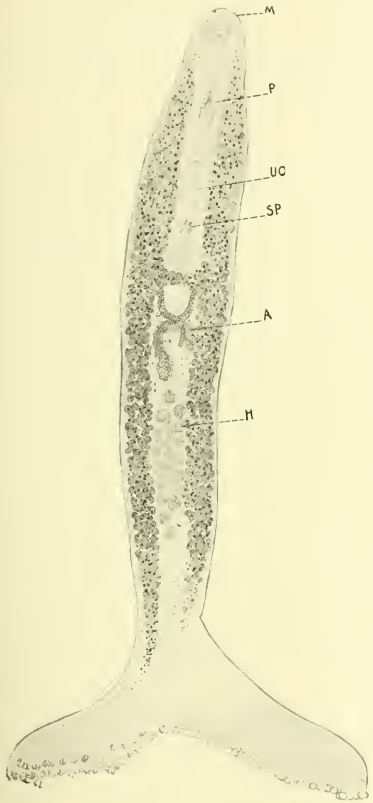

Fig. A.

Fig. B.

Fig. A. *Microcotyle pyragraphorus*. *M* mouth and oral suckers. *P* spined penis. *Uo* uterine opening. *SP* spines on bottom of genital recess. *OV* ovary. *H* testicles.

Fig. B. *Microcotyle pyragraphorus*. a tong-like clasping organ. b unstalked sucker with chitinous skeleton.

the drawings; probably the tong-like structures can open quite widely although no muscular fibres can be seen between the handles to control their movements. The blades, however, are solidly sup-

Name	Author	Length mm	Breadth mm	Diameter mouth sucker mm	Cirrus	
					Length and form mm	Pair of suckers
M. trachini	Parona & Perugia	9—11	0,5	0,056 round	Spatuliform 1,3	8–)
M. donavani	Van Beneden & Hesse	6	—	—	Oval long	2 2 rs of s ll suc s
M. mugilis	Vogt	10	1	Bilocular 0,09 × 0,06	2 oval	2
M. alcedinis	Par. & Per.	4	0,5	Bilocular 0,07 × 0,04	Wide in front narrow behind	40–5
M. erythrini	V. Ben. & Hesse	4—5	0,5	Oval 0,07 × 0,04	2 asymmetrical	4
M. salpae	Par. & Per.	7—8	0,75	Oval 0,136 × 0,08	Oval in first half filiform in second	4
M. sargi	Par. & Per.	7—8	0,8	Oval 0,098 × 0,056	3,5 oval in first half, narrow in second	60 0
M. labracis	V. Ben. & Hesse	10—14	1,5	Bilocular 0,140 × 0,070	4 conical, elongated	(
M. chrysophrii	V. Ben. & Hesse	14	1	Oval 0,135 × 0,090	4 bilobate in first half, narrow in second asymmetrical	
M. canthari	V. Ben. & Hesse	4—10	1,6	Oval, simple 0,08 × 0,056	4 filiform	90–00
M. mormyri	Lorenz	5—8	0,5	Bilocular 0,120 + 0,082	2 lanceolate	65–00
M. caudata	Goto	3,2	—	Bilocular	1/4 length of worm	2

meter ckers m	Testes	Vaginal aperture	Cloacal aperture	Eggs	Host
×0,042	—	Unarmed short vaginal canal	Unarmed	Four; with short posterior appendage 0,210×0,060 yellow	*Trachinus radiatus*
—	—	—	Globose with many small hooklets	Fusiform reddish hooked anterior filament; pointed posterior.	*Labrus donavani*
×0,05	Numerous	Unarmed	Complete circle of 35 hooks 0,014 mm in length	?	*Mugil cephalus*
<0,042	8—10	Double vagina with spines	Unarmed	Numerous yellow 0,168×0,070 obtuse posterior filament	*Smaris alcedo*
07	16 in one row	Unarmed	Crown of minute triangular spines. 2 groups of 12 spines	Fusiform 0,23×0,09	*Pagellus erythrinus*
<0,056	—	Unarmed	Incomplete crown of 16 hooks measuring 0,028. Bunch of spicules above	?	*Box salpa*
<0,028	—	Surrounded by fine spicules	External circle of 22 hooks measuring 0.042. Bunch of inner spines 0,014	2; 0,182×0,070 terminal filament with anchor	*Sargus*
<0,056	—	Bulb with small corpuscles 0,28×0,112	Series of radial spines 0,014 diameter of armature 0,14	2; 0,320×0,126 posterior filament an anchor	*Labrax lupus*
<0,056	—	Unarmed	Armed with 50 spines 0,108—0,045	Numerous fusiform 0,182×0,070 posterior filament like fish hook	*Chrysophrys aurata*
<0,056	—	Double vaginal aperture 0,070 dentate margin	Crown of 60 spines 30 in circle 0,072, 16 superior 0,020, 14 inferior 0,030	Numerous, fusiform reddish, anterior hooked prolongation 0,056×0.028	*Cantharus griseus*
<0,056	16—18	Unarmed bulb 0,023×0,07	Incomplete crown of hooks superior 0,07, inferior 0,035, arranged in 3 groups	Numerous 14—16 yellow 0,196×0,070	*Pagellus mormyri*
-	23	Median dorsal	Level of intestinal bifurcation conical spines 0,01 mm	—	*Sebastes*

Name	Author	Length mm	Breadth mm	Diameter mouth sucker mm	Cau	
					Length and form mm	Pairs sucke
M. sebastes	Goto	5,5	—	Bilocular	1/3	29
M. elegans	Goto	4 asymmetrical	—	Bilocular	1/3	50
M. reticulata	Goto	6—10 slightly asymmetrical	—	Simple	1/3	42 rig 23 le
M. truncata	Goto	3,3	—	—	Short triangular	10
M. fusiformis	Goto	2	—	Bilocular	—	33
M. chiri	Goto	4,2	—	—	Continuous with body	30
M. sciaenae	Goto	4 asymmetrical	—	Bilocular	1/2 of body at angle	75 rig 60 le
M. pomatomi	Goto	4	—	—	1/3 body	70
M. stenotomi	Goto	2,5	—	—	1/3	46
M. hiatulae	Goto	3,5 asymmetrical	—	—	1/4	23
M. longicauda	Goto	6	—	—	7/10	120
M. lichiae	Ariola	8	1,17	—	—	31—21

c)iameter suckers mm	Testes	Vaginal aperture	Cloacal aperture	Eggs	Host
—	occupy $^1/_5$ of body	Median dorsal	In front of bifurcation, conical spines 0,017	—	*Sebastes*
—	27	Median dorsal	In front of bifurcation, conical hooks 0,005	—	*Scombrops cheilodipteroides*
—	v. deferens armed with hooks. Many testes $^1/_2$ body	Median dorsal	Behind bifurcation, sharp straight conical spines 0,016 forming hemisphere a bunch rising above.	—	*Stromateus argenteus*
—	$^2/_5$ of body	Median dorsal	At bifurcation, 23 points 0,013 mm in uncomplete circle	—	*Pristipoma japonicum*
—	15	Median dorsal	At posterior end of pharynx thin conical hooks 0,007	—	*Centronotus*
—	25	Median dorsal	At bifurcation, hooks like those of *M. reticulata* 0,015	—	*Chirus hexagrammus*
—	27 large	Median dorsal	At bifurcation. 2 groups of needles in circles 0,011 shorter ones 0,002	—	*Sciaena sina*
—	50	Median dorsal	In front of bifurcation, spacious; recurved spines 0,013—0,016.	—	*Pomatomus saltatrix*
inute	12	—	At bifurcation lined with conical spines 0,004—0,005	—	*Stenotomus chrysops*
—	15	Median dorsal	In front of bifurcation, conical recurved spines 0,015—0,018	—	*Hiatula onitis*
—	55 small	Median dorsal	Anterior spines conical and recurved; posterior divided in median line; anterior 0,013—0,016, posterior 0,09	—	*Cynoscion regale*
—	—	Median dorsal	5 rows of small spines arranged concentrically behind bifurcation. Genital openings separate	20 0,0133 × 0,0101 truncate filament	*Lichia amia*

Name	Author	Length mm	Breadth mm	Diameter mouth sucker mm	Cau	
					Length and form mm	Pairs sucke
M. acanthurum	Par. & Per.	10	1	—	—	60 wi 2 hoo
M. incisa	Linton	2,4—4,3	0,42—0,56	Simple 0,11 × 0,16	1/3	45
M. pyragraphorus	MacC. & MacC.	4—5,4	0,6—1,0	Bilocular 0,11 × 0,05	Transverse asymmetrical	40 rou 62 ton like
M. macroura	MacC. & MacC.	15	2,5	Simple 0,12 × 0,16	1/4—2/7 longitudinal asymmetrical	25
M. eueides	MacC. & MacC.	8	1,2	Simple 0,08	Transverse twisted, symmetrical 4,5	88
M. acanthophallus	MacC. & MacC.	7	0,67	Simple 0,04	Leaflike asymmetrical	43

plied with muscle and the chitinous skeleton is imbedded in it projecting anteriorly and at the junction of the handles in the form of short teeth which are quite definite here although their existence seemed questionable in *M. macroura*. They measure 0,11 × 0,05 mm.

Sections of the unstalked suckers present the same form with projecting teeth, although it is extremely difficult to understand why no evidence of these teeth appears when the apparatus is examined while lying flat. The appearance when viewed as they lie, is shown in another figure (Fig. Bb). It is seen that the skeleton is reduced to marginal ribs, the meridional sternum like rod is no longer complete but exists in the form of two separate rods. Further, one half of the sucker is provided with two sharply triangular chitinous elements which seem rather independent of any close connection with the rest. They measure 0,05—0,08 mm in diameter.

iameter suckers mm	Testes	Vaginal aperture	Cloacal aperture	Eggs	Host
—	—	—	Crown of bent hooks 0,014 second portion covered with spines. Whole armature 0,21 × 0,11	Eggs with 2 filaments	*Brama raja*
? × 0,08	24	?	?	0,18 × 0,07	*Neomaenis griseus*
× 0,05 × 0,08	20	?	Sac with spicules at bottom in close array. Opening unarmed. Genital openings separate, armed penis	No eggs	*Trachinotus carolinus*
0,12 0,33 0,04	100	Unarmed median dorsal	W shaped chitinous rod in one specimen	0,22 × 0,12 anchor posteriorly yellow	*Roccus lineatus*
× 0,06	32	Unarmed median dorsal	Heart shaped many rows of forked spicules pointing inward	0,15 × 0,09 short filament	*Roccus lineatus*
× 0,04	60	Unarmed median dorsal	Unarmed muscular surrounding mass	None	*Roccus lineatus*

Microcotyle macroura n. sp.

Several examples of this species were found clinging to the gills of the striped bass (*Roccus lineatus*).

The worm is large and stout, measuring 1,2—1,5 cm in length and 2—3 mm in breadth (Fig. C). It is somewhat lancet shaped with a broad leaf like caudal sucker bearing appendage which may project straight in the long axis of the worm or be twisted from side to side. It is, however, ordinarily to be regarded as a continuation in the long axis of the worm and does not appear, as in some species, as a transversely placed foot.

The suckers vary in number; in two of the larger specimens there are fifty while a somewhat smaller example has only forty. This variability is recognised in other forms and it seems quite possible that the number increases with the age of the worm. The suckers which have a skeletal framework of chitinous rods vary in size also; starting at the root of the sucking foot, they are small but gradually they become very large along the sides only to

decrease again to a very small size at the posterior tip. Their more intimate structure may be described later.

The skin of the body in general is thin, smooth and unarmed. At the tapering anterior end there is the mouth opening guarded on each side by a flattened rounded sucker measuring $0{,}12 \times 0{,}16$. Between and behind these can be seen the small pharynx, a short way behind which is the genital pore in the median ventral line. The body contains much scattered pigment, and its lateral portions are occupied, from the level of the foot to that of the genital pore by abundant masses of vitellarium. The intestine is practically invisible in the anterior part of the body but it extends into the foot and sends out branching coeca filled with blackish material between the suckers. In the space left between the marginal masses of vitellarium, one can see the lobules of the testis and count about a hundred of these lobules. In front of the testes is the large coiled ovary with its conspicuous connection with the vitellarian ducts.

Little more can be easily made out from the study of the whole worm except the character of the egg which stands out very sharply through its yellow color and high refractive power. This single egg is elliptical with anterior and posterior prolongations. The posterior one is a relatively short rod with a double recurved anchor like hook at the end; the anterior is a long extremely fine whiplash like filament which extends out through the genital pore and waves about freely outside the body of the worm.

Sagittal sections were made to determine the structure of the worm and their study shows the following:

At the anterior extremity there is a wide mouth, opening, under an overhanging lip, into a cavity, on each side of which there is placed one of the anterior suckers. These are imperforate and do not open to the outside at all, but like cheek pouches, their cavity looks into the sides of the mouth cavity which is quite wide and sacculated posteriorly. Into it projects the small pharynx which is by no means a strong muscular structure but composed of cells with large round nuclei. Externally it has a delicate layer of circular muscle fibres. Its central lumen is extremely narrow and it is difficult to see its opening into the wide oesophagus which ventrally projects some distance in front of it. Thus the pharynx comes to stand out quite free in the prepharynx and to lie as it were on the dorsal surface of the oesophagus. Muscle bundles run up to it from points quite far back in the body wall.

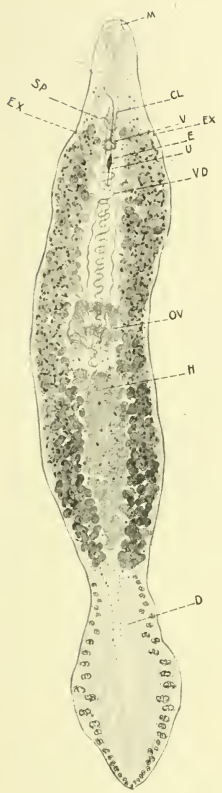

Fig. C.

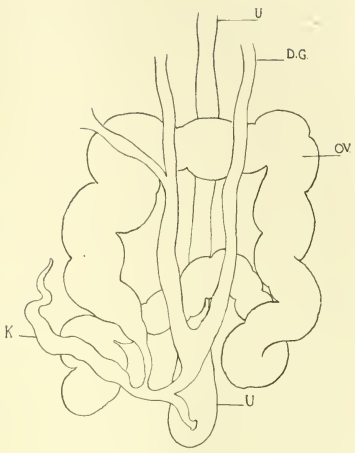

Fig. D.

Fig. E.

Fig. C. *Microcotyle macroura.* *M* mouth opening. *CL* genital cloaca. *V* vaginal opening on dorsal side. *E* egg with long anterior filament projecting from the cloaca. *U* uterus. *VD* vas deferens. *EX* lateral excretory pores. *OV* ovary. *H* testicles. *D* intestinal coeca. *SP* chitinous spicoules.

Fig. D. *Microcotyle macroura.* Semi-diagrammatic sketch of female genitalia. *DG* yolk ducts. *OV* ovary. *U* uterus. *K* duct of unknown nature, possibly canalis genito-intestinalis.

Fig. E. *Microcotyle macroura.* Sucker showing chitinous skeleton.

The oesophagus, which is wide and provided with an extremely delicate wall, divides a short way behind the pharynx into two lateral intestinal coeca which are themselves extremely indistinct in outline and so thin walled and easily torn in section that it is very difficult to follow them back. They seem to have no musculature in their walls and quickly come to look like irregular spaces among the lobules of the vitellarium, never assuming the clear cut character seen in some other trematodes. Posteriorly they appear to become more definitely tubular and are elongated into the foot where they give off long saccular branches which extend laterally between the suckers. These branches are often filled with a black granular material, which marks them out very clearly. One of them runs to the neighborhood of each sucker but at times they are so distended that this relation is disturbed. Apparently such branches run between the lobules of the vitellarium and the testes throughout the body, and the same granules, sometimes deeply colored and contained in cells, can be seen in them; but one can make out no musculature nor any definite epithelium in the wall.

The nervous system seems to be very well developed, consisting, as usual, of two large ganglia, one on each side of the oesophagus behind the pharynx and connected over it by a wide commissure. It sends off two broad trunks to the posterior part of the body and others anteriorly but one cannot trace them in the sections at our disposal.

The genital pore or cloaca lies in the median line ventrally near the anterior end of the body and just at the level of the bifurcation of the intestine. It receives the outlet of the uterus and the penis, the latter lying dorsal and anterior to the former.

The penis or ejaculatory apparatus is composed of a club shaped or pear shaped muscular sac made up chiefly of longitudinal and oblique muscle fibre and lined with a cuticular prolongation. Within it there arises from about the middle a free narrow protrusible tube the lumen of which is continuous backward through the solid muscular fundus of the sac into a tube of similar calibre surrounded by a layer of circular muscle fibres which runs backward through the body. There is no definite collection of prostatic cells about it.

The coiled tube which forms a sort of vas deferens runs with the most tortuous course but maintaining well the midline of the body ventral to the ovary to a point at about the level of the

anterior end of the group of testicular lobules. There it doubtless receives the vasa efferentia from these lobules, although they can only occasionally be traced in the sections. The lobules of the testis of which there are about one hundred, are sharply outlined thin walled sacs filled loosely with a mass of spermatozoon forming tissue.

The process of the formation of spermatozoa can be seen beautifully in these lobules, for all stages are found side by side. There are irregular masses of large cells lying close against the wall of the lobule and it is apparently from such large elements that, by further subdivision, rosettes or balls of very much smaller cells are formed; later stages show even these minute segments subdivided and long filaments of protoplasm streaming out from the central mass. In other instances one sees pale bluish spheres in which a few well formed spermatozoa are scattered about a formless central dense mass as though from one of the rosettes nearly all the fully formed spermatozoa had been cast off. Such free spermatozoa are to be found also in sheaves.

In the parenchyma just ventral to the ejaculatory apparatus there is embedded a curious structure of chitinous appearance. Its connections are very hard to make out but apparently it stands in some relation to the cirrus. It consists of four central rods arranged almost in the form of a "W" the outer points of which are continued in a curve to a point far behind in the parenchyma (Fig. C *sp*). Of the function of such a formation it is hard to gather any idea although chitinous spines are by no means uncommon about the genital openings in other forms. Here the spicules seem to be entirely embedded in the parenchyma and quite away from the surface.

The ovary lies in the middle of the body as a long tubular structure much folded and coiled upon itself (Fig. D). Starting posteriorly at the right side it curves across to the left, turns forward on itself, then across again to the right side and back nearly to the point where it began. In this course the ova which it contains become continuously larger and more mature. The oviduct is a rather wide tube which runs backward to meet the common yolk duct which results from the union of the two main lateral yolk ducts which run anteriorly and branch off to the lobules of the vitellarium. The combined canal runs further back, giving off a thick walled channel which contains yolk cells and granules and then turns dorsally to join at its beginning the bulbous end of the uterus.

The channel which is given off turns forward and becomes wider. It runs a short way forward and to one side. At first it was regarded as another yolk duct, but it is unpaired and much thicker walled than the others. It comes to an end anteriorly but in our material, it is not possible to be sure that it ends blindly. It is filled with cells from the yolk gland and anteriorly it comes to be surrounded by lobules of the vitellarium and sacculations of the extremely indefinitely outlined intestine as it itself fades away. It seems possible that this may be the canalis genito-intestinalis which has been described by so many authors and which, as Odhner states, occurs in all the *Microcotylidae*; but the connection at one end at least is so indefinite and the conception of the intestino-genital canal so startling that we hesitate to ascribe to it this significance.

The uterus begins as a club shaped structure densely surrounded by elongated cells which are radially arranged and possibly function as a shell gland. It is, in the sections before us, filled with yolk in the form of nucleated cells exactly as is the case with the canal just described. Receiving the common canal from the ovary and other glands at its lowermost point it runs in a staight line forward into the anterior part of the body where it spreads out into a long fusiform sac which finally opens by a rather wide canal at the genital pore.

This sac may contain one or more eggs which are yellow oval, measure 0,22 . 0,12 and are provided anteriorly with a long filament and posteriorly with an anchor shaped hook.

At a point in the mid dorsal line a short way behind the level of the genital pore, there is an opening which leads into a vagina. This tube is curiously kinked and supplied at that point on one side only with a strong mass of muscle tissue. Behind this it becomes somewhat saccular and is surrounded by a dense mass of nucleated cells. It suddenly becomes very thin walled and gives off one extremely delicate tube which may be followed back into the interior of the body. It is so delicate, however, that we have not been able to follow it to its union with the yolk duct, as the case may be, in the single series of sections at our disposal. It seems entirely probably, however, that such a union does occur although a great distance must be traversed by this exceedingly delicate tube.

On the whole, then, the study of the female genitalia of this form is rather incomplete since it has been impossible to make out

the connections of the vagina, or to recognise definitely any receptaculum seminis or a canalis genitointestinalis. Possibly when more material is secured this may be remedied.

The accompanying sketches will give a better idea of the character of the suckers than any description, for they are of complicated structure (Fig. E). They vary in size, growing larger toward the middle of each lateral row and smaller at the root of the foot and at its tip. Somewhat elevated upon pedicels, their aperture is transversely flattened so that there is an anterior and a posterior half which close together like the jaws of a trap or the metal rims of a purse.

The suckers are composed of thick muscular walls in which the fibres are arranged radially to the lumen as in other suckers, but they differ from others in the possession of a chitinous skeleton.

The suckers are composed of thick muscular walls in which the fibres are arranged radially to the lumen as in other suckers but they differ from others in the possession of a chitinous skeleton embedded completely in the muscle so as not to project freely anywhere. One might at first sight receive the impression that this chitinous framework acted like so many double hooks to anchor the worm in the tissue of the host, but more careful study shows that it serves only as a skeleton to give strength to the action of the sucker.

The anterior wall of each sucker has an arrangement of chitinous spicules different from that of the posterior wall. There is a median curved sternum like structure which both at the fundus and toward the edge of the anterior lip spreads out into a "Y" shaped end. At the fundus there is jointed to it a short piece which extends back into the posterior hemisphere and is prolonged by two narrower pieces. From each of these there runs a rib like frame arching through the muscle of the posterior half of the sucker to the lateral angle where it meets similar ribs running from each end of the median plate in the anterior wall. Thus from the lower end there courses a thick bar in the middle of the muscle of the anterior lip to the lateral angle and from the upper end a similar though narrower bar over the fundus of the sucker to the same point. In some cases these two bars are not jointed at the lateral angle but form one piece. The median plate lies near the inner surface of the sucker and indeed may project into its lumen. Sec-

tions frequently show what seems to be this band or plate actually crossing the cavity of the sucker free from its wall like the free muscular bands that sometimes leap from one wall to the other of the heart, but one cannot make out this condition in the sucker viewed as a whole. Occasionally, too, in sections the chitinous ends of the median band seem to be denuded of their covering and to project a short way almost like teeth into the orifice of the sucker, but this appears to be an artefact. They show, however, that in addition to the coarse skeletal framework there are some fine chitin-like filaments which course over the inner surface of the sucker like wire guyropes to further strengthen the whole structure.

The suckers vary in size from 0,12 anteriorly to 0,33 mm and diminish again at the tip to 0,04.

Single examples of two other species of *Microcotyle* were found on the gills of *Roccus lineatus* and may be described here although necessarily imperfectly because the material does not allow of a complete study.

Microcotyle cueides.

This form resembles in general *Microcotyle pyragraphorus* from the Pompano in possession of a broad wavy foot upon which the suckers to the number of one hundred and seventy-six are arranged. This foot is asymmetrically placed so that one side is rather longer than the other as shown in the drawing (Fig. F). The body is very delicate and thin and narrowed at each end. The total length is about 8 mm, the greatest width of the body about 1,2 mm, while the foot measures about 4,5 mm in width extending 1,5 mm on one side of the median line and 3 mm on the other. There is a slight widening of the anterior portion of the body about the genital pore which is guarded by numerous spicules. Numerous pigmented cells are scattered over the body especially abundantly among the lobules of the vitellarium along the lateral margins.

The mouth sac is provided as usual with two lateral imperforate suckers, the pharynx is small and inconspicuous. The intestinal coeca extend far back into the foot where they branch and become evident from their content of black granules.

The ovary is large and coiled across the middle of the body. Its oviduct evidently joins with the common duct from the vitellarium to reach the straight uterus which then runs forward to the genital pore. The yolk ducts are united both anteriorly and again just before

they run to connect with the oviduct. The condition of the specimen does not permit one to make out a vagina nor any other details of the arrangement of the female genitalia except that there is an egg in the anterior part of the uterus which has a somewhat peculiar form. It is elliptical with a very long and delicate anterior filament which becomes coiled in a dense mass just near the outlet of the uterus. Where the filament joins the body of the egg, there is a transverse partition. The hinder end of the egg as it lies has only a short blunt pointed prolongation quite unlike the anchor shaped rod seen in *M. macroura*. The egg measures 0,15 × 0,09 mm.

The uterus opens into the somewhat heart shaped ventral genital pore which is surrounded by a condensation of the tissue which is thickly studded with delicate Y shaped chitinous spicules all of which point away from the opening. There are about ten rows of these minute spicules as shown in the drawing and their arrangement seems to differ from that in any other species.

The lobules of the testes which lie behind the ovary number about thirty-two. They are rather small and indistinct and stain very palely. The ejaculatory apparatus must be very feebly developed for it is not visible at all in this specimen nor is any seminal vesicle to be seen.

The suckers (Fig. H) are all elevated on muscular stalks along the edge of the foot. There are none of the tong like structures seen in *M. pyragraphorus* and the short rounded suckers seem to be rather poorly supplied with muscle. Their chitinous skeleton is rather simple consisting of a central curved rod forked at its extremities, and giving off from the short end a rod which forms the median support of the opposite muscular wall. It forms the point of origin also of the proximal portion of one of the pairs of marginal bands. The other of the marginal bands appears to join them loosely at the angle. One gets the impression that all of these bands are merely supporting in character and are embedded in muscle but it appears that the terminal portions may so bend as to protrude from the muscle, for when a sucker is seen edgewise, it gives the appearance of being armed with teeth. Thus, although the elements of the skeleton are more closely bound together at the base of the sucker than in *Microcotyle pyragraphorus* (from Pompano) the loose pieces seen at the margin of one half in that form are not represented here at all.

Fig.F. *Microcotyle eueides.* *M* mouth. *GC* genital cloaca. *U* uterus with egg *DG* yolk ducts. *OV* ovary. *H* testicles.

Fig.G. *Microcotyle eueides.* Armature of genital cloaca with Y shaped spines.

Fig.H. *Microcotyle eueides.* Sucker with chitinous skeleton.

Fig.J. *Microcotyle acanthophallus.* *P* spined penis. *UO* uterine opening. *DST* vitellarium. *OV* ovary. *H* testicle.

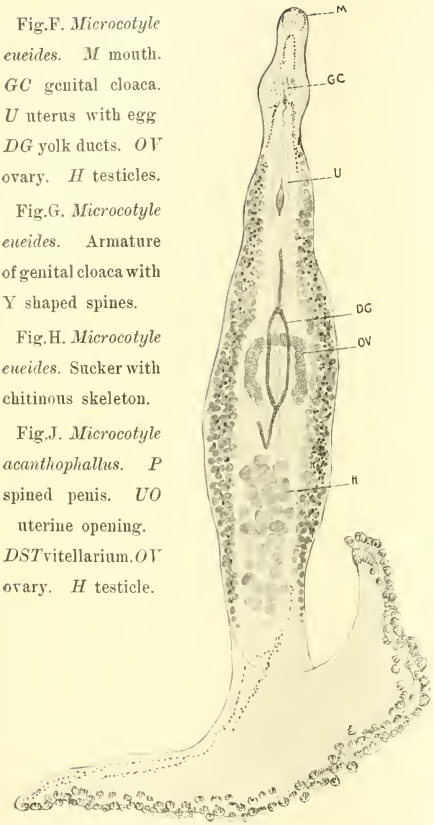

Fig. F.

Fig. G.

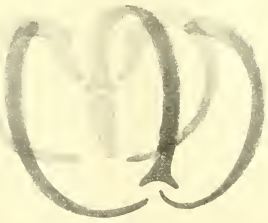

Fig. H.

Fig. J.

The other form, of which one specimen only was found in *Roccus lineatus*, may be described as follows:

Microcotyle acanthophallus n. sp.

In the specimen before us the sucker bearing disc forms a straight continuation of the body and bears eighty-six suckers ranged laterally in two rows and all alike (Fig. J). The whole worm measures about 7 mm × 0,67 mm. It is gracefully tapered posteriorly but in front narrows sharply to the neck, which is cylindrical to the region of the pharynx where it again narrows. The spiny penis is very conspicuous and can be everted through an opening a short way behind the pharynx — hence the name given to the species. The uterine opening, surrounded by a circular muscular mass, lies much further back at the level of the shoulder where the body suddenly narrows to the neck. Here, too, is the anterior limit of the vitellaria which extend back to dwindle away and disappear some way in front of the foot. There is no spiny armature surrounding the uterine opening.

The mouth cavity has as usual two lateral suckers measuring 0,04 mm and between them is the small pharynx. The intestinal coeca extend back into the foot where they are made evident by the black granular contents.

The testicular lobules are about sixty in number and lie compressed by one another in the posterior median part of the body. The vas deferens is indistinct but appears to run tortuously forward in the median line to empty into a long club shaped sac which begins in the median line just in front of the uterine opening. It

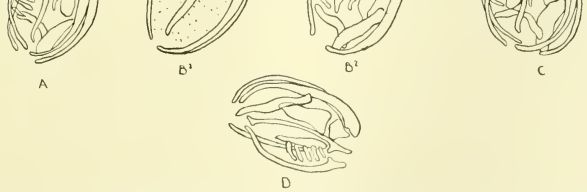

Fig. K. *Microcotyle acanthophallus*. Sucker chitinous skeleton. *A*, *B* and *C* viewed from above, *D* viewed from below. B^1 represents the upper half and B^2 the lower half.

extends forward to the male genital opening and in its anterior portion seems to be practically filled with the spines which doubtless become recurved on the eversion of the penis. At the base of this spiny portion there is a small cone shaped mass of red granules whose function we cannot tell.

Very little can be discerned with regard to the female genitalia. There is a central somewhat coiled ovary the oviduct from which receives the common duct from two lateral yolk ducts, but there are no eggs and the uterus, although doubtless it runs straight forward to the orifice described above, cannot be made out.

It is perhaps wrong to describe a new species with so little knowledge of the female genital apparatus but the character of the penis and of the suckers seems so peculiar that the establishment of a species seems justified and we hope to make the more detailed study of the internal organs soon, when the worm is found in greater numbers. Being a parasite of such a common fish as *Roccus lineatus*, it is pretty sure to be found again before long.

The suckers are all on muscular stalks: They are stout heavy jawed and give the impression of being supported by a much stronger skeleton than that seen in *M. eueides*, *pyragraphorus* or even proportionately those in *M. macroura*. They are asymmetrically formed and will be unterstood best by reference to the figures in one of which the upper and lower halves of the suckers are represented separately. In spite of what seems an entirely improbable arrangement of the skeletal elements, they all show precisely the same structure. The upper half has three skeletal supports, a heavy curved one on one side contrasting with the delicate curved ramus of the other side, while the median support is only slightly curved and turns inward at its end in the form of a tooth. The lower half has the same arrangement at the sides, the heavy ramus standing opposite that of the upper half but the median rod is replaced by five large chitinous plates and five small curved rodlets arranged as shown in the sketch. These presumably strengthen greatly the floor of the sucker. Viewed edgewise, the sucker presents strong teeth which must be the product of the incurving of these rods for, as in the other species, although one finds teeth on making a vertical section of the sucker or viewing it edgewise, they cannot be seen when the sucker is lying flat. The suckers measure 0,06 × 0,04 mm.