

NEW GYRODACTYLOID TREMATODES FROM AUSTRALIAN FISHES.
TOGETHER WITH A RECLASSIFICATION OF THE SUPER-FAMILY
GYRODACTYLOIDEA.

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(Plates ix.-xxii., and one Text-figure.)

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Australian Trematodes have received considerable attention from certain parasitologists, among whom are to be mentioned especially S. J. Johnston and W. Nicoll. These authors, however, have confined their attention almost entirely to digenetic species. Of the monogenetic forms no Gyrodactylid has so far been recorded from Australia; indeed, only two species have been described from the Southern Hemisphere, viz. *Fridericianella ovicola* Brandes and *Lophocotyle cyclophora* Braun from South America. A considerable number of forms are known from central Europe, mainly as a result of the work of van Beneden and Hesse, Wagener, Perugia and Parona, Diesing, Creplin, Wegener and a few others. A number of species have been discovered in North America, most of them by MacCallum, while Goto has recorded a few from Japan.

In the present paper seventeen new species are described, all from the gills of Australian marine and freshwater fishes. As was to be expected, these were found, with two exceptions, to be generically quite distinct from any hitherto described. Some have proved to be so remarkable that they must fall into a new family (*Protygyrodactylidae*), whilst others cannot be included in any of the other known subfamilies, as defined by various authors. This has made possible a considerable extension of our conception of this group of Heterocotylean Trematodes and the opportunity has been taken to suggest a reclassification of the group and to incorporate, and to a certain extent rename, some remarkable species described by MacCallum from North America. This matter has been rendered very difficult by the imperfect accounts of some of the forms; indeed, so many essential characters have been omitted from these descriptions, that it has been found necessary, occasionally, merely to append certain genera to certain subfamilies or families from which they may have to be removed when our knowledge of them is more complete.

With the exception of two new species, one assigned to *Monocotyle* and the other to *Calacostoma*, all the new Australian forms described in this paper fall into new genera; indeed most of the species considered are so distinct from one another that they have had to be regarded as new generic types. Since only a relatively small number of host-species was examined for the presence of these trematodes, and as the parasites were often present on the gills, especially in the freshwater forms, in enormous numbers (sometimes as many as a dozen on a single minute gill-filament), it seems that this group, if more extensively

investigated, will be found to be exceedingly well represented in our waters, the existence of such an array of monotypic genera being scarcely likely.

An interesting result of the work is the establishment of a totally distinct and sharply defined subfamily, *Lepidotreminae*, to include certain genera found on fishes in the freshwater rivers of Central Queensland (inland drainage system) as well as closely allied genera occurring on our marine fishes.

Though the rivers of Central Queensland now belong to an extensive inland drainage system, they formerly had a communication with the ocean. Mr. A. McCulloch, Zoologist to the Australian Museum, Sydney, with whom we discussed this matter, drew our attention to the fact that all Australian freshwater fishes belong to families which are essentially marine, e.g. most of them belong to the perch family (*Serranidae*), others to the *Atherinidae*, *Mugilidae*, etc., while the catfishes belong to the *Plotosidae* (See Tate Regan, Proc. Zool. Soc. Lond., 2, 1909, p. 770, footnote).

Of course there is a large anadromous fish population, e.g. species of *Galaxias*, *Anguilla*, gobies, mullets, etc., but we have not yet systematically searched members of these groups.

We might point out that almost the whole of the freshwater material dealt with in this paper came from the Thomson River at Longreach, Central Queensland,—a tributary of Cooper's Creek; and most of the remainder from the Upper Burnett River which flows into the Pacific. Both collections were made by Miss M. J. Bancroft, B.Sc., whilst engaged in an attempt to ascertain the cause of widespread mortality of fish in Queensland waters (Johnston and Bancroft, 1921).

The types of all the new species described in this paper have been deposited in the Australian Museum, Sydney.

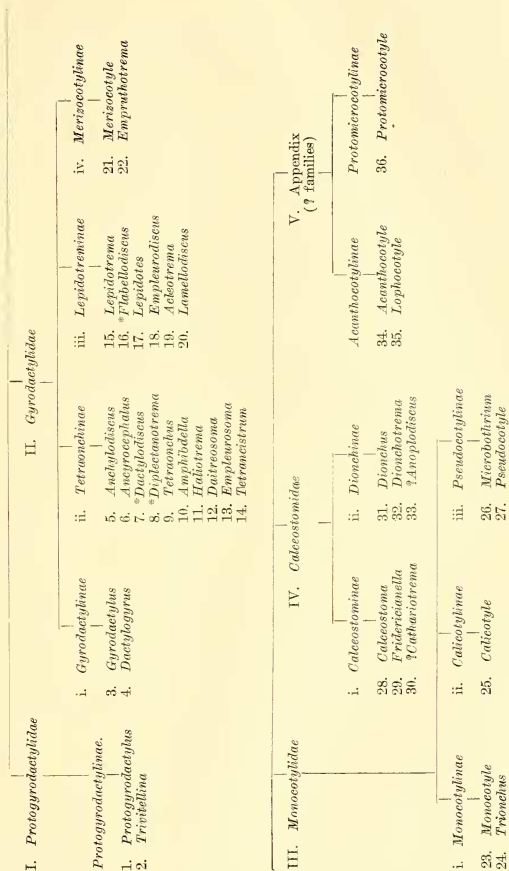
In the present paper there are proposed one new superfamily (*Gyrodactyloidea*); one new family (*Protogyrodactylidae*); five new subfamilies (*Protogyrodactylinae*, *Lepidotreminae*, *Merizocotylinae*, *Dionchinae*, *Protomicrocotylinae*); and seventeen new genera or subgenera. Of the latter, five are based on species described by G. A. MacCallum from North American fish, while the other twelve are founded on new species described in this paper as infesting Queensland fish.

These twelve, with their type species, are as follows:—*Protogyrodactylus* (*P. quadratus*); *Trivitellina* (*T. subrotunda*); *Anchylodiscus* (*A. tandani*); *Haliotrema* (*H. australe*); *Daitreosoma* (*D. constrictum*); *Empleurosoma* (*E. pyriforme*); *Lepidotrema* (*L. therapon*); *Flabellodiscus* (*F. simplex*); *Lepidotes* (*L. fluviatilis*); *Empleurodiscus* (*E. angustus*); *Acleotrema* (*A. girellae*); *Lamelodiscus* (*L. typicus*).

The five new genera proposed for species already known are *Diplectanotrema*—for *Diplectanum pleurovitellum* MacC.; *Empruthotrema*—for *Acanthocotyle raiae* MacC.; *Cathariotrema*—for *Monocotyle selachii* MacC.; *Dionchotrema*—for *Acanthodiscus remorae* MacC.; *Protomicrocotyle*—for *Acanthodiscus mirabilis* MacC. No less than thirty-six genera are herein listed under the new superfamily.

In addition to the seventeen Australian species described as new, fresh names have been proposed for two others described by MacCallum from North American Elasmobranchs, and belonging to the genera *Amphibdella* and *Monocotyle*.

The following table indicates the scheme of classification proposed in the present paper:

Superfamily *Gyroductyloidea* J. & T.

*Names so marked indicate subgenera of the preceding genus.

TREMATODA HETEROCOTYLEA.

Superfamily *GYRODACTYLOIDEA*, n. superfam.

This superfamily includes certain monogenetic trematodes characterised by the absence of suckers of the ordinary type, although the higher and more specialised members of the group may have structures which function as such.

The organ of attachment to its host is a posterior clasping disc which may or may not be distinctly marked off from the body of the worm. The disc is supplied with a hook apparatus which may reach an extraordinary degree of complexity.

At the anterior end of the parasite (except in the *Monocotylidae*) are masses of glandular tissue, which open on the surface by very characteristic "head organs," or, in the higher members of the superfamily, by a very large number of minute ducts, not concentrated in groups. In the *Monocotylidae* these glands have apparently disappeared.

The mouth leads into a buccal cavity which may be short or fairly long; never very long. A pharynx is always present. An oesophagus may be present or absent. The intestine has one or two limbs, with or without caeca.

Excretory ducts open either at the anterior end or, in some forms, probably at the posterior end.

Eyes may be present or absent. The nervous system consists of a poorly developed brain, below or considerably behind the eyes. A pair of lateral nerves, from which smaller branches arise, are given off from the brain.

The testis is a compact or only slightly lobed organ, single or double, and never lies anterior to the ovary. The vas deferens may be a simple tube hardly expanded into a vesicula seminalis, or it may be widely dilated, sometimes enormously so in the Australian species. A bulbous ejaculatorius may or may not be present. The cirrus may range from a simple chitinous tube to a structure of considerable complexity, while an accessory clasping apparatus may occur.

The ovary may be a branched or unbranched organ, lying either in the midline or asymmetrically. A vagina may be present (single or double) or absent, and there may be a receptaculum seminis connected with it.

Shell-glands may vary from simple glandular thickenings of the ootype, to very prominent glands connected by long ducts with the female duct. The female aperture usually lies immediately behind the male opening, but sometimes at a considerable distance from it, generally laterally. Never more than one egg is present in the uterus. The egg may be laid, or it may be retained in the uterus to develop into a young worm which may, while *in utero*, produce a second generation.

The yolk system may be poorly or strongly developed. In the most primitive members of the group there is a very distinct communication between the yolk system and the intestine in the posterior region of the animal.

The members of the group occur, as far as is known, on the gills, nasal gland, or skin of fishes, both Teleosts and Elasmobranchs.

Key to families of Gyrodactyloidea.

- A. a. Glandular structures present on head B.
 b. Glandular structures entirely absent *Monocotylidae*
 B. a. Ducts from the glands concentrated into distinct "head-organs" C.
 b. Ducts from glands scattered diffusely over part of the head . *Calceostomidae*

- C. a. Minute, very robust worms, in which the yolk system has, in addition to the ordinary transverse duct anterior to ovary, at least one posterior transverse duct which communicates with the intestine *Protogyrodactylidae*
 b. Slender worms, in which this character of the vitelline system is quite absent *Gyroductylidae*

Family I. PROTOGYRODACTYLIDAE, n. fam.

These are primitive, minute Gyrodactyloidea, about as broad as long, with a greatly developed clasping disc bearing two pairs of relatively very large clasping hooks and numerous minor hooks which are rather larger than usual.

The cephalic glands open to the exterior by well-defined head-organs. There is a prominent pharynx. The intestine is bifurcated, the limbs ending blindly or uniting posteriorly. Intestinal caeca absent.

Neither testis nor ovary is branched. There is no vagina. The uterus is very short. The cirrus is a simple chitinous tube, enclosed in a cirrus-sac. The yolk system is very remarkable in that it consists of numerous long thin "yolk-tubes," arranged in two sets, the one anterior, the other posterior, to the ovary. The transverse yolk-ducts so formed are connected by a longitudinal median yolk-duct which opens into the ootype. The posterior transverse yolk-duct has a distinct connection with the intestinal limbs.

Found, so far, only on the gills of freshwater fishes.

Type genus, *Protogyrodactylus* J. & T., 1922.

The family also includes *Trivitellina* J. & T. Should the discovery of other genera belonging to the family necessitate its subdivision, then these two, owing to their close relationship would be included in the same subfamily, *Protogyrodactylinae*.

1. PROTOGYRODACTYLUS, n. gen.

Protogyrodactylidae, slightly broader than long; the clasping disc very broad, not sharply marked off from the body, strongly "padded," bearing four very large, and twelve minor hooks, the latter rather larger than usual. A very short oesophagus present; the limbs of the intestine not united posteriorly. Four eyes present, lying above the brain. A single posterior transverse yolk-duct connected with the intestine.

Found on the gills of freshwater fishes.

Type species, *Protogyrodactylus quadratus* J. & T.

PROTOGYRODACTYLUS QUADRATUS, n.sp. (Plate ix., Fig. 1-5; x., Fig. 6.)

The worm is short and thickset, a little broader than long, and about three times as long as thick. Its length is about .23 mm. On account of the wing-like expansions of the sides, the head is distinctly marked off from the body of the animal. Two distinct head-lobes are developed on it.

The disc is very prominent, but is not sharply marked off from the rest of the body, as is indicated in the section on Plate ix., figure 3. It is provided with four hooks, two of which are very large, powerful and strongly curved, the other two somewhat smaller, straighter and more slender. The bases of the hooks are supported by a transverse chitinous bar, articulating with the ends of which are (1) a pair of small pieces of chitin, to which the powerful muscles of the disc become attached in part, and (2) a pair of larger inwardly-directed chitinous pieces. There are also twelve minor hooks, rather larger than usual,

ten of which are arranged around the margin of the disc, while the other two are more centrally situated (Pl. x., fig. 6).

The disc has a curiously swollen appearance. In section the swelling is seen to be due to the presence of a mass of peculiar tissue, apparently synectial in nature, arranged as a number of thick masses vertical to the longitudinal axis of the animal (Pl. ix., fig. 4). This tissue probably acts as a kind of "padding."

The animal is covered with a thin cuticle which undergoes strong chitinisation on the disc. Longitudinal and transverse muscle-layers can be distinguished, the former presenting a marked development on either side of the mid-ventral line and assuming the form of two very large muscles passing from the anterior end of the animal backward to become inserted into the hook apparatus of the disc. The posterior portion of these muscles is further strengthened by the addition of another pair, each member of which passes upward, closely applied to the ovary, to become continuous with the longitudinal muscle-layer on the dorsal side.

The mouth is ventral, but not at the anterior extremity. It leads into a large pharynx which, in turn, opens by a short oesophagus into the intestine. The latter broadens out posteriorly and ends blindly. Into its anterior end, close to the oesophagus, there opens, on either side, a mass of elongated glands. Three pairs of head-organs are also visible at the anterior end, but the corresponding glands could not be seen, probably on account of the large mass of yolk surrounding them. No trace of excretory system could be recognised.

Of the nervous system only the brain was visible. In close connection with this are two pairs of eyes, the anterior being smaller and closer together than the posterior pair. They lie sunk within the body at a distance from the dorsal surface equal to about one-fifth of the thickness of the animal in this region.

The testis is a large triangular organ, situated above and partly behind the ovary, in the mid-dorsal region (Pl. ix., fig. 4). The vas deferens is a short, wide, rather irregularly bent tube, opening into the large transversely-placed vesicula seminalis which is connected by a short duct with the cirrus. The latter is a thin, slightly bent tube, lying in a spacious cavity enclosed by the cirrus-sac. The male opening lies mid-ventrally immediately behind the pharynx.

The ovary is situated slightly anterior to, and below, the testis. The oviduct or uterus is a short wide tube opening close behind the male aperture. The shell-gland is only slightly developed, being merely a glandular thickening of the oviduct. There is no vagina.

The structure of the yolk system is remarkable. There are numerous elongated yolk-tubes which converge in two systems and unite to form two transverse yolk-duets, one lying in front of the ovary and testis, the other posterior to them. The anterior system arises by the junction of three minor systems on either side, which bring the yolk from the anterior, middle, and more posterior regions of the body.

The posterior transverse duct is formed by the junction of a large number of "yolk-tubes" from the lateral body regions, posterior to the anterior system; into this duct there also open a pair of large yolk-duets (Pl. ix., figs. 1, 4) which bring the yolk from the dorsal region of the animal. From the middle of the posterior transverse yolk-duct a longitudinal duct is given off, which passes forward beneath the ovary and opens into the ootype. It could not be observed whether the anterior transverse yolk-duct united separately with the ootype, or whether it and the median longitudinal yolk-duets had a common duct leading into the ootype.

The posterior transverse duct possesses a wide lumen and is very remark-

able in that it is connected by a wide opening with the cavity of the intestinal limbs (Pl. ix., fig. 3).*

The uterus does not contain more than one egg. The latter is almost spherical and is provided with a large spine, measuring about .025 mm. in diameter.

Found, generally in pairs, on the gills of *Therapon carbo* Ogilby and McCulloch, and *T. hilli* Castelnau from the Thomson River, Longreach, Central Queensland.

2. TRIVITELLINA, n.gen.

Protogyrodactylidae, rather longer than broad; clasping disc sharply marked off from the body and not strongly "padded," bearing four very large, and twelve minor hooks, the latter rather larger than usual; three pairs of "head-organs"; oesophagus absent; limbs of the intestine united posteriorly; four eyes; beside the anterior yolk system, there are two posterior systems, one of which is connected with the intestine.

Found on the gills of freshwater fishes.

Type species, *Trivitellina subrotunda* J. & T.

TRIVITELLINA SUBROTUNDA, n.sp. (Plate x., fig. 7.)

This minute organism, measuring about .2 mm. in length and .18 mm. in greatest breadth, is a short, thickset parasite with lateral, somewhat wing-like expansion, and, except for the presence of the disc, is almost circular in shape. The posterior two-thirds of the worm generally lie well beneath the surface of the gill-filament, only the anterior third protruding. The disc projects backward and is sharply marked off from the rest of the body, differing in this respect from *Protogyrodactylus*.

The curious "padding tissue" characteristic of the last-named is absent, but seems to be represented by a modified parenchyma present at the posterior end of the animal and consisting of three paired masses, with a smaller mass between them. The anterior masses approach the intestine, while the posterior lie within the disc and are closely related to the small hooks on it.

The disc is proportionally large and its posterior part is ornamented with curious chitin-pieces. Four large hooks are present, the dorsal pair being the smaller, and each of the four is supported by a small chitinous rod, giving the hook a triradiate appearance. The posterior hooks are very large and strongly curved outwards, their bases being connected by a transverse bar. The base of each large hook articulates with a small triangular chitin-piece into which the muscles of the hook are inserted. Each is supplied with a pair of muscles: (1) the longitudinal musculature of the body, which runs forward as far as the pharynx, and (2) a small transverse muscle, which arises from the ventral portion of the disc. The latter is armed also with six pairs of rather large secondary hooks whose distribution is shown on Plate x., figure 7.

*The presence of a communication between the female system and the intestine has been described by Iijima as occurring in certain monogenetic Trematodes (*Polystomum*, *Diplozoon*, *Octobothrium*). Von Graff found two such connections in the land Planarian, *Rhynchodemus*, and one in *Palmatoplana*; Bendl (Zool. Anz., 35, 1909, p. 294) found one to occur in the Rhabdocoel, *Phaenocora*, while Haswell discovered a genito-intestinal canal in the Polyclad, *Enterogonia pigraus*.

Professor Haswell has recently drawn our attention to a paper by Merton (Zool. Anz., 41, 1913, p. 413) in which a remarkable organ called "vesicula resorbiens" by him, is described as lying in the wall of the intestine of *Tenuoccephala semperi*, into which it may apparently open at intervals, the organ communicating directly with the female ducts.

The mouth opens ventrally, some distance behind the anterior end. The long buccal cavity communicates with a pharynx which passes almost vertically upwards so that, in dorsal view, the latter appears spherical instead of ovoid. The pharynx opens postero-dorsally into the intestine which is practically a ring-shaped sinus with a large lumen, lined by a single layer of flattened epithelial cells. At either side of the pharynx is a mass of digestive glands connected with the intestine.

The cephalic glands have undergone a curious change in position owing to the head being flattened transversely and the glands coming to occupy a position at the angles of the head. Their ducts consequently pass, not forward, but inward. Three pairs of head-organs are present. There are two pairs of eyes, situated well within the body-parenchyma, the anterior pair being very small and the posterior more than usually large. The brain could not be distinguished. No trace of excretory system was recognisable. The ovoid testis lies practically in the centre of the animal, and antero-laterally gives off a large uncoiled vas deferens which passes forwards into a transversely-dilated vesicula seminalis. The cirrus closely resembles that of *Protogyrodactylus*, as does also the curious cirrus-sac.

The female genitalia are more difficult to observe. The ovary, which lies below and somewhat in front of the testis, is strongly elongated transversely. The uterus appears to be a short duct with a wide lumen. The nature of the shell-gland could not be definitely made out, but it appears to be merely a glandular thickening of the ootype. The comparatively large spherical egg measures about .05 mm. in diameter and possesses a backwardly directed spine.

The vitellaria are of the *Protogyrodactylus* type, i.e. there are long "yolk-tubes," converging to form transverse ducts. Of these there are three, not two as in that genus, one being situated in front of the ovary and the other two posterior to it. The anterior transverse vitelline duct is formed by the convergence of a very large number of elongated yolk-tubes, occupying the anterior half of the body. Of the posterior yolk-ducts, one is situated ventrally, the other more dorsally. The dorsal posterior transverse duct lies immediately behind the ovary and receives the secretion from two systems of yolk-tubes, a posterior and an anterior, on either side. This transverse duct has a communication with the intestine, similar to that of *Protogyrodactylus*. The ventral posterior transverse duct, which possesses no communication with the intestine, is rather narrower and lies a little behind the dorsal duct. The three transverse yolk-ducts are joined by a common median duct, running below the ovary and apparently opening into the ootype.

Found on the gills of *Therapon fuliginosus* Macleay, from the Thomson River, at Longreach, Central Queensland.

Family II. GYRODACTYLIDAE Van Beneden and Hesse, 1863.—emend. J. & T.

(Syn. *Amphibdellidae* Carus, 1885.)

These are elongated Gyrodactyloidea with well developed clasping disc which may or may not be distinctly marked off from the remainder of the body, and may, in the highest members of the group, bear suckers. The disc bears large and small hooks, sometimes forming a chitinous armature of great complexity.

Cephalic glands are present and always open to the exterior by means of well defined head-organs.

The pharynx may be large or small; the intestine single or with two limbs,

with or without caeca. Eyes may be present or absent. Both testis (always single) and ovary are unbranched organs which may be situated laterally or in the midline. The vesicula seminalis may undergo enormous distension. The chitinous penis may be simple or very complex. The vagina may be present or absent, single or double. The vitellaria are never in the form of elongated converging "yolk-tubes" and there is never any connection with the intestine.

Key to subfamilies of Gyrodaetyliidae.

- A. a. Adhesive disc provided with numerous small suckers *Merizocotylinae*
- b. Disc devoid of such suckers B.
- B. a. Disc provided with a pair (dorsal and ventral) of accessory structures, consisting of concentrically arranged rows of scales or broader lamellae *Lepidotreminae*
- b. Disc devoid of such structures C.
- C. a. Disc with four large hooks *Tetraonchinae*
- b. Disc with two large hooks *Gyrodaetylinae*

Subfamily I. GYRODAETYLINAE Monticelli, 1892—emend. J. & T.

Gyrodaetyliidae in which the disc is distinctly marked off from the rest of the body, and bears two large hooks, with fourteen or sixteen minor hooks. Head with very distinct lobes related in position to the head-organs. Eyes present or absent. A prominent pharynx. The intestine bilobed and devoid of caeca; a posterior communication between the limbs present or absent. Ovary and testis unbranched organs. The penis a fairly simple chitinous tube. Accessory copulatory structures may be present. A vagina present or absent.

Found on the gills of freshwater and marine fishes.

3. GYRODAETYLUS Nordmann, 1832.

Gyrodaetylinae in which the disc bears two large and sixteen minor hooks. A single pair of head-lobes present; no eyes; intestinal limbs end blindly. Vagina absent; the worm may be viviparous. Gonads situated just behind the middle of the body.

Found on the gills of freshwater fishes.

Type, *G. elegans* Nordm., 1832, from *Cyprinus* and many other European freshwater fish.

The following species belong to *Gyrodaetylus*:—*G. elegans* Nordm., 1832; *G. medius* Kathariner, 1894; *G. rarus* Wegener, 1910; *G. groenlandicus* Levin, 1881; *G. fairporti* van Cleave, 1921. *G. gracilis* Kathariner, 1894, is perhaps a synonym of *G. elegans*.

No members of the genus have yet been described from Australia.

4. DACTYLOGYRUS Diesing, 1850.

Gyrodaetylinae in which the disc bears two large and fourteen minor hooks, but the large hooks may undergo considerable diminution in size in some species. Four head-lobes. Intestinal limbs (usually ?) communicate behind. Penis generally with an accessory copulatory structure. Vagina probably always present. Gonads situated in, or just behind, the middle of the body.

Found on the gills of freshwater and marine fishes.

Type, *D. auriculatus* (Nordm., 1832) Dies., 1850.

The genus has not yet been recorded from Australia; Goto and Kikuehi (1917) have, however, described a form, under the name *D. inversus*, from Japan.

The following species appear to belong to *Dactylogyrus*:—*D. parvus* Wegener, 1910; *D. difformis* Wag., 1857; *D. fraternus* Wegener, 1910; *D. minor* Wag., 1857; *D. crucifer* Wag., 1857; *D. cornu* Linst., 1878; *D. intermedius* Wegener, 1910; *D. falcatus* (Wedl., 1857) Dies., 1858; *D. alatus* Linst., 1878; *D. sphyryna* Linstow, 1878; *D. similis* Wegener, 1910; *D. fallax* Wag., 1857; *D. macracanthus* Wegener, 1910; *D. amphibothrium* Wag., 1857; *D. anchoratus* (Duj., 1845) Wag., 1857; ? *D. forceps* Leuckart, 1857; *D. gracilis* Wedl., 1861; *D. major* Wag., 1857; *D. malleus* Linstow, 1877; *D. megastoma* Wag., 1857; *D. mollis* (Wedl., 1857) Dies., 1858; *D. siluri* Wag., 1857; *D. tenuis* (Wedl., 1857) Dies., 1858; *D. trigonostoma* Wag., 1857; *D. tuba* Linst., 1878; *D. inversus* Goto and Kikuchi, 1917 (Japan); *D. dujardinianus* Dies., 1850; *D. auriculatus* (Nordm., 1832), Dies., 1850; *D. uncinatus* Wag., 1857.

Subfamily II. TETRAONCHINAE Monticelli, 1903.—emend. J. & T.

(Syn. *Diplectaninae* Monticelli, 1903; *Amphibdellidae* Carus, 1885.)

Gyrodactylidae with the cuticle devoid of scaly papillae. The disc either sharply constricted off from the body, or merging into it directly. Four large hooks always present. Eyes present or absent. The intestine either a single median tube, or bifurcated, with the limbs ending blindly or joining up behind. Intestinal caeca present or absent.

Testis occasionally, ovary never, lobed. Vagina present or absent. Penis generally simple, occasionally somewhat complex, but never attaining the extraordinary degree of complexity seen in the next subfamily (Lepidotrematinae). Occasionally an accessory male copulatory structure present.

From the gills of marine and freshwater fishes.

This subfamily includes the following genera and subgenera:—*Anchylodiscus*, n.gen.; *Ancyrocephalus* Creplin, 1839; *Dactylo-discus* Olsson, 1893; *Diplectanotrema*, n.gen.; *Tetraonchus* Diesing, 1858 (type genus); *Amphibdella* Chatin, 1874; *Haliotrema*, n.gen.; *Daitreosoma*, n.gen.; *Empleurosoma*, n.gen.; *Tetrancistrum* Goto and Kikuchi, 1917.

Key to genera of Tetraonchinae.

- A. 1. Body very distinctly constricted near mid-region B.
2. Body not constricted C.
- B. 1. Testis and ovary in posterior region of body; eyes absent; intestinal limbs not connected behind *Haliotrema*.
2. Testis and ovary near middle of body; eyes present; intestinal limbs connected behind *Daitreosoma*.
- C. 1. Intestine bifurcated D.
2. Intestine not bifurcated *Tetraonchus*.
- D. 1. Intestinal limbs provided with caeca *Tetrancistrum*.
2. Intestinal limbs devoid of caeca E.
- E. 1. Disc connected with body by a distinct petiole, and developed laterally into short processes *Dactylo-discus*.
2. Otherwise F.
- F. 1. Body rather long and slender; intestinal limbs ending blindly G.
2. Body robust; intestinal limbs connected behind *Empleurosoma*.
- G. 1. Yolk system confined to a region behind the transverse yolk-duct *Amphibdella*.
2. Yolk system extending as far as, or almost as far as, the pharynx H.
- II. 1. Yolk system consisting of a longitudinal row of separate yolk-glands. *Diplectanotrema*.
2. Yolk system continuous on each side I.
- I. 1. Vagina absent *Anchylodiscus*.
2. Vagina present *Ancyrocephalus*.

5. ANCHYLODISCUS, n.gen.

This genus is characterised by the occurrence of four very large hooks on the clinging disc, together with fourteen minor hooks scattered over it. Three pairs of head-organs. Four eyes, the anterior pair farther apart than the posterior. Pharynx large and rounded. Intestinal limbs end blindly. Vesicula seminalis not highly dilated. Testis directly above ovary. Penis a simple chitinous tube. Shell-glands probably simply glandular thickenings of the walls of the oviduct. Vitelline system very well developed. Egg of relatively enormous size.

Found, so far, only on the gills of Siluroid fishes in Queensland.

Type species, *Anchylodiscus tandani* J. & T.

ANCHYLODISCUS TANDANI, n.sp. (Plate x., figs. 8, 9; xi., figs. 10, 11.)

This parasite is rather small, but thick-set, measuring about .3 mm. in length, .06 to .08 mm. in breadth.

The head-end is indistinctly marked off from the remainder of the animal. The disc (Pl. x., fig. 9), which is very prominent and fairly sharply marked off from the body, is armed with four relatively very large hooks, each slightly bifurcated basally, the bases of each pair of hooks being joined by a simple cross-bar. The edge of the disc is prominently lobed to form partial supports for the larger hooks. Fourteen minute hooks are also present.

Of the body musculature the outer circular and delicate internal longitudinal layers are visible. The longitudinal layer of the posterior end is strongly developed to form the musculature supplying the disc.

Three pairs of head-organs are present. Anterior to the median pair, the "head" possesses a pair of small but distinct lobes. The cephalic glands lie laterally to the anterior pair of eyes.

The mouth appears to open ventrally, but could not be definitely observed. The pharynx is prominent, its anterior portion lying immediately behind the posterior pair of eyes. There is a definite oesophagus of moderate length. The bifurcated intestine ends blindly. Unicellular glands are visible in the pharynx. There is also a pair of prominent glands situated on either side of the oesophagus.

No trace of the excretory system could be recognised. Of the nervous system, only the brain was visible, lying immediately between the eyes. The latter are very large and prominent and are situated in the body parenchyma, immediately below the body wall. Their arrangement differs from that of most other Gyrodactylids in that the smaller anterior eyes are farther apart than the posterior.

The reproductive organs are of a rather simple type. The testis is elongated and lies dorsally to the ovary, reaching from well in front to a short distance behind it. The vas deferens arises from it laterally, passes in the dorsal region of the body almost to the right side, then turns forward, inward and downward to open in the middle line into a large, transversely-placed, reniform vesicula seminalis which lies close behind the pharynx. The more anterior portion of the vas deferens undergoes a slight dilatation a short distance before the permanent vesicula. From the latter the vas deferens passes backward as a rather narrow tube and opens into a small rounded bulbus ejaculatorius, lying at the base of the cirrus. The latter is a simple chitinous tube, bent almost into a complete circle and opening immediately in front of the female aperture.

The ovary lies in the midline, immediately below the testis. It is slightly oval and elongated longitudinally. A vagina is absent. The oviduct leaves the ovary ventrally and travels forward. It has not been observed in whole specimens, but is plainly visible in sections. The shell-glands are represented merely by a glandular thickening in the uterus along its whole length. The vitellarium follows the path of the intestine fairly closely. It is very strongly developed in the posterior region of the worm, where it occupies practically the whole of the body. Transverse yolk-ducts open into the oviduct immediately in front of the ovary. No permanent yolk-reservoir is present.

The egg is of relatively immense size, forcing the other structures in its neighbourhood out of position when it is fully developed (Pl. xi., fig. 11). The intestine becomes bent to one side and the vas deferens appears to be pulled from its lateral position to lie more centrally, close beside the intestine. Posteriorly the egg bears a short blunt spine. The egg figured, which came from a rather small adult, measured .075 mm. in length by .035 mm. in breadth.

Found on the gills of the freshwater jewfish or catfish, *Tandanus tandanus* Mitchell, from the Burnett River, South Queensland.

ANCHYLODISCUS SP.

A worm belonging to this genus was found in very small numbers on the gills of a closely allied catfish, *Neosilurus hyrtlui*, from the Paroo River, South-west Queensland. No detailed study of its anatomy was possible.

6. ANCYROCEPHALUS Creplin, 1839.

(Syn. *Diplectanum* Diesing, 1858, and other authors; *Tetraonchus* Diesing, 1858, in part.)

More or less elongated Tetraonchinae, in which the disc is not very sharply marked off from the body. Supporting chitinous armature of the disc present or absent. Minor hooks varying greatly in number; occasionally absent, never more than fourteen. Eyes present. Intestine bifurcated, the limbs devoid of caeca and not joining behind. Position of testis and ovary at times in the middle, or in anterior region, or well within the posterior half of body. Testis usually simple but occasionally slightly lobed. Penis simple; accessory copulatory structures at times present. Vagina always present. Vitelline system extending on either side as a continuous gland from the pharynx to the region immediately behind the termination of the intestine.

From the gills of marine and freshwater fishes. Known, as yet, only from Europe and North America.

Type species, *A. paradoxus* Creplin, 1839.

In 1857 Wagener placed a number of new species in the genus *Dactylogyrus*, a procedure which has led to considerable confusion in the nomenclature of this group. One species, *D. aequans* Wagener, 1857, was made, in the following year, the type of a new genus *Diplectanum* by Diesing, who also placed *Dactylogyrus pedatus* Wagener in this genus. Wagener, at the same time (1857), described under the name *Dactylogyrus unguiculatus*, a worm which proved to be identical with *A. paradoxus* Creplin, and added another species, *Dactylogyrus monenteron*. Diesing, in 1858, placed these two forms, as well as *Gyrodactylus cruciatus* Wedl., in a new genus, *Tetraonchus*, failing to recognise the identity of *T. unguiculatus* with Creplin's original species (*A. paradoxus*). It was not till 1889 that Monticelli showed these two forms to be the same. The name was

however not altered till Lühe (1909) reintroduced that of Creplin. In 1889 Parona and Perugia added Wagener's *Dactylogyrus echeneis* to *Diplectanum*.

In 1910 Wegener removed *T. monenteron* from *Tetraonchus*, owing mainly to the character of its intestine, proposing for its reception a new genus, *Monocoelium*. Of the three original species of *Tetraonchus*, *T. cruciatus* is now definitely placed under *Ancyrocephalus*; *T. unguiculatus* is identical with *A. paradoxus* of Creplin; hence, as suggested by Stiles and Hassall (1908, p. 370), *T. monenteron* becomes by elimination the type of the genus *Tetraonchus*, Wegener's name (*Monocoelium*) being a synonym.

The remaining species listed under *Tetraonchus* and *Diplectanum* belong to *Ancyrocephalus*.

Lühe uses the latter term in a wide sense to include both *Tetraonchus* (of authors) and *Monocoelium*.

MacCallum (1915, 1917) described a number of new species of *Diplectanum* which he regarded as a subgenus of *Tetraonchus*, i.e. *Ancyrocephalus*. Monticelli (1903) on the other hand, actually proposed a new subfamily, *Diplectaninae*, for the reception of the genus, regarding it as quite distinct from his *Tetraonchinae*.

So far as we have been able to observe from the available published accounts of MacCallum and of the earlier workers, no anatomical distinction of generic value can be recognised amongst the various species included under *Ancyrocephalus* and *Diplectanum*.

The genus *Ancyrocephalus*, as defined above, would include *A. paradoxus* Creplin, 1839; *A. cruciatus* (Weöl., 1857) Lühe, 1909; *A. vanbenedenii* (Par. and Per., 1890) J. and T., 1922; *A. aequans* (Wag., 1857) J. and T., 1922; *A. echeneis* (Wag., 1857) J. and T., 1922; *A. pedatus* (Wag., 1857) J. and T., 1922; *A. sciaenae* (Ben. and Hesse, 1863) J. and T., 1922; *A. teuthis* (MacCallum, 1915) J. and T., 1922; *A. lactophrys* (MacCallum, 1915) J. and T., 1922; *A. balistes* (MacCallum, 1915) J. and T., 1922; *A. longiphallus* (MacCallum, 1915) J. and T., 1922; *A. tylosuri* (MacCallum, 1917) J. and T., 1922.

7. Subgenus a. DACTYLODISCUS Olsson, 1893.

Small *Tetraonchinae* in which the disc is connected to body by a long petiole, and is produced laterally into a number of finger-like processes. Minor hooks apparently absent. Four eyes present; intestine probably bifurcated. Testis and ovary solid and near the middle of the animal. Large unlobed vesicula seminalis. Penis apparently simple. Opening of oviduct probably provided with hooklets. Anterior fifth of worm devoid of vitellaria.

Olsson did not mention the characters of the genus very fully, nor did he indicate whether a vagina was present. The above diagnosis is based on his figures and description of the type species.

The accentuated constriction of the disc from the body, a condition which is already evident in *Ancyrocephalus tylosuri* (MacCallum, 1917), and the irregular lobes of the disc, an indication of which is seen in the same species, are characters which are scarcely of generic value. A careful determination of the presence or absence of the vagina would be of much greater value. The form, however, probably deserves to rank as a subgenus of *Ancyrocephalus*. Monticelli (1903, p. 336; 1905, p. 79) quoted Olsson's genus as a synonym of *Tetraonchus*.

From the gills of *Thymallus vulgaris* and *Coregonus lavaretus*.

Type species, *Ancyrocephalus (Dactylodiscus) borealis* Olsson. Known only from Sweden.

8. Subgenus b. *DIPLECTANOTREMA*, n. subgen.[Syn. *Diplectanum* (in part).]

A small worm, having the usual characteristics of *Ancyrocephalus*, but differing in the very remarkable disposition of the vitellaria, which are arranged in the form of numerous separate yolk-glands along the whole of the length of the body. Ovary and testis situated in anterior quarter of the animal.

From the gills of the marine fish *Teuthis hepatus* and *Anisotremus virginicus*. Known only from the United States.

Type species, *A. (Diplectanotrema) pleurovitellum* (MacCallum, 1916).

9. *TETRAONCHUS* Diesing, 1858.—emend. J. & T.

(Syn. *Dactylogyrus* G. R. Wagener, 1857 (in part); *Monocoelium* G. Wegener, 1910.)

Tetraonchinae in which the disc is broader than the body. Four large hooks articulating with a large chitinous supporting apparatus (furcula); fourteen minor hooks. Four eyes. Intestine not bifurcated; devoid of caeca. Testis in middle of body. Vagina apparently absent. Penis with accessory clasping apparatus.

Type species, *T. monenteron* Wagener, 1857, from the gills of *Esox lucius*. The genus is known only from Europe (freshwater). The synonymy of this genus has been discussed in connection with *Ancyrocephalus*.

10. *AMPHIBDELLA* Chatin, 1874.

Relatively large *Tetraonchinae* measuring about 4 to 6 mm. in length. Head rather pointed. Disc fairly distinctly marked off from body. Twelve minor hooks always (?) present. No eyes. Intestine bilobed, devoid of caeca, the limbs not joining behind. Vagina apparently absent. Yolk system confined to a region posterior to the transverse yolk-duct. Penis simple.

Type species, *A. torpedinis* Chatin, 1874. From the gills of marine fishes (*Torpedo* and allies).

Not yet reported from Australia.

Monticelli (1889, p. 116; 1890; 1903, p. 336) regards *Amphibdella* as a synonym of *Tetraonchus*, i.e. of *Ancyrocephalus*. The pointed head, absence of vagina, and the remarkable position of the yolk system are characters which oppose this view.

Known species, *A. torpedinis* Chatin, 1874 (Mediterranean) *nec* MacCallum, 1916; *A. flavolineata* MacCallum, 1916 (Massachusetts).

AMPHIBDELLA MACCALLUMI, nom. nov.

(Syn. *A. torpedinis* MacCallum, 1916, *nec* Chatin.)

A comparison of MacCallum's figure of *A. torpedinis* with that given by Parona and Perugia (1890) leads us to conclude that the Mediterranean and American forms belong to different species and hence we have removed the latter from Chatin's species and renamed it as above.

Host, *Tetranarche occidentalis* (from Massachusetts).

11. *HALIOTREMA*, n. gen.

Tetraonchinae in which the disc is distinctly marked off from the body, and is provided with four large hooks supported by chitinous bars, as well as with

fourteen minor hooks. Head with two pairs of head-lobes. Body slightly constricted near mid-region. Eyes absent. Intestinal limbs devoid of caeca and without a terminal junction. Vagina with chitinous lumen. Testis and ovary lying in the mid-line and occupying the posterior third of the mid-region of the body of the worm. Penis large, not simple.

From the gills of marine fishes.

Type species, *Haliotrema australe* J. & T.

HALIOTREMA AUSTRALE, n.sp. (Plate xi., figs. 10, 12, 13, 14.)

Length of adult .64 mm.; maximum breadth .24 mm. The disc is distinctly marked off. Two pairs of head lobes are present. Slightly in front of its mid-region the body undergoes a definite constriction which is not so pronounced, however, as in *Daitreosoma*.

The disc bears two pairs of large hooks (Pl. xi., figs. 10, 12), each with a very distinct biramous basal portion whose roots are connected by a very definite and apparently chitinous membrane, complete except in one small place near the point of origin of the roots. The supporting chitin bars are two in number and slightly crescentic in shape, the convexity of the bars articulating with one another. Fourteen minor hooks are present, distributed as shown in Pl. xi., fig. 10. Of the body musculature the longitudinal layer is fairly well developed; behind, the fibres concentrate to form the muscles of the disc. Distinct circular fibres are absent, but there is a slight development of oblique muscles.

The mouth is a small transverse slit, lying ventrally at a considerable distance behind the anterior termination of the worm. The pharynx is large and distinct. Leading into the short, conical buccal cavity are two pairs of gland-cells. Into the short oesophagus open the ducts of a number of digestive glands; but in the specimens available the exact connections of these glands could not be observed. The intestine is bifurcated, the limbs approaching each other slightly in the region of the body constriction but diverging again behind. No junction takes place between the limbs posteriorly. Caeca are absent.

Situated in each side of the head, and stretching considerably behind the pharynx, is a mass of gland-cells. Their ducts were not visible, but they appear to be connected with the head-organs which lie in the first lobe of the head. It is possible that some of the posterior gland-cells supply the pharynx or oesophagus. Eyes are absent. The brain lies immediately in front of the pharynx.

The testis is a large solid organ lying between the intestinal limbs, almost at the posterior end of the animal. The vas deferens passes forward as a wide tube opening in the region of the body constriction into the vesicula seminalis. The latter, which is a fairly large structure with strongly lobed outer margin, extends forward almost as far as the beginning of the intestine, then bends back upon itself and continues as a large vas deferens which runs beside the penis and opens into it behind. The penis is a very distinct chitinous tube, lying slightly obliquely and enclosed in a fairly distinct penis-sac. It consists of two parts, a posterior simple tube, which appears to have a distinct articulation with an anterior portion, the latter, at its distal end, developing into a curious chitinous structure shown in Pl. xi., fig. 14.

The ovary is much smaller than the testis, in front of which it lies. Ova are prominent in its anterior region. The oviduct is a fairly wide tube, but only its proximal portion could be seen. Shell-glands could not be detected. A



very distinct vagina is present, opening on the ventral surface near the right side of the animal in the vicinity of the body constriction. The lumen of the vagina, on its distal half, is strengthened with a very prominent chitinous lining which extends posteriorly into a definite receptaculum seminis which gives off a short narrow pouch to the right. The vitellaria are very well developed, lying above and below the intestinal limbs which they embrace over their whole length. The transverse yolk-duct is clearly visible at a considerable distance in front of the ovary, and at its middle is dilated into a distinct yolk-reservoir. No ripe eggs were present in the material available.

Found on the gills of the marine black-spotted goat fish, *Upeneus signatus* Gunther, from Moreton Bay, S.E. Queensland.

12. DAITREOSOMA, n.gen.

Tetraonchinae in which the disc is not very sharply marked off from the body. Four large hooks present on disc, together with a pair of minor hooks. Body markedly constricted into a short anterior and long posterior portion. Intestinal caeca absent. Intestinal limbs communicating behind. Vagina present. Cirrus a long thin tube. Ovary and testis not lobed. Yolk does not extend into the posterior third of the body.

Found on the gills of freshwater fishes of the genus *Therapon*.

Type species, *D. constrictum*, n.sp.

DAITREOSOMA CONSTRICTUM, n.sp. (Plate xii., figs. 15-19; xiii., fig. 20.)

This worm measures about .45 mm. in length, .16 mm. in greatest breadth.

The anterior third of the body is marked off by a deep constriction from the posterior two-thirds, giving the worm a characteristic appearance. In general shape the parasite varies considerably according to the state of contraction; if uncontracted there appears a long, rather narrow, posterior portion which bears the disc, but if well-contracted, the worm may be oval.

The disc which is not very sharply marked off from the body, bears two pairs of large hooks, the ventral pair being much the larger and more strongly curved, lying in a pair of postero-ventrally directed lobes of the body wall (Pl. xii., fig. 16). At their bases they articulate with a large transverse chitinous bar and each with a small anteriorly and slightly inwardly directed chitin-piece, on which the well developed longitudinal muscles are in part inserted. The dorsal hooks are more slender and not so strongly curved. They are directed upward, the ventral hooks downward. At the side is a pair of small lateral lobes, each armed with a very small chitinous hook.

The body cuticle is smooth. The longitudinal muscle-layer has undergone great development in the ventral region to form a pair of longitudinal muscles, arising below the ovary and inserted, at their distal end, into the hook apparatus of the disc. These two muscles are joined by a second longitudinal pair lying internally to them and converge proximally in the vicinity of the posterior end of the intestine. These muscles form definite projections on the ventral body-wall.

The mouth is situated median-ventrally; the pharynx is prominent, broader than long and there is no definite oesophagus. The intestinal branches pass backward, approach each other in the region of the body constriction, then diverge again, but join immediately behind the testis. Intestinal caeca are absent. Ventrally, immediately behind the constriction, there are on either side two large masses of heavily-staining tissue which appear to open into the in-

testine and are perhaps digestive glands. A few simple glands are also present in the walls of the pharynx.

Situated laterally to and just behind the pharynx are two masses of glands, whose ducts run forward and inward to terminate in three pairs of head-organs. The excretory system could not be recognised. Of the nervous system, only the brain could be seen, lying between the eyes. The latter are situated immediately below the epidermis.

The testis is a large organ, posterior to, and partly enveloping, the ovary. The vas deferens is a thin-walled tube with a rather wide lumen even when empty. It is capable of immense distension and may act as a large vesicula seminalis, with lobed walls, occupying a considerable part of the dorsal region of the worm. Anteriorly it becomes continuous with a large ejaculatory bulb opening into the cirrus by an ejaculatory duct. The latter is a very long thin tube which passes first backward, then, bending upon itself, runs forward and inward towards the midline where it enters the cirrus. The latter is a simple chitinous tube which passes vertically downwards, and is retractile into the cirrus-sac, in which it may generally be seen coiled up.

The ovary is a large rounded structure, immediately in front of the testis; from its anterior end the oviduct travels vertically downward and into it the vagina opens. Into the latter, immediately before it communicates with the oviduct, there enters the vitelline duct. The oviduct then travels forward as a wide tube to terminate immediately behind the male aperture. The shell-gland is represented by a simple glandular thickening of the wall of the oviduct. The vagina is a narrow tube passing straight to the left side of the animal, where it opens in the region of the body constriction on a small bulbous expansion. It is provided, in its anterior portion, with a large thick-walled receptaculum seminis. The yolk system is well developed, but confined to the anterior two-thirds of the body, where it lies in close relation with the intestine. In the region of the body constriction a pair of transverse yolk-ducts is formed which open into an ill-defined yolk-reservoir.

The egg is oval, .048 mm. in length and .024 mm. in breadth, and bears at its posterior end a short blunt spine (Pl. xii., fig. 17).

The species was found, sometimes in large numbers, on the gills of *Therapon carbo* Ogilby and McCulloch, from the Thomson River, at Longreach, Central Queensland.

DAITREOSOMA BANCROFTI, n.sp. (Plate xiii., figs. 21, 22.)

This species closely resembles *D. constrictum*, but differs from it in the following characters:—

It is a slightly larger worm, measuring, when full grown, .56 mm. in length; .19 mm. in greatest breadth. The head is not regularly rounded as in that species, but is sharply indented immediately in front of the mouth (Pl. xiii., fig. 22). The four head-organs are close together, the last not so distinctly separated from the others as in the foregoing species.

The vesicula seminalis is quite different from that of *D. constrictum*. It lies only on the left side of the body (Pl. xiii., fig. 21) and does not undergo the great dilatation characteristic of that species, but appears as a tube bent slightly upon itself anteriorly, only moderately distended, and distinctly lobed only on its outer wall.

The vagina does not terminate in a small rounded bulb, but possesses a narrow funnel-shaped opening lying on the left side, within the body constriction.

This is especially plain in the specimen figured, where the body had been accidentally drawn out, the body constriction being in consequence obliterated. The receptaculum seminis is rather small. The yolk-reservoir is clearly visible.

Found on the gills of *Therapon hilli* Castelnau, from the Thomson River, at Longreach, Central Queensland.

13. EMPLÉUROSOMA, n.gen.

Small *Tetraonchinae*, with strongly developed lateral body regions. Disc not sharply marked off from body; provided with four large and two very small hooks, as in *Daitreosoma*. Eyes present. Intestinal limbs communicating posteriorly and devoid of caeca. Vagina absent. Cirrus a simple elongated tube. Yolk confined to the anterior region of the body.

Found on the gills of a freshwater fish.

Type species, *E. pyriforme* J. & T.

EMPLÉUROSOMA PYRIFORME, n.sp. (Plate xrv, fig. 31; xv, figs. 32-34.)

This is a small parasite, about .37 mm. in length, and .11 mm. in greatest breadth, with broadly expanded sides and rather thick body.

The disc, which is not sharply marked off from the body of the worm, is provided with two pairs of large hooks, viz., a posterior ventral pair, the bases of which are joined by a short transverse chitinous bar; and a more anterior, laterally directed pair, each of which is ankylosed at its base with an inwardly and posteriorly directed chitin-bar. These large hooks are all slightly biramous at their bases. Laterally the clasping disc possesses two small lobes each bearing a small hook, as in *Daitreosoma*. The large posterior hooks also articulate at their bases each with a very minute chitin-piece. To these chitin-pieces the musculature of the hooks is attached.

Four ventral longitudinal muscles supply the disc; an outer pair serving the more anterior pair of hooks, and a median pair inserted into the small chitin-pieces articulating with the posterior hooks. A transverse muscle uniting these basal pieces is also present.

The body-wall is thick and devoid of epidermal papillae. The circular muscle-layer is strongly marked; while the inner (longitudinal) series is prominent ventrally but could not be detected dorsally and laterally. In the posterior half of the animal the ventral longitudinal muscles are highly developed to form the four longitudinal muscles supplying the disc, as already described. These muscle-layers separating the several organs from the intestine are prominent in the anterior region of the animal. The body parenchyma in the posterior narrow portion of the worm is curiously developed, giving it a peculiar globular appearance, somewhat similar to that seen in *Daitreosoma*. There are four pairs of prominent head-organs on either side, the glands which supply them lying laterally to the pharynx. On either side of the pharynx are two pairs of remarkable glands which open on the body surface, ventrally, close to the cirrus; it is possible that they possess a copulatory function.

The mouth opens ventrally. The large, almost spherical pharynx is followed by a very short oesophagus. The two limbs of the intestine unite behind and are devoid of caeca. The intestinal walls are of remarkable thickness, but consist, nevertheless, of only a single layer of narrow columnar and very vacuolated cells, resting on a prominent basal membrane.

Neither excretory nor central nervous systems could be detected. Two pairs of eyes are present, situated well within the parenchyma, each pair at

approximately equal distances apart. The posterior pair lies above the pharynx, the anterior pair immediately anterior to that organ. Connected with the posterior pair is a definite globular vesicle.

The large testis lies immediately anterior to the end of the intestine and in section appears wedge-shaped. The vas deferens is a short wide tube opening into the large vesicula seminalis. The cirrus is a simple slightly curved chitinous tube. No other male sexual organs appear to be present.

The small ovary is situated anteriorly to the testis and somewhat transversely. The oviduct is given off from its ventral portion and runs forward close below the vesicula seminalis. A vagina is absent.

The shell-glands appear to be simple glandular thickenings of the uterus. The female opening is situated immediately behind the male aperture in the median ventral line. No eggs were present in any of the specimens examined. The yolk system is strongly developed but is confined to the anterior region of the animal. The transverse yolk-ducts lie immediately in front of the ovary. No reservoir was visible.

Found on the gills of *Therapon unicolor* Gunther, from the Barnett River, South Queensland.

14. TETRAONCISTRUM Goto and Kikuchi, 1917.

Rather small *Tetraonchinae* measuring 1.2 to 2 mm. in length. Body dilated in middle. Disc not sharply marked off from body and devoid of minor hooks. Eyes absent. Pharynx elongated; intestine bilobed, provided with caeca, the limbs communicating behind. Testis and ovary situated about the middle of the body. Penis simple, with accessory chitin-piece attached. Vagina present.

From the gills of a marine fish of genus *Siganus*. From Japan.

Type and only known species, *T. sigani* Goto and Kikuchi, 1917.

Subfamily III. LEPIDOPTREMINAE, n-subfam.

These are *Gyroactylidae*, which have, as a common characteristic, the development of scale-like papillae over the greater part of the body except in *Lamellodiscus*. On the disc these papillae are arranged in the form of a pair of scaly sucker-like organs (for which the name *Squamodisc* is proposed) which may or may not be provided with accessory hooks. Four powerful hooks, with basal supporting apparatus are present; also numerous minute hooks.

Two pairs of eyes. Intestine forked, ending blindly, not lobed. Ovary and testis solid. Penis simple or very complex. Vagina present.

From the gills of freshwater and marine fishes in Queensland.

This subfamily includes the following new genera:—*Lepidotrema* (type genus), with a subgenus *Flabellodiscus*; *Lepidotes*; *Empleurodiscus*; *Acleotrema*; *Lamellodiscus*.

Key to Genera of Lepidotreminae.

- | | |
|---|------------------------|
| A. a. "Squamodisc" provided with accessory hooks | D. |
| b. "Squamodisc" devoid of such hooks | B. |
| B. a. Body covered with scaly papillae; each of the concentric ridges of "squamodisc" consisting of numerous scales | C. |
| b. Body devoid of scaly papillae; concentric ridges consisting of only two very broad lamellae | <i>Lamellodiscus</i> . |
| C. a. Cirrus-sac very highly developed; very large genital chamber present | <i>Acleotrema</i> . |
| b. Cirrus-sac simple, genital chamber not markedly developed | <i>Lepidotes</i> . |

- D. a. Disc much broader than body, squamodisc provided with very numerous (about 25 to 30) accessory hooks *Empleurodiscus*.
 b. Disc with only about eleven such hooks, disc not as broad as body E.
 E. a. Cirrus a rather simple structure *Flabellodiscus*.
 b. Cirrus very long, and showing a remarkable complexity of structure
Lepidotrema.

15. LEPIDOTREMA, n.gen.

Lepidotreminae. The members of this genus are characterised by the presence of about eleven rows of scales on each of the two sucker-like organs of the disc, together with a row of generally about nine hooks on each, arranged like a spread fan. Fourteen minor hooks are scattered over the disc. The large hooks of the disc are supported by four powerful chitinous bars imbedded in the substance of the disc.

The penis is exceedingly complex. The testis is more or less degenerate in the adult, the sperms being stored in an immensely dilated vesicula seminalis. The vagina is extraordinarily large.

Found, so far, only on the gills of freshwater fishes belonging to the genus *Therapon*.

Type species, *L. therapon* J. & T.

LEPIDOTREMA THERAPON, n.sp. (Plate xv., figs. 35-37; xvi., figs. 38-42; xvii., figs. 45-49.)

Length of adult .5 to .77 mm.; breadth .19 mm. The body is covered with minute scale-like papillae, very minute anteriorly but increasing in size towards the posterior end of the worm.

The disc (Pl. xvi., fig. 40, *a-f*) is provided with an exceedingly powerful clinging apparatus. In the living condition the true posterior end of the disc is turned ventrally, i.e. the true dorsal surface of the disc is turned backward. Four large hooks are present. The ventral pair (Pl. xvi., fig. 40, *c*) are slender, and strongly hooked, and articulate basally each with the end of a chitinous bar which runs towards the centre of the disc, but does not quite reach its fellow. These two bars articulate at their inner ends with a much smaller curved piece of chitin which can be observed only by compressing the disc, its plane being vertical to that of the chitinous bars (Pl. xvi., fig. 40, *e*). Each of these bars is also provided on its outer half with a strong ring-shaped chitinous projection. The dorsal pair of hooks have a biramous basal portion, the two limbs or roots being united by a strong membrane. The anterior (ventral) limbs articulate with the chitinous bars which also give support to the ventral hooks, but the posterior limb has no such chitinous support. Two other inwardly-directed bars of chitin are also present, articulating with the more dorsal pair. They do not quite reach each other, but a slightly curved piece of chitin similar to and at right angles with the one already described, connects them. Fourteen minor hooks are also present, their disposition being indicated in Pl. xvi., fig. 42.

The dorsal and ventral surfaces of the disc (posterior and anterior in the attached animal) each bear, towards their proximal ends, a remarkable sucker-shaped disc, consisting of blunt teeth arranged in eleven curved rows which radiate outward from a point at the proximal end of the disc (Pl. xvi., fig. 40, *f*). In close connection with each of these discs are a number of hooks, varying from seven to eleven, connected by a membrane and spread out like a fan. The rows of blunt teeth, and probably also the hooks, are to be regarded as modifications

of the papillae which cover the body. The disc is supplied with muscles which originate from a powerful band in the dorsal region of the posterior end of the body, but their detailed arrangement has not been determined.

On account of the minute size of the worm, the structure of the body-layers is difficult to observe. The most remarkable characteristic of the epidermis is the presence on it of numerous sealy papillae. Delicate longitudinal muscle-layers lie below this, but their arrangement could not be accurately observed. The body parenchyma is well developed.

The very small mouth is situated ventrally immediately in front of the pharynx; the buccal cavity is quite short and the pharynx large, prominent, and projecting upward. Numerous unicellular glands occur in the anterior two-thirds of the wall of the pharynx. No definite oesophagus is present. Immediately behind the pharynx lies a mass of glands (? unicellular), which open into the intestine and are especially visible in young specimens. The forked intestine ends blindly at the posterior end of the worm, but immediately before the termination a junction takes place between the two limbs. In young forms this fusion does not occur. There are no caeca. The intestine is lined by a single row of flattened cells.

Four pairs of head-organs are present, but no corresponding lobes are developed on the head. Through these structures pass the ducts from a pair of prominent masses of unicellular glands, one on either side, antero-laterally to the pharynx. The excretory system could not be traced satisfactorily. At the anterior end, immediately behind the mass of gland-cells there occurs, on each side, a duct terminating on the body-surface by a slightly bulbous opening. Into each of these ducts there appears to open a very fine longitudinal duct, while one of a somewhat similar nature can be seen along each side just above the anterior termination of the lateral vitellaria. It is probable that these structures are parts of a complex excretory system (Pl. xv., fig. 36).

The brain lies anterior to the pharynx and gives off on each side a pair of nerves to the eyes which consist of a mass of minute pigment cells. The eyes lie close to the brain, i.e. within the "head," being situated, however, nearer the dorsal than the ventral surface. The posterior pair are the larger.

In this species the male organs reach maturity before the female. In young forms the testis is very large (Pl. xvi., fig. 41) occupying a great portion of the body behind the ovary which at this stage is quite immature. In these the vas deferens arises from the outer edge of the testis and leads into a long thin vesicula seminalis which proceeds nearly as far forward as the pharynx, then becoming bent on itself. A bulbous ejaculatorius is present, but is difficult to detect and its connection with the vesicula could not be made out in these young forms. The cirrus in these is a simple chitinous tube, lying in the cirrus-sac. In close connection with the posterior end of the vesicula are two large glands, probably prostate, which, when viewed in cleared specimens, have a slightly granular appearance, while in transverse section they appear to consist of a number of deeply-staining rings, each arranged concentrically round a nucleated cell.

In adult forms the testis (Pl. xvi., fig. 38) is greatly reduced or practically absent, having diminished very much in size, with its cavity practically obliterated and containing merely connective tissue fibres, though a few sperms may occasionally be still visible. Sometimes (as in the specimen figured) the testis does not degenerate quite so much (Pl. xv., fig. 35). The adult vas deferens is much thicker and its opening into the vesicula is pushed forward. The vesicula, which has increased enormously in size, due to the emptying into it

of the sperms from the testis, appears as a large flattened structure, somewhat lobed at its edges, occupying the greater part of the dorso-medial region of the body from immediately behind the pharynx to the ovary. The whole structure is filled with sperms floating in an albuminous material. The prostate glands have now increased greatly in size. The bulbous ejaculatorius has enlarged considerably and communicates with the seminal vesicle by a plainly-visible duct. The cirrus has grown greatly in size and complexity and has developed a flange which travels along one side of it for about two-thirds of the length of the organ, and then suddenly passes over to the other side and ceases abruptly. This portion of the cirrus runs horizontally, but thence onward it slopes downward and gradually develops another flange which continues almost to the genital opening. The whole structure is enclosed in the large cirrus-sac (Pl. xvi., fig. 39).

The female organs do not mature at so early a stage as do the male. The ovary lies immediately anterior to the testis and on its right side gives off an extension. The oviduct is a narrow tube arising from the median ventral surface of the ovary and travelling forward near the ventral surface of the animal. The extremely large vagina opens on the left ventral side on a level with the prostate glands. A receptaculum seminis is absent. The female genital opening is situated a little behind the male aperture. The oviduct and uterus are extremely thin-walled structures. The shell-glands (Pl. xvii., fig. 49) consist of large masses of glandular cells, situated around and opening into the ootype, but visible only in sections. Never more than one egg is present in the uterus at a time. The egg, which measures .07 mm. by .048 mm., is provided with a short posteriorly-directed spine. The nucleus is visible among the abundant granular yolk material.

The vitellaria are well developed and arranged in two broad bands, one on either side of the body, almost entirely obscuring the intestine. Posteriorly, immediately behind the testis, the yolk accumulates in a large median mass. In adults the organs may extend anteriorly to the pharynx and there is also a slight development of them all along the dorsal surface posterior to this organ.

The individual parasites do not appear to have much effect on the host, though a slight hypertrophy of the gill-tissue has been observed in a few cases. But the great numbers in which this parasite occurs on the gills, must render it a source of considerable irritation to its host, as many as twelve individuals having been counted on a single gill-filament.

Found on the gills of *Therapon carbo* Ogilby and McCulloch, from the Thomson River, Longreach, Central Queensland.

LEPIDOTREMA TENUE, n.sp. (Plate xvi., fig. 43; xviii., figs. 52, 53.)

Length .69 mm. by .14 mm. This species closely resembles *L. therapon* both anatomically and in general appearance, but the majority of the specimens examined were considerably longer and more slender. The clasping disc is very similar in the two species, the large hooks, chitin bars and scaly "discs" being indistinguishable, but the disposition of the minor hooks is different, as is seen by comparing figures 43 and 42 (Pl. xvi.). A very short oesophagus is developed and there is no fusion of the intestinal limbs posteriorly. The most marked differences are visible in the reproductive organs. As in *Lepidotrema therapon*, the testis matures in quite young forms. Degeneration of this organ occurs as in that species, though it is not so complete, a testis containing developing sperms being plainly visible in even the largest forms. Corresponding with this

the vesicula seminalis is rather smaller than in *L. therapon*. In some individuals it is almost free from sperms, in others much dilated, the dilatation taking place in a characteristic manner resulting in the formation of a strongly lobed structure. The prostate glands are often very prominent. The cirrus is quite similar to that of *L. therapon*.

The female reproductive organs are like those of the last species. There is a marked development of the vitellaria—even more so than in *L. therapon*—so strongly that in some forms none of the other internal structures are visible through it. In general disposition the yolk system is, in other respects, the same as that of *L. therapon*.

The egg measures .076 mm. by .048 mm., its spine being slightly longer than that of the last species.

Found on the gills of *Therapon hilli* Castelnau, from the Thomson River at Longreach, Central Queensland.

LEPIDOTREMA FULIGINOSUM, n.sp. (Plate xvi., fig. 44; xvii., figs. 50, 51.)

Length .64—.75 mm., breadth .14—.16 mm. This species closely resembles the other species of the genus. The distinctions most easily observed are in the disposition of the minor hooks on the disc and in the structure of the reproductive organs. The arrangement of the minor hooks is clearly seen in the figure (Pl. xvi., fig. 44), and differs from those already described in having one small hook situated between each pair of supporting cross-bars.

Even in full-grown adults the testis is large and distinct, though the size of the vesicula seminalis indicates that the male gland has undergone considerable diminution. The greater part of the vas deferens is dilated into an immense vesicula which travels forward on the right side of the body nearly as far as the end of the penis, then, passing over to the left side, bends back again and communicates by a rather long vas deferens with the penis. The latter closely resembles that of the two previously described species. Two prostate glands are present but not very large.

The vagina is even larger than in the two preceding species. In one rather fortunate preparation the vagina could be seen opening into the ootype a very short distance in front of the opening of the two transverse vitelline ducts (Pl. xvii., fig. 51). Shell-glands were not recognised. The oviduct is remarkable in that it is highly dilated in its mid-region and is lined by a highly refractive cuticle, evidently of a chitinous nature. It opens ventrally on the left side immediately behind the opening of the vagina.

The egg, which measures .064 mm. by .048 mm., resembles that of the other species of the genus.

Found on the gills of *Therapon fuliginosus* Macleay, from the Thomson River at Longreach, Central Queensland.

16. Subgenus *FLABELLODISCUS*, n. subgen.

Lepidotreminae. In external appearance this subgenus closely resembles *Lepidotrema*, but the organisation of the reproductive system is considerably simpler. The penis is a simple chitinous tube, the twisted flange, so characteristic of *Lepidotrema*, being quite absent. The vagina which is bent once upon itself, is longer than, but not so thick-walled as in the genus mentioned. The testis lies above this more anterior part of the ovary and is rather small in the adult. The vesicula seminalis is exceedingly large.

Type species, *Lepidotrema (Flabellodiscus) simplex* J. & T.

Found, so far, only on the gills of *Therapon fuliginosus* Macleay.

FLABELLODISCUS SIMPLEX, n.sp. (Plate xviii., figs. 54-55; xix., figs. 61, 62.)

Length .53 mm., breadth .1 mm. The disc is broader than the body, measuring .112 mm. across.

In external appearance this parasite closely resembles *Lepidotrema*, even in regard to the arrangement of the discal armature. The disposition of the minor hooks is shown in Pl. xix., fig. 61. One pair of hooks is present between the cross-bars, as is the case also in *Lepidotrema fuliginosum*. The ventral transverse cross-bar differs slightly from that generally found in the last-named genus in being slightly angular, the edge opposite the obtuse angle giving off the small supporting chitin-piece.

The scale-like papillae of the epidermis are absent on the dorsal surface (Pl. xix., fig. 62). No further details of the structure of the body walls could be seen distinctly.

The alimentary canal and its associated glands are similar to those of *Lepidotrema*, the blindly-ending intestine being in both cases devoid of caeca.

In one specimen examined part of the nervous system could be seen. The brain lies between the eyes, immediately anterior to the pharynx, the lateral nerve cords curving round part of the pharynx and passing down the sides of the worm, close to the alimentary canal. Immediately behind the eyes two pairs of nerves are given off, one running upward to the head, the second inward towards the pharynx. Several other branches arise from the lateral nerve-trunks, both on their inner and outer sides (Pl. xviii., fig. 55). The nerve-trunks in the posterior region of the worm could not be recognised. No trace of excretory system could be detected.

It is in the structure of the reproductive system (Pl. xviii., fig. 54) that the worm differs so much from *Lepidotrema*.

The testis is a curious uniform structure, situated above the anterior end of the ovary. The vas deferens is a long, very narrow, convoluted tube which opens into a highly dilated vesicula lying transversely across the body, immediately in front of the ovary, while the remainder of the sperm duct is a short slightly convoluted tube, which leads into the cirrus. The base of the latter is imbedded in a great mass of muscle. The cirrus is a much simpler structure, the twisted chitinous flange present in *Lepidotrema* being quite absent. It opens in the mid-ventral region of the animal a short distance behind the pharynx. Connected with its termination is a minute unicellular prostate gland.

The anterior end of the ovary is bent sharply upon itself and it is from this region, and not from the median portion of the gland, that the female ducts arise. The oviduct, which is visible only with great difficulty, is a rather wide tube running forward to a point a little behind the end of the cirrus. It is imbedded in a dense parenchyma of a rather fibrous nature, in which lie a number of large pyriform cells, heavily staining, and evidently to be regarded as shell glands, but their ducts could not be seen. The vagina is remarkable in that it does not run outwards along the ventral body wall as in other species of the genus *Lepidotrema*, but lies immediately below the dorsal body wall imbedded, in part, in the dense parenchyma which surrounds the oviduct. It is a much narrower tube than is found in that genus. Shortly after leaving the oviduct it dilates, and this dilatation is seen to contain a kind of granular material, giving it a resemblance to a prostate gland. This portion may be regarded as a receptaculum seminis, filled with sperms. The tube there narrows, passes forward to a point immediately in front of the opening of the oviduct, then turns sharply upon itself, travels backward, downward, and finally forward again

along the ventral body wall where it opens in the midline. This curious arrangement possibly serves to act like a valve, preventing the sperms from leaving the vagina.

The vitellaria of the fully-grown worm are strongly developed and are in general arrangement similar to those of *Lepidotrema*. In the young forms yolk itself is present only to a small extent.

The egg measures .05 mm. by .044 mm. It is rather more rounded than in *Lepidotrema* and the spine is absent.

In young specimens the reproductive system is of the same type, the vesicula seminalis appearing as a narrow transverse tube immediately in front of the ovary. The cirrus is much simpler than in the adult (Pl. xix., fig. 61).

Found on the gills of *Therapon fuliginosus* Macleay, from the Thomson River, at Longreach, Central Queensland.

17. LEPIDOTES, n-gen.

Lepidotreminae. In this genus the scale-like body papillae are confined to the posterior half of the worm and the squamodisc is devoid of hooks. The posterior disc has four large hooks, supported by intermediate chitinous bars, as well as six pairs of smaller peripheral hooks.

Four pairs of head-organs are present. The intestine ends blindly and is devoid of caeca. Four eyes. Penis simple. Vagina simple, opening laterally; receptaculum seminis present.

Found, so far, only on the gills of a freshwater fish, the golden perch or yellow-belly, *Plectroplites ambiguus* Richardson.

Type species, *L. fluviatilis* J. & T.

LEPIDOTES FLUVIATILIS, n.sp. (Plate xx., figs. 65-72; xxi., fig. 73.)

This is a rather large species, measuring .95 mm. in length, and .26 mm. in greatest breadth. In preserved specimens the greyish colour of the parasite contrasts sharply with the creamy-yellow of the gill filament.

The shape of the worm varies considerably according to the state of contraction, being sometimes long and slender, at other times much shorter and rather thick-set. The disc (Pl. xx., fig. 67) is very prominent and the arrangement of the hook apparatus complex. Four large hooks are present, the dorsal pair long and slender, the ventral shorter and possessing a biramous basal portion. Muscles can be seen inserted into the base of the hooks.

As in *Lepidotrema* there is a complex chitinous supporting apparatus which does not, however, articulate with the hooks, but seems rather to strengthen the disc. It consists of three bars, a central one with two ventrally and outwardly directed projections, and two lateral outwardly directed pieces closely articulated with the latter. Only six pairs of minute peripheral hooks could be detected.

The two scaly sucker-like discs are very prominent, but are entirely devoid of the fan-like hook-armature so characteristic of *Lepidotrema*. Twenty-five rows of scales are present on each disc (Pl. xx., fig. 69).

The chitinous cuticle is modified on the posterior half of the body to form numerous forwardly projecting papillae which are not so densely arranged as in *Lepidotrema*. Longitudinal and circular muscle-layers are recognisable. The body-parenchyma of the posterior half of the animal is of an extremely loose texture, giving this tissue a reticulate appearance.

The mouth lies ventrally, immediately in front of the pharynx. The latter is large and rounded in dorsal view, and bears numerous unicellular glands in its

walls. There is no definite oesophagus. The intestine is devoid of caeca and the two limbs bulge outwards in the region of the testis and end blindly. There are two glands situated one on either side of, and immediately posterior to, the pharynx; they seem to open into the intestine.

There are four pairs of head-organs from which the ducts pass backward to join the cephalic glands. In young forms the head-organs are all clustered closely together; but already in medium-sized forms the adult condition is attained (Pl. xx., fig. 70).

Of the nervous system, only the brain and the origin of the main nerves could be recognised. There are two pairs of eyes, each consisting of a mass of minute oval pigment-grains, lying well within the body-parenchyma.

The sexual apparatus is very complex and difficult to follow out. The following description is based on an examination of whole mounts and serial sections.

The testis is extremely large, occupying all the space between the branches of the intestine. Within the testis the immature sperms are arranged in numerous small clusters, but further details of sperm formation could not be observed in this organ. The vas deferens is a wide tube, passing forward and opening immediately behind the pharynx into a portion of the vesicula seminalis. The latter consists of three large globular portions. The anterior, dorsally situated part appears to open by a duct given off from its lower surface into the ventral portion of a second division lying immediately behind it and likewise dorsally. This opens, in turn, into a third, more ventrally situated portion which appears to open directly into the large bulbus ejaculatorius. This latter is a thick-walled vesicle which opens by a narrow duct into the cirrus. Sperms appear to undergo development in the vesicula, for not until they are found in the ejaculatory bulb do they possess a typical sperm-appearance. The heads are minute and spherical, the tail relatively long, the whole sperm measuring about .008 mm. The cirrus, which lies in a large cirrus-sac, is a rather simple chitinous tube, bent once upon itself. Into the cirrus also open, by a pair of long ducts, two prostate (?) glands and also a large number of very prominent heavily-staining glands ("cirrus glands"), originating as far back as the ovary.

The prominent ovary is situated asymmetrically in front of the testis, on the right side of the body. Into the narrow oviduct opens a large yolk reservoir, generally difficult to see, since it seldom contains yolk. The vagina is a simple tube passing directly to the left side where it opens ventrally. In connection with it there is a large receptaculum seminis, frequently seen full of sperms. In whole specimens it is almost completely obscured on account of the great development of the vitellaria.

The oviduct passes forward as a very thin tube opening close behind the male aperture. Distinct shell-glands could not be recognised but these organs seem to be represented by certain glandular swellings in the walls of the ootype. The large, oval egg, measuring .07 mm. by .04 mm., is well supplied with yolk. Posteriorly it bears a small blunt spine. Of fifty specimens examined only two contained an egg.

The vitelline system is fairly well developed. Two wide transverse yolk-ducts are present immediately behind the ovary and transfer the yolk to a reservoir which is generally very difficult to detect, except when filled.

In general appearance the young differ considerably from the adults. In the smallest forms the head-organs are clustered closely together. Testis and ovary are small. Vesicula seminalis, bulbus ejaculatorius and cirrus are visible;

but prostate glands were not seen. The large "cirrus-glands" are already well developed, as is also the yolk system. The disc, though at first sight quite different from that of the adult, is built on the same plan (Pl. xx., fig. 72). It is proportionally much larger than the adult disc, which evidently becomes formed from that of the young worm by the addition of a quantity of "padding tissue" which is plainly visible within it, giving it a more spherical appearance. In slightly larger worms this immature form of the disc is retained, but the cephalic glands are already of the adult type.

Found on the gills of the golden perch, *Plectroplites ambiguus* Richardson, from the Thomson River at Longreach, Central Queensland.

18. EMPLEURODISCUS, n.gen.

Lepidotremineae. In this genus the scale-like papillae cover practically the whole of the body, being absent only in the head region. The scales of the squamodisc are arranged generally in from seven to nine rows. A large number (25 to 30) of sharp accessory hooks are present. There are 14 minor hooks. The posterior disc is exceedingly broad, being nearly thrice the width of the rather slender body. The cephalic glands are connected with four pairs of head organs. Four eyes are present. The two limbs of the intestine end blindly and are devoid of caeca. The testis is solid; the cirrus simple. The ovary lies transversely in front of the testis. There is no vagina.

Found on the gills of the freshwater fish, *Therapon unicolor* Gunther.

Type species, *E. angustus* J. & T.

EMPLEURODISCUS ANGUSTUS, n.sp. (Plate xix., figs. 56-60, 63-64.)

Length about .32 mm.; breadth .05 mm.

This worm is characterised by the great relative width of the disc, which measures nearly thrice the body breadth. Its armature (Pl. xix., fig. 64) is more complex than that of any other member of the *Gyrodactyloidea*. Four large hooks are present, a dorsal pair with a biramous basal portion, and a more simple slender ventral pair. A complex set of chitinous bars lies between these hooks, but does not form a definite articulation with them, serving probably rather to strengthen the disc as a whole. This chitinous apparatus consists of two pairs (a large and a small) of inwardly directed chitin-pieces which articulate with a complexly made intermediate portion. Muscles can be seen inserted at the base of the hooks. Fourteen minute hooks are also present, their distribution being shown in the figure. Four appear to lie on the dorsal side of the disc, while the others are ventral. Two squamodiscs occur, each bearing nine rows of modified "scales." Each disc is also provided with a variable number, generally about thirty, of sharp slender hooks. The clinging disc of the worm is thus armed with as many as eighty hooks.

The scale-like papillae, characteristic of the *Lepidotremineae*, are absent only on the head. Of the body-muscles, a well-developed circular, and poorly-developed longitudinal layer could be detected.

The head organs of this species are very prominent; a large anterior pair and two smaller posterior pairs being present and it appears that the latter are actually protrusible (Pl. xix., fig. 60). The cephalic glands supplying them are very small and lie well in front of the eyes, close behind the last pair of head-organs.

The mouth lies mid-ventrally, in front of the eyes. A long buccal cavity leads into the pharynx. Lateral to the very short oesophagus is a pair of digestive glands. The forked intestine is devoid of caeca and ends blindly.

No trace of nervous or excretory systems could be seen. There are two pairs of eyes immediately in front of the pharynx, situated just below the body wall in the parenchyma.

The testis is well developed, lying immediately behind the ovary, and in some specimens appears to be distinctly lobed. The vas deferens, which runs dorsally to the ovary and to the right of the uterus, becomes dilated into a large vesicula seminalis and, after narrowing, appears to open directly into the cirrus, no bulbus ejaculatorius being visible. Into the base of the cirrus there opens a small prostate gland. The cirrus is a short incompletely-closed chitinous tube, bent once upon itself and opening immediately anteriorly to the female genital aperture.

The ovary lies transversely in the middle of the body. The oviduct is a very wide, non-collapsible tube opening a short distance behind the oesophagus. The well developed shell-glands are arranged in two groups on either side of the oviduct into which they open each by a long delicate duct. There is no vagina. The vitelline system which is not very strongly developed, lies in close connection with the intestine and discharges its yolk by means of two narrow transverse yolk-ducts, situated immediately anterior to the ovary.

The egg which is relatively large, measuring approximately .06 mm. in length, was rarely present. It is somewhat oval in shape and possesses a short posterior spine.

Found on the gills of *Therapon unicolor* Gunther, from the Burnett River, South Queensland.

19. ACLEOTREMA, n.gen.

Lepidotreminae. Disc considerably broader than body, with four large hooks and a supporting chitin apparatus; fourteen minor hooks. The sucker-like organs consist of about fifteen rows of modified scales and are devoid of accessory hooks. Greater part of body protected by short proclinate spiny papillae. Four eyes present. Ovary and testis in the vicinity of the middle of the body. Vagina thin-walled, bent upon itself anteriorly and opening in the midline. Penis rather simple, but lodged in a highly developed cirrus-sac. Penis and vagina communicate with a remarkable chitinous cavity which opens on the ventral surface.

From the gills of a marine fish of the genus *Girella*.

Type species, *A. girellae* J. & T.

ACLEOTREMA GIRELLAE, n.sp. (Plate xiii, figs. 23-25; xiv, figs. 26-30.)

Length of adult worm averages about .7 mm., breadth of body about .16 mm., breadth of disc about .23 mm.

This is a rather slender species with a disc considerably broader than the body. There is much variation in shape according to the state of contraction or elongation of the individuals; at times the extension of the posterior portion may be remarkably great, the worm in this condition having a totally different appearance from that usually seen. It is chiefly the region posterior to the termination of the intestine which undergoes this elongation.

The disc is provided with fourteen minor hooks, arranged as in Pl. xiii, fig. 25 and Pl. xiv, fig. 27, as well as with four large hooks which are supported by, and articulate with a chitinous basal armature. The latter consists of a powerful transverse chitin-bar, the ends of which articulate each with a second, proximally bifurcated chitin-bar, while the two hooks on either side come into relation with the end of the bar. One of these hooks is rather slender and possesses

two well-defined roots. In the other, which is a much more powerful hook, such a basal bifurcation is absent. The disc is provided with two pairs of groups of unicellular glands, the lateral pairs (Pl. xiii., fig. 25) being especially well-defined and appearing to open, by numerous converging ducts, upon the surface of the disc. The two accessory adhesive organs or squamoides consist each of about fifteen rows of modified body papillae, and are quite devoid of definite hook apparatus. The disc is well provided with muscles which are modifications of the longitudinal body musculature of the parasite, though it is possible that the circular layer also enters into their formation. The longitudinal muscles of the posterior lateral portion of the worm are arranged on each side in a bundle which passes outwards (Pl. xiii., fig. 25) to become inserted on the large hooks of the corresponding side. From the upper part of the disc near its junction with the body, there arises on each side a bundle of muscles passing obliquely to the hooks of the other side. The musculature of the sucker-like organs is in the form of a pair of muscles travelling down the ventral mid-line of the body.

The cuticle is developed into numerous forwardly projecting papillae, each very sharply pointed (Pl. xiv., fig. 28), but not so closely arranged as in *Lepidotes*. They are especially well developed near the disc, but gradually diminish and disappear towards the anterior half of the animal. The longitudinal layer of body-muscles is fairly distinct, but cannot be said to be strongly developed. The fibres of the outer layer run mostly in an irregular oblique manner; only in places could distinct circular muscles be detected. In the region of the genital openings the musculature undergoes a pronounced modification, a powerful group of irregularly arranged oblique, circular and longitudinal fibres being found, surrounding the huge genital cavity to be described below. Into this mass are also inserted well-defined columns of dorso-ventral fibres. The mouth is a transverse slit opening on the ventral surface, a little in front of the region of the brain. The buccal cavity is short, the pharynx large and distinct, and the oesophagus short. Into the posterior part of the pharynx opens a group of unicellular glands, clearly visible in the living animal, but in stained preparations appearing only as a dark mass. The intestine is bifurcated and devoid of caeca. In section its wall is seen to be composed of a layer consisting of several clear hyaline cells. There is no junction of limbs posteriorly.

Three pairs of head-organs are present, their ducts originating from masses of gland-cells which cause a slight projection on each side of the head. The brain, which lies immediately anterior to and above the pharynx, gives off three pairs of nerves; a small pair to the anterior extremity; the second, slightly larger, pair laterally to supply the sides of the anterior half of the body; the third pair very large and passing right along the animal, lying in close contact with the intestine (Pl. xiv., fig. 27).

The excretory system is clearly visible in living specimens as an irregular tube running close to the intestine and receiving branching vessels in the region of the testis. Posteriorly the limbs communicate close in front of the termination of the intestinal branches. The system opens on either side at about a third of the body-length from the anterior end by a pair of dilated excretory vesicles. Flowing into the base of this vesicle are the excretory vessels of the head, which in the region of the brain have a curiously complicated course (Pl. xiv., fig. 27).

The ovary lies transversely in the mid-region of the body, the oviduct leaving it on its left side to pass inward and then anteriorly where the vagina opens into it. It then passes forward, sweeping round as the uterus past the male

and vaginal apertures, to open beside the cirrus sac. Its anterior half is lined with chitin and is therefore very clearly visible. The vagina travels forward after joining the narrow uterus and close behind the male opening bends inward, then turns sharply upon itself, and again bends inward, thus producing a most efficient mechanism for the retention of sperms in the vagina. The latter opens into the large genital cavity, described below. In the walls of the oviduct lie the shell-glands which are not visible in whole mounts of adult animals, but can be clearly seen in sections. They will be more fully described in the young form in which they are clearly recognisable.

The testis is a pyriform structure lying close behind the ovary. The vas deferens passes forwards and in the region of the cirrus-sac bends upon itself, then again forward to open into the penis. The vas is a fairly widely dilated tube but no special portion of it can be regarded as a vesicula seminalis. The penis is a rather simple chitinous tube with a distinct curve near its termination. It is lodged within a highly developed cirrus-sac (Pl. xiv., fig. 26) which consists proximally of a large rounded structure lined with an outer layer of circular muscles, internal to which is a group of radiating muscles, inserted upon the beginning of the penis. The sac extends forward and embraces the penis for a considerable distance. Distally it opens by a distinct, heavily chitinised aperture into the great genital cavity (Pl. xiv., fig. 29). This remarkable structure encloses a relatively large space, with collapsed walls, lined by chitin. Into its front portion open the penis and the vagina. The whole is surrounded by a complex musculature. Probably this organ is to be regarded as having an accessory copulatory function.

On the gills of the same fish which provided the specimens upon which the above description is based there were present other worms, which are probably the young of this species, since the arrangement of the discal armature, head-glands, and intestine are identical; but the genital organs are rather simpler than those above described, though they are founded on essentially the same plan (Pl. xiv., fig. 30). Ovary and testis are well developed, but the former has not yet attained the size it does in the adult worm. The walls of the oviduct lodge a number of small unicellular shellglands, whose ducts pass forward and evidently open each directly into the ootype. The uterus, which is sharply marked off from the latter, is considerably wider and passes straight forward to open close to the male genital aperture. The vagina which is connected with the uterus by a narrow chitinous duct, is constricted anteriorly, then dilated again into a small bulb which gradually tapers off to form a narrow duct opening to the exterior. This terminal portion of the organ already has an indication of the twisting which subsequently becomes so evident. The vagina opens into a small crevice, doubtless the rudiment of the remarkable structure that occurs in the adult. The vas deferens is a fairly straight tube, connected distally with a small bulbus ejaculatorius opening into the penis. The latter is less heavily chitinised than in the adult. The prominent bulbous expansion of the proximal part of the adult cirrus-sac can scarcely be detected in many cases while in others, evidently more advanced individuals, it is more distinct, but not so pronounced as in the adult forms.

Found on the gills of the marine black bream or black fish, *Girella tricuspidata* Q. and G. from Caloundra, South-east Queensland.

20. LAMELLODISCUS, n.gen.

Small slender *Lepidotremaine* in which the body is devoid of scaly papillae. Disc well developed, with the accessory locomotory disc (squamosidisc) peculiarly

modified in such a way as to present numerous concentric rows consisting each of a pair of laterally elongated lamellae. Eyes present. Intestine ends blindly. Cirrus simple. Vagina present. From the gills of marine fishes.

Type and only species, *L. typicus* J. and T.

LAMELLOMISCUS TYPICUS, n.sp. (Plate xxi., figs. 74, 78, 78a.)

A rather small worm, measuring about .124 mm. in greatest width and .528 mm. in length. The anterior end is narrow, especially immediately behind the pharynx, while in the region of the testis the worm is at its maximum breadth, there being a distinct constriction immediately before this region. Disc connected with body by a rather long pedicle.

The disc bears four large hooks of which the ventral is somewhat bifurcated at its base (Pl. xxi., fig. 74). All four articulate with a strong chitinous cross-bar. Seven minor hooks are present, their dispositions being as indicated in Pl. xxi., fig. 74. The accessory disc (squamodisc) undergoes a remarkable development, each of the concentric rows consisting, not of scaly papillae as in the other *Lepidotreminae* hitherto described, but of a single pair of laterally-elongated lamellae.

The integument is remarkable in that no trace of scaly papillae could be discovered. This is perhaps correlated in some way with the curious development of the squamodisc, a structure which, as already stated, is probably produced as a modification of these scaly papillae. The muscle-system is feebly developed, the transverse system being scarcely evident in preparations. In the posterior region, however there are two pairs (a dorsal and a ventral) of bundles of longitudinally running fibres passing to the disc (Pl. xxi., fig. 74).

The cephalic glands are well developed and lodged on each side of the pharynx in a pair of distinct swellings (Pl. xxi., fig. 78), their ducts travelling forward to open through three pairs of head-organs.

The mouth is situated sub-terminally; the pharynx is very small, and the oesophagus extremely short. The intestinal limbs are entirely devoid of caeca and end blindly a little before the disc.

Two pairs of eyes are present immediately in front of the pharynx; those of the posterior pair being larger and closer together than the anterior. The brain is situated beneath them, but no details of the nervous system could be observed.

The testis is situated in the middle of the body and is so large that it produces a distinct bulging of the body in this region. The vas deferens appears to originate at its posterior portion; it travels forward, then turns inward towards the midline and then forward again to pass as a rather widely dilated duct serving as a seminal vesicle, into the region of the cirrus, narrowing suddenly before it enters the latter structure from above. The cirrus is a medium-sized, simple chitinous tube, passing directly backward to terminate at the male genital aperture.

The ovary is a curved organ lying just in front of the testis. The oviduct passes inward from its most anterior portion and then forward as the uterus. The vagina is a simple thin-walled tube, which appears to be lined with a thin layer of chitin. It passes backward, crosses the path of the uterus, then turns inward and forward again and opens into the ootype. There is formed a small distension in its posterior region, which apparently serves as a receptaculum seminis. Shell-glands could not be seen.

The vitelline system is very well developed. It closely follows the limbs

of the intestine, but undergoes a great development in the mid-region of the body, there occupying a considerable area immediately anterior and posterior to the testis, when it stretches right across the body so as to encircle the male gland. The yolk is transferred to the female tubes by a pair of transverse yolk-ducts, situated considerably anterior to this region. No eggs were present in the specimens examined.

From the gills of the common marine bream (silver bream), *Sparus australis* Gunther, from Moreton Bay.

Subfamily IV. MERIZOCOTYLINAE, n. subfam.

Syn. *Anisocotylinae* Monticelli, 1903 (in part).

Gyrodactylidae in which the disc is provided with suckers as well as major hooks. Cephalic glands open by distinct head-organs. Testis single or double. Ovary unbranched. Vagina present.

From the gills and nasal glands of marine fishes.

This subfamily includes the following genera:—*Merizocotyle* Cerfontaine and *Empruthotrema* J. and T.

21. MERIZOCOTYLE Cerfontaine, 1894.

Medium-sized worms, in which the disc is provided with a small number (five to seven) of central suckers and a ring of from twelve to eighteen marginal suckers, the latter provided each with a minor hook. Two major hooks present. Four eyes. Cirrus simple. Testis and ovary single and compact. Two vaginae present (according to MacCallum). Vitellaria well developed.

From nasal gland and gills of stingrays in America and Europe.

Type species, *M. diaphana* Cerf.

This genus has been placed by various authors in the *Monocotylidae*, *Anisocotylinae* and *Tristomidae*. The presence of distinctly glandular head-organs undoubtedly shows its relationship with the *Gyrodactylidae*. At the same time the double vagina and the remarkable "sucker-disc" are characters which distinctly separate the genus from members of any other subfamily belonging to that family. (See also under genus *Lophocotyle*).

Known species:—*M. diaphana* Cerf., 1894; *M. minor* Cerf., 1898; *M. dasybatis* MacCallum, 1916.

22. EMPRUTHOTREMA, n.gen.

Medium-sized robust *Merizocotylinae*, about 1.6 mm. in length, in which the disc is nearly as wide as the body, and is provided with fourteen marginal and five central suckers. Major hooks are absent, but minor hooks are found marginally, one between each pair of suckers. Anterior end broad and provided with three head-organs, doubtless glandular. Small pharynx; short oesophagus. Intestinal limbs end blindly. Testis double and very large; penis fairly simple. Ovary compact; shell-glands strongly developed. Vagina paired.

From the gills of *Raja erinacea*—Massachusetts.

Type species, *E. raiae* (MacCallum, 1916).

This species has been described and figured by MacCallum as a species of *Acanthocotyle*, a decision which is obviously incorrect. The author does not mention the presence of cephalic glands, but his figure suggests that they do occur; in almost every other respect the worm is closely allied to *Merizocotyle*.

Family III. MONOCOTYLIDAE Tschernberg, 1879.

Small, slender or robust, medium-sized *Gyrodactyloidea* in which the glandular head-organs are absent. The disc has developed into a sucker-like structure, a character which is already present in the *Merizocotylinae*. Major hooks present, though apparently at times absent. Eyes present or absent. Testis simple and compact or broken up into follides. Ovary simple. Vagina present (or absent?), generally paired. Intestine bifurcated, caeca present or absent.

From the gills of Elasmobranchs.

It is customary to include the *Monocotylidae* with the *Tristomoidea*, but the affinities of the group are much more with the *Gyrodactylidae*, *Merizocotyle* forming an intermediate link.

The following genera belong to the family:—*Monocotyle* Tschbg., 1878; *Trionchus* MacCallum, 1916; *Calicotyle* Dies., 1850; *Microbothrium* Olsson, 1869; *Pseudocotyle* v. Ben. and Hesse, 1865; perhaps also *Leptocotyle* Montie., 1905.

Key to sub-families of Monocotylidae.

- A. a. Disc about as broad, or a little broader than body *Monocotylinae*
 b. Disc much narrower than body B.
 B. a. Anterior end of worm narrow, posterior end very broad; disc divided by radii into several suckers and armed with hooks *Calicotylinae*.
 b. Both ends attenuated, disc very small, devoid of radii, and of large hooks *Pseudocotylinae*.

Subfamily I. MONOCOTYLINAE Gamb., 1896.

Slender *Monocotylidae* in which the disc is about as broad as body and provided with two or three major hooks. Testis compact. Vagina single (or double?).

In addition to *Monocotyle*, we are including *Trionchus* in this subfamily.

23. MONOCOTYLE Tschernberg, 1878.

Elongated worms with large posterior clasping disc, divided by eight radii into as many suckers. Two major hooks and numerous minor hooks, the latter scattered over the disc, especially at its margin. Mouth very large, situated at anterior end. Vagina single (or double?). Intestinal limbs end blindly. Eggs oval and provided with a filament. From Elasmobranchs.

Type species, *M. myliobatis* Tsch.

Known species:—*M. myliobatis* Tsch., 1878 (Europe); *M. ijimae* Goto, 1894 (Japan); *M. dasybatis* MacCallum, 1916 (U.S.A.).

MONOCOTYLE MINIMA, nom. nov.

(Syn. *M. dasybatis minimus* MacCallum, 1916.)

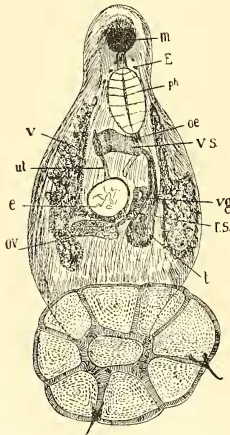
In 1916 MacCallum described two species of *Monocotyle* from a stingray, *Dasybatus pastinacus*, from Massachusetts,—viz., "*M. dasybatis* nov. sp." and "*M. dasybatis minimus* nov. sp." Both are well figured and a glance is sufficient to show that the two are quite distinct, not only in their dimensions but in regard to the major hooks of the disc, the oral region, disposition of the ovary and testis, etc. No suggestion was made by the author that the second species was to be regarded as a variety or subspecies of the former, but the two were evidently considered as quite distinct species. It seems to us that the second name is a pure trinomial and accordingly invalid as a combination. In order to

avoid unnecessary confusion we have deemed it expedient to rename the species as *Monocotyle minima*.

MONOCOTYLE ROBUSTA, n.sp. (Text-fig. 1.)

This is a rather small stout species, measuring about .72 mm. in length and .30 mm. in maximum body-breadth. The disc is nearly circular and relatively very large, measuring about .31 mm. in diameter. The anterior end of the worm is narrow and dome-shaped, but the body immediately behind the pharynx broadens out, reaching its maximum breadth in the region of the ovary, then narrowing considerably to be joined by a relatively broad pedicle to the disc.

The disc bears a small sucker in its middle, from whose walls eight radii pass outwards and divide the margin into as many marginal suckers. The disc is therefore a very powerful adhesive organ, but its efficiency is increased by a pair of large hooks situated on the outer angles of the two posterior suckers. In other species minor hooks have been described, one belonging to each sucker;



Text-fig.1.—*Monocotyle robusta*, entire animal.

but in this form their presence has not been seen with certainty. Each of the larger hooks has two roots, one very long, the other relatively short and provided with minute muscles.

The skin is quite devoid of papillae. Longitudinal and circular muscle-layers can be distinguished, but only the latter is well developed, especially in

the region of the mouth which must be a fairly labile organ. The pharynx which lies close behind the mouth is relatively very large, measuring nearly .1 mm. in length. There is a short oesophagus. No details of the intestine could be made out in the material available.

Immediately in front of the pharynx are four eyes, the posterior two being larger and situated farther apart.

The genitalia are rather difficult to observe on account of the closeness with which they are massed together in this short animal. The ovary is situated in the midline slightly behind the middle of the animal. It is bent once upon itself in the transverse direction and then opens by a short oviduct into the uterus. The latter is a long narrow tube, apparently lined distally with a thin layer of chitin. It opens close beside the pharynx, and when an egg is present is seen to be considerably distended in this region where the shell-glands lie. A very short vagina is present, opening on the mid-ventral region by a very distinct aperture. What appears to be a very large receptaculum seminis is to be seen in close connection with the vagina.

The vitelline system is very well developed and obscures all structures beneath it. The transverse yolk-duets pass inward towards the female duets immediately in front of the ovary. The yolk-glands extend from the region of the pharynx right to the posterior end of the body, where they are especially abundant.

The testis is fairly large, lying beside and close behind the ovary. The vas deferens passes forward on the left side of the body, to open into a very prominent vesicula seminalis close behind the pharynx. The penis seems to be a fairly large, though not very distinct structure, lying close to the vesicula, but its exact structure could not be made out.

From the gills of a common stingray, *Urolophus testaceus* Mull. & Henle from Sydney.

24. *TRIONCHUS* MacCallum, 1916.

"The mouth large and sub-terminal, much like an ordinary sucker; genital pore central; cirrus chitinous; single testicle posterior to ovary; a relatively large sucker disc with one large locus in the centre and three small marginal ones. There are also on the disc three hooks, one large one terminating in two points and also two smaller ones" (MacCallum). To which may be added:—pharynx remarkably small; ovary very large and bent in a semicircle; vagina apparently absent.

Type and only known species, *T. dasybatis* MacCallum, 1916, from the gills of *Dasybatus pastinacus* at Wood's Hole, Massachusetts.

Subfamily II. *CALICOTYLINAE* Monticelli, 1903.

Rather large robust *Monocotyliidae*, much broader behind than in front; the disc very much narrower than the body and divided into a number of suckers. Large hooks present on disc. Vagina double. Testis broken up into numerous follicles. Cirrus simple.

Calicotyle Dies. is the only genus as yet known belonging to this subfamily.

25. *CALICOTYLE* Diesing, 1850.

Disc divided by seven radii into as many marginal suckers; a small central sucker also present on disc. Minor hooks absent, but two large powerful hooks present. Testis elongated transversely and broken up into numerous follicles.

Cirrus simple. Ovary small, elongated transversely and coiled slightly. Vagina double.

From marine fishes (Elasmobranchs).

Type species, *C. kroyeri* Diesing, 1850. There are various spellings for this name e.g. *Calycotyle*, *Callocotyle*, *Calliocotyle*, *Callicotyle* but *Calicotyle* has precedence.

Known species: *C. kroyeri* Dies., 1850 (Europe); *C. mitsukurii* Goto, 1894 (Japan); and *C. stossichi* Braun, 1899 (Europe).

Subfamily III. PSEUDOCOTYLINAE Monticelli, 1903.

Robust *Monocotylidae*, with attenuated ends; sucker exceedingly small and devoid of hooks or suckers. Intestinal limbs provided with caeca. Vagina paired or unpaired. Testis compact or broken up into follicles.

26. MICROBOTHRIUM Olsson, 1868.

Pseudocotylinae with "elliptical body with attenuated ends. Vagina unpaired, opening on left of ventral surface. One large compact testis"—(Pratt). From Elasmobranchs (N.W. Europe, Canada).

Type and only known species, *M. apiculatum* Olss., 1869.

The genus was described as a member of the *Tristomidae*. In 1879 Taschenberg considered it to be a synonym of *Pseudocotyle*, as also did Monticelli (1903), Braun (1890) and Stafford (1904). Pratt's figures (1900) show them to be distinct, and in view of our lack of the necessary literature we have listed the two genera separately.

Although Monticelli (1892, 1905) referred to *Microbothrium* as a synonym of *Pseudocotyle*, yet he admitted (1905, p. 70, footnote) that it might be retained as a subgenus of the latter, and at the same time proposed *Leptocotyle* as a subgenus, its type species being *P. minor*.

Olsson (1869) in describing *M. fragile*, assigned this parasite of *Raja batis* doubtfully to *Microbothrium*. Braun (1890) placed it under *Pseudocotyle*. In 1897 Jaegerskiold described an ectoparasitic Triclad (*Micropharynx parasitica*, n.g. et sp.) from two other Scandinavian rays *R. clavata* and *R. laevis*, and mentioned its possible identity with Olsson's species. Stafford (1904) accepted the synonymy and reported the presence of the worm in Canadian waters. In view of these statements the species can be removed from the Gyrodactyloidea.

27. PSEUDOCOTYLE v. Beneden and Hesse, 1865.

Pseudocotylinae in which the vagina is very small and paired. Testis broken up into numerous follicles. Intestinal caeca very long and slender.

From skin of Elasmobranchs.

Type species, *P. squatinae* Ben. and Hesse, 1865.

Known species: *P. squatinae* Ben. and Hesse, 1865; *P. minor* Montic. 1888.

As already mentioned above, it has been stated that *Microbothrium* is a synonym of *Pseudocotyle*. In 1905 Monticelli proposed a subgenus, *Leptocotyle*, to receive *P. minor*, but as we have not access to the literature, we refrain from discussing its status.

Family IV. CALCEOSTOMIDAE (Parona & Perugia, 1890) Monticelli, 1903—emend. J. & T.

Gyrodactyloidea in which the cephalic glands do not open by ducts concentrated into head-organs, but remain scattered over a considerable area on

either side of the head. Posterior disc showing a tendency towards sucker-like structure, though no distinct sucker is produced. Correlated with this, there is a diminution or even disappearance of the major hooks. Eyes present or absent. Intestine with or without caeca. Testis single or double. Ovary simple or branched. Cirrus simple. Vagina present or absent.

From the gills of fishes.

The name *Calceostomidae* was first used by Parona and Perugia in 1890, but was employed to designate a subfamily, Monticelli in 1903 raising the subfamily to the status of a family.

We have subdivided the family into the *Calceostominae* and *Dionchininae*.

Subfamily I. CALCEOSTOMINAE Monticelli, 1892.

(Syn. *Calceostomidae* Parona and Perugia, 1890.)

Calceostomidae with a bifurcated intestine provided with very marked caeca. Vagina (apparently) present or absent. Testis single. The head develops a pair of head lappets.

Including the genera *Calceostoma* v. Ben., 1858, and *Fridericianella* Brandes, 1894.

28. CALCEOSTOMA van Beneden, 1858.

Calceostominae. Large worms, measuring from about 5 to 8 mm. in length. Posterior disc broader than body and somewhat cup-shaped; unarmed or provided with an armature consisting of a central group of two comparatively small hooks as well as minute marginal hooks. From the anterior end, immediately in front of the eyes, are developed a pair of very remarkable head-lappets. A pair of large glands occupy the greater part of the head and open by numerous ducts in the vicinity of the mouth. Eyes present (or absent according to accounts of the European species). Pharynx large; intestine bifurcated with prominent caeca. A single elongated testis; cirrus rather simple. Ovary branched. Vitellaria well developed. Vagina absent.

Found on the gills of marine fishes.

Type species, *C. calceostoma* (Wagener, 1857) J. & T., 1922, Syn., *C. elegans* van Beneden, 1858. Other known species, *C. inerme* Par. & Fer., 1889.

CALCEOSTOMA GLANDULOSUM, n.sp. (Plate xxi., figs. 75-77; xxii., figs. 79-86.)

This is a large worm, measuring about 5 mm. in length and .9 mm. in breadth.

The disc is broader than the body of the worm and somewhat cup-shaped in general appearance, with a very strongly crenated margin. The dorsal and more posteriorly lying portion of the "cup" is marked off from the anterior and more ventrally situated part by a prominent septum which has a less strongly crenated free edge (Pl. xxii., fig. 86). The anterior section of the cup is rather larger than the posterior and contains the powerful hook apparatus. This consists of two large hooks articulating with a small chitinous complex which, in turn, rests at the end of a long bar of chitin. An intricate system of muscles is developed in connection with the whole apparatus. The hooks are powerful, sharply-pointed and curved almost into a semicircle. The basal part of each is broad, with short irregular projections, the mechanical action of which upon the chitinous complex probably serves to give perfection to the action of the whole clasp apparatus. The chitin complex, with which the hooks articulate, rests upon the top of a long supporting bar and is provided on each side, on its more ventral

portion, with three long processes, the upper two pairs being the largest; while the more dorsal part is developed into two pairs of short stout bosses. The hooks articulate with the complex between the ventral pair of processes. The musculature of the hook apparatus is attached to these processes. A pair of very large powerful muscles, lying on either side of the median chitin bar, are inserted on the common base of the two large more dorsally and posteriorly situated of the processes, while weaker muscles are attached to the smaller processes. Numerous transverse muscles—excessive development of the outer circular muscle-layer—are inserted on the longitudinal supporting bar and add to the complexity of the whole structure. A more weakly developed transverse muscle lies immediately in front of the longitudinal chitin-bar and lodges a small sesamoid-like piece of chitin which articulates with the base of the latter.

Immediately internal to the erenated margin of the disc are two rows of numerous very minute hooks, each with a bifurcated basal attachment (Pl. xxii., fig. 84).

The head develops two prominent head-lappets (characteristic of *Calceostoma*) provided with the euriens ornamentation seen in the figure. The fact that blood-corpuseles from the host occur in the intestine of the parasite suggests that these organs have a suctorial function; though it is also possible that an undulating movement, for which they seem well adapted, would serve to waft food towards the mouth.

The integument (Pl. xxi., fig. 76) possesses a well developed cuticle, below which lie the muscle-layers with which it is connected by a rather loose sub-cuticular tissue. The outer circular musculature is very poorly developed, and in places quite absent. The longitudinal layer is strongly marked and interior to it lies a second circular layer, much more prominent than the outer circular.

In the posterior region of the animal, behind the intestine, lie masses of unicellular glands which appear to open on the ventral surface.

The mouth lies ventrally immediately behind the lappets and just in front of the pharynx. The buccal cavity is short; the pharynx large, prominent, and devoid of gland-cells within its walls. There is no definite oesophagus. The intestine is bifurcated, the two limbs joining again behind the testis. Intestinal caeca are well developed, especially on the outer side of the intestine, one pair extending forwards half way along the pharynx. There is a similar posterior extension considerably behind the connecting piece of the intestinal limbs. The intestine is lined by a single layer of cells.

In the anterior portion of the body are two great masses of unicellular glands beginning considerably behind the pharynx at the sides of the body and gradually broadening out to form two prominent masses just in front of the pharynx. From each cell a duct is given off (Pl. xxii., fig. 82) uniting with ducts from neighbouring cells. In this way are formed a large number of transverse ducts which run below the pharynx and appear to open into the buccal cavity and, possibly also, into the ventral part of the pharynx.

It is possible that these glands are homologous with the cephalic glands of *Gyrodactylidae*, the characteristic head-organs of that family being probably an accumulation of numerous ducts which are seen separated and distributed in *Dionchus* where the arrangement seems to be intermediate between the two types of structure.

No other glandular organs could be seen in connection with the intestine.

The excretory system can be observed in serial section lying immediately below the intestine on each side (Pl. xxi., fig. 75) as a tube with a moderate

lumen containing a small amount of spongy tissue. In close connection with these ducts are a number of muscle fibres. The tubes extend forward as far as the pharynx, increasing in size and becoming more infiltrated with spongy connective tissue, then pass forward and downward to open by a number of minute openings into the posterior portion of the vestibule which is surrounded by the head lappets (Pl. xxi., fig. 77). Posteriorly the longitudinal ducts can be traced as far back as the end of the intestine. In the region of the pharynx the excretory ducts give off a large spongy sinus-like extension over this structure, thus forming a connection between the left and right tubes. Dorsally to the pharynx this connecting branch also receives two smaller ducts which run along the dorsal surface above the intestine and immediately below the body-wall for about half the length of the animal.

Two pairs of eyes are present lying below the body-surface, immediately in front of the pharynx. The anterior eyes are rather farther apart and somewhat smaller than the posterior. Both pairs, however, are abnormally small and this may account for their reported absence in the European species. Moreover, in specimens which have been compressed, the granules of the eyes generally break apart and this may further account for their not having been found previously in this genus.

The brain is very feebly developed and is visible in section simply as a small mass of nervous tissue between and before the eyes. The lateral nerves could not be observed.

There is a large, very faintly lobed testis reaching back as far as the posterior junction of the intestinal limbs. The vas deferens is given off from it anteriorly in the median-ventral line, then passes to the left slightly and dilates into a large vesicula seminalis, a second vesicle being formed a little further on. The vas deferens continues thence as a narrow tube forwards, then backwards to communicate with the cirrus. Into its most anterior portion opens the duct from a very prominent prostate gland. The cirrus is a simple chitinous tube, passing vertically downwards and giving off a second chitin-tube to the right (Pl. xxii., fig. 81).

The strongly branched ovary lies well in front of the testis. The oviduct passes almost vertically downward from it (Pl. xxii., fig. 81) after receiving the yolk from an indistinct yolk-reservoir, then forward as a moderately distinct tube, opening to the exterior close behind the male genital aperture. The shell-glands appear to be merely glandular thickenings of the uterine walls. The egg has not been found. The vitelline system is strongly developed and closely follows the contour of the intestine, which it almost surrounds, appearing therefore, in side view, as a double-layered system. The transverse yolk-duct lies immediately in front of the centre of the ovary and opens into the ootype just before that structure bends down to continue forwards as the uterus.

Found on the gills of the marine jew-fish, *Sciaena antarctica* Castelnau, from Caloundra, South Queensland.

Two other species of *Calceostoma* have already been recorded from marine fishes, *C. calceostoma* (Wagener)—usually known as *C. elegans* Ben.—and *C. inermis* Parona and Perugia, both from Europe. In these species eyes have not been seen; if they are present, their minute size and the ease with which they disintegrate may account for their not having been observed. The head-lappets of *C. glandulosum* are rather less prominent than those figured for *C. calceostoma*. A comparison of the hook apparatus with that of the known species is not possible, since the descriptions given indicate that certain of its components had

either been missed, or had dropped off. Wagener's species is stated to possess a single large central hook, but it is possible that the minor hooks have not been observed in this form. In *C. inermis*, on the other hand, it may be that the large hooks have dropped off, or, as frequently happens in *C. glandulosum*, are hidden by the folding of the clasping disc.

29. FRIDERICIANELLA Brandes, 1894.

Calceostominae. A rather large species (4 to 5 mm. in length) in which the head-lappets, though prominent, do not attain the extraordinary development seen in *Calceostoma*. Glandular protuberance on one side of body. Eyes? Ovary not branched. Vagina present. Single testis. Intestine similar to that of *Calceostoma*.

Type and only known species, *F. ovicola* Brandes, from the eggs of *Arius commersonii*, a fresh- and brackish-water fish from South Brazil. The male of this fish carries the eggs in its mouth till the emergence of the young, a fact which probably accounts for the curious position recorded for the parasite which we suspect normally infests the gills of its host.

According to Brandes there is a vitello-intestinal duct present, opening apparently on to the dorsal body surface! It seems more reasonable to accept Goto's suggestion (1899) that this is the true vagina, the "Seitenwulst" of Brandes being probably an accessory copulatory organ.

APPENDIX TO *Calceostominae*.

30. CATHARIOTREMA, n.gen.

In this subfamily is possibly to be included a worm described and figured by MacCallum (1916) as *Monocotyle selachii*. The remarkable nature of the anterior end and the presence of numerous minor suckers on the adhesive disc seem to exclude the species from that genus. The head-lobes are exceedingly suggestive of *Calceostoma*, while the "sense-papillae" may readily be regarded as the scattered openings of cephalic glands. If this view be eventually found to be correct, then the genus, for which the name *Cathariotrema* is suggested, must undoubtedly be classed amongst the *Calceostominae*. Meanwhile, it is simply classed as an appendix to that group.

Diagnosis:—Rather large forms in which the disc is distinctly broader than the body and is provided with numerous minute suckers. Two large hooks and many minor hooks present. Anterior end provided with large lappets, enclosing the mouth behind. Eyes absent. Intestine bifurcated, devoid of caeca, and ending blindly behind. Testis and ovary simple. Vagina apparently present. Vitelline system very extensive. From the nasal glands of sharks.

Type, *C. selachii* (MacCallum, 1916) J. & T., from *Carcharias obscurus* and *Cestracion zygaena* (= *Sphyrna zygaena*)—from Massachusetts.

Subfamily II. DIONCHINAE, n. subfam.

Calceostomidae in which the posterior disc possesses two diminutive major hooks and at times numerous minor hooks. Distinct head-lappets absent. Eyes present. Intestine bifurcated, devoid of caeca. Testis double (see, however, Appendix to *Dionchinae*). Penis simple. Ovary unbranched. Vagina present or absent.

From the gills of marine fishes.

Including the genera *Dionchus* Goto, 1899; *Dionchotrema*, n.gen.; *Lophocotyle* Brann, 1896; and possibly *Anoplodiscus* Sonsino, 1890.

Monticelli (1903) placed *Dionchus*, *Anoplodiscus*, *Lophocotyle* and *Merizocotyle* in the *Monocotylidae*, *Anisocotylinae*; while Pratt (1900) grouped the first, third and fourth of these in his key as a separate section of the *Monocotylidae*, while the second was placed among the *Gyrodactylidae*.

31. DIONCHUS Goto, 1899.

Dionchinae. Goto defined the genus thus:—"Body flat and elongated; with a single posterior sucker, the inner surface of which is divided by radial ridges into ten areas, with one pair of chitinous hooks. Mouth at a short distance from the front end; intestine bifurcated, simple. With four eye-spots. Porus genitalis communis submarginal. Testes two, one lying in front of the other. No vagina."

To this diagnosis may be added:—strong development of cephalic glands whose ducts do not become concentrated into head-organs, but open separately round the margin of the head.

Type and only known species, *D. agassizi* Goto, 1899, from gills of a marine fish *Remora brachyptera*. From Newport, Rhode Island, U.S.A.

Goto regards this form as combining Gyrodactylid and Monocotylid characters, showing a specially close resemblance to *Fridericianella* in the former group, a genus which seems to us to be intermediate between *Calceostoma* and *Dionchus*.

32. DIONCHOTREMA, n.gen.

(Syn. *Acanthodiscus* MacCallum, 1916, *nec* 1918; *nec* Uhlig, 1906.)

A small species with the disc distinctly marked off from the body and provided with two large and numerous smaller hooks. Cephalic glands prominent, opening on the surface by scattered apertures. Eyes present. Intestine bifurcate. Ovary simple. Vagina present. Vitelline system well developed. Two testes. Penis simple.

Type (and only known) species, *D. remorae* (MacCallum, 1916) J. & T.

From the gills of *Echeneis naucrates*, from New York Aquarium.

The presence of distinct cephalic glands opening apparently diffusely on the head, two large discal hooks and a pair of testes show that *Dionchotrema* is closely allied to *Dionchus*. In the latter genus, however, the vagina is lacking.

MacCallum (1916) placed this form in the Family *Gyrodactylidae*, genus *Acanthodiscus*, a name which had not previously been used in connection with Trematoda. Two years later he employed the same name, designating it as a new genus, so presumably he had intended employing it as such in 1916, though it was not so indicated and no generic diagnosis was given. The two species which he referred to this generic name are considered by us to represent two different genera and, since the name was already preoccupied by Uhlig in 1906 for a Molluscan genus, we have proposed two new genera viz., *Dionchotrema* for his *A. remorae*, and *Protomicrocotyle* for his *A. mirabilis* (see later).

APPENDIX TO *Dionchinae*.

33. ANOPLODISCUS Sonsino, 1890.

In 1890 Sonsino described a new trematode to which he gave the name *Anoplodiscus richiardi*, from the gills of a marine fish, *Pagrus orphus*. He regarded it as having affinities with the Tristomids and Gyrodactylids. His very insufficient description was slightly amplified in 1905 by Monticelli. From

the account given by the latter it seems possible that the species dealt with is a member of the *Gyrodactyloidea*, with affinities towards *Dionchus*.

St. Remy and also Perrier regarded it as belonging to the *Udonellidae*. Monticelli placed it in the *Calceostominae* (1892) but at a later date (1905) considered it as in no way related to *Calceostoma* and placed it in the *Monocotylidae*, forming with *Lophocotyle*, *Merizocotyle*, *Dionchus* and *Lintonia* the subfamily *Anisocotylinae*, to which reference has already been made. Pratt included it amongst the *Gyrodactylidae*. The insufficient descriptions published prevent us from being able to classify the genus definitely.

It is apparently to be diagnosed as follows:—Body fairly elongate, anterior end sub-truncate; cephalic glands present (?), opening to anterior end by numerous scattered apertures. Disc not sharply marked off; devoid of hooks. Eyes absent. Intestine not bifurcated; extending to posterior end of animal. Testis and ovary in anterior portion of body; single and not lobed. Penis simple. Vagina absent.

From the gills of a sea bream, *Pagrus orphus* (Mediterranean).

Type and only known species, *A. richiardi* Sonsino, 1890.

V. APPENDIX TO *Gyrodactyloidea*.

Subfamily I. ACANTHOCOTYLINAE Montic., 1903.

34. ACANTHOCOTYLE Monticelli, 1888.

Small or medium-sized trematodes in which the posterior disc is provided with numerous radiating rows of minute hooks; two larger hooks, or a small terminal accessory disc bearing minor hooks may be present. Anterior end provided with head-organs into which unicellular glands open; or (apparently) with several small suckers. Intestine bilobed, devoid of caeca. Eyes present or absent. Testis very extensive and in the form of numerous small follicles. Vagina apparently present. Ovary simple, unbranched. Yolk system very extensive. Parasitic on the skin of rays.

Type species, *A. lobianchi* Monticelli, 1888.

Known species: *A. lobianchi* Montic., 1888; *A. oligotera* Montic., 1899; *A. elegans* Montic., 1890; *A. concinna* Scott, 1902; *A. monticellii* Scott, 1902; *A. verrilli* Goto, 1899; *A. branchialis* Willem, 1906 and *A. bothi* MacCallum, 1913. A species which MacCallum (1916) described as *A. raiae* is clearly not a member of this genus; no head-organs are mentioned: it appears to be a member of the *Merizocotylinae* and has been referred to under *Empruthotrema*.

The affinities of this genus are doubtful. Both Monticelli and MacCallum gave an account of species in which they mention the presence of oral suckers. Goto (1899) described *A. verrilli* as having cephalic glands opening on the head in the typical Gyrodactylid manner and as a result of his examination of some specimens of Monticelli's *A. lobianchi*, stated that what this author took for oral suckers were in reality the openings of glands, similar to those occurring in *A. verrilli*. Monticelli (1890, 1899) also described two other forms, *A. oligotera* and *A. elegans*, which Goto did not re-examine. MacCallum (1913, 1917) described another form *A. bothi* from the United States, in which he saw four pairs of oral suckers which he calls tactile areas in his figure (1917, fig. 27), and actually noticed the worms attaching themselves by these alone. He does not, however, state whether glands open into these organs or not. MacCallum (1916, p. 23) regards the genus as belonging to the *Gyrodactylidae*, while Monticelli considers it as a member of the *Tristomidae* (1888) *Acanthocotylinae* (Montic., 1903). Until the other species are more fully described it will not be possible

to determine their systematic position. Monticelli's subfamily name, *Acanthocotylineae* may be retained at present. Meanwhile, the following suggestions may be made:—

It seems certain that *A. verrilli* Goto and *A. lobianchi* Montic. are Gyrodactyloidea, allied, perhaps, to the *Gyrodactylineae*. The presence of an accessory armed disc in *A. verrilli* is suggestive of what occurs in the *Lepidotreminae*, but there is probably no real relationship. The follicular nature of the testis shows Microcotylid affinities, a view which is strengthened when we consider that in this genus *Acanthocotyle* we have a transition between head-organs and the oral suckers of that group. This view is rendered more probable when we remember that in *Empleurodiscus* the head-organs are actually protrusible and may therefore have some secondary attaching function.

APPENDIX TO *Acanthocotylineae*.

35. LOPHOCOTYLE Braun, 1896.

Body flat, tongue-shaped, with distinctly marked off head region, at the front of which two groups of unicellular glands open. Disc large, circular, provided with numerous large radial ridges, and a ring of hooklets marginally. Intestine bifurcate, provided with caeca. Genital pore close behind pharynx just to left of midline. Testes numerous; vas deferens with large convoluted vesicula; cirrus with straight spicule. Ovary oval, in front of testis. Vagina ?. Eggs provided with operculum and with basal filament. Parasites on body of marine bony fish.

Type and only known species, *L. cyclophora* Braun.

From *Notothenia* sp., locality Puerto Toro (Hamburg Magellan-Expedition).

This genus which, in its form and intestinal characters, reminds one of *Epibdella*, is usually considered as a member of the *Monocotylidae*, but the presence of glandular head-organs will not admit of its inclusion in that group. Monticelli (1903, p. 336; 1905, pp. 68-70) grouped it along with *Dionchus*, *Merizocotyle*, *Anoplodiscus* and *Lintonia* * in his subfamily *Anisocotylineae* but the non-existence of a generic name corresponding with the subfamily designation prevents the retention of Monticelli's name. Pratt (1900) placed it next to *Dionchus* but the presence of numerous testes and intestinal caeca, as well as the general structure, seem to us to prevent its inclusion in the *Calceostomidae*. The testicular arrangement and general form of the worm remind one of *Acanthocotyle* Montic., but the latter does not possess intestinal caeca. In the light of our present knowledge we propose to attach the genus provisionally as an appendix to the *Acanthocotylineae*.

Subfamily II. PROTOMICROCOTYLINAE, n. subfam.

36. PROTOMICROCOTYLE, n.gen.

(Syn. *Acanthodiscus* MacCallum, 1918, *nec* 1916; *nec* Uhlig, 1906.)

An elongate minute form, with distinct disc clearly marked off and bearing several hooks. Four small suckers towards the posterior end of the body. Pos-

**Lintonia* was proposed by Monticelli (1904) to receive *Nitzschia papillosa* Linton from *Gadus callarias* from Massachusetts. We have not been able to consult Monticelli's paper but Linton's figures and short account (1898) show that the species cannot rightly be included under *Nitzschia*. The general form and the character of the testes suggest that *Lintonia* belongs to the *Gyrodactylidae* but in view of our lack of information regarding the "lateral suckers," as to whether they are "bothria" or else glandular "head-organs," we are unable to state whether the genus is to be regarded as a member of the Gyrodactyloidea or the Tristomoidea.

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Explanation of lettering.

a.d. attaching disc; *b.c.* buccal cavity; *b.e.j.* bulbus ejaculatorius; *br.* brain; *c.* cirrus; *c.b.a.* chitinous basal apparatus; *c.g.* cephalic glands; *c.m.l.* circular muscle layer; *c.s.* cirrus-sac; *ct.* cuticle; *c.v.d.* converging vitelline ducts; *d.* ducts from glands; *d.p.* dermal papillae; *e.* eggs; *E.* eye; *ex.* excretory ducts; *ex.o.* opening of excretory ducts; *g.c.* gland-cells; *g.ch.* genital chamber; *g.o.* one of the female genital openings; *h.* major hook; *h.a.* hook apparatus in section; *h.l.* head-lappet; *h.o.* "head-organ"; *i.* intestine; *i.c.* intestinal caeca; *i.c.l.* inner circular muscle-layer; *l.m.l.* longitudinal muscle-layer; *m.* mouth; *m.h.* minor hooks; *od.* oviduct; *oe.* oesophagus; *ov.* ovary; *p.g.* penial glands; *ph.* pharynx; *pr.* prostate gland; *p.t.* padding tissue; *pt.* *vd.* posterior transverse vitelline duct; *r.s.* receptaculum seminis; *s.c.t.* subcuticular tissue; *sh.g.* shell-glands; *s.m.* sphincter muscle; *s.* spine; *t.* testis; *t.v.d.* transverse vitelline duct; *u.o.* uterine opening; *ut.* uterus; *v.* vitellaria; *v.d.* vas deferens; *v.g.* vagina; *v.g.c.* gland-cells whose ducts open ventrally; *v.r.* vitelline reservoir; *v.s.* vesicula seminalis; *x.* opening of transverse vitelline duct into intestine.

EXPLANATION OF PLATES IX.—XXII.

Plate ix.

Figs. 1-5. *Protogyrodactylus quadratus.*

1. Entire animal, ventral view; 2. Cirrus and adjacent structures; 3. Transverse section through posterior transverse yolk-duct, showing opening into the intestine;
4. Longitudinal vertical section at about mid-region of worm; 5. Egg.

Plate x.

Fig. 6. *Protogyrodactylus quadratus.*

Disc in ventral view.

Fig. 7. *Trivitellina subrotunda.*

Entire animal, ventral view.

Figs. 8-9. *Anchylodiscus tandani.*

8. Entire animal, ventral view; 9. Disc in side view.

Plate xi.

Figs. 10, 12-14. *Haliotrema australe.*

10. Disc in ventral view; 12. Major hooks and supporting apparatus; 13. Entire animal, ventral view; 14. Cirrus.

Fig. 11. *Anchylodiscus tandani.*

To show the relative size of egg.

Plate xii.

Figs. 15-19. *Daitreosoma constrictum.*

15. Entire animal; 16. Attaching disc; 17. Egg; 18. Large hooks; 19. Transverse section in region of body constriction.

Plate xiii.

Fig. 20. *Daitreosoma constrictum.*

Reproductive organs.

Figs. 21-22. *Daitreosoma bancrofti*.

21. Reproductive organs; 22. Head.

Figs. 23-25. *Acleotrema girellae*.

23. Portion of disc viewed from its anterior side, to show articulation of major hooks. Three minor hooks are also shown; 24. Entire animal showing its capacity for great elongation; 25. Disc in ventral view.

Plate xiv.

Figs. 26-30. *Acleotrema girellae*.

26. Entire animal; 27. Entire animal, showing excretory and digestive systems; 28. Skin papillae; 29. Genital organs of adult; 30. Genital organs from young animal.

Fig. 31. *Empleurosoma pyriforme*.

Transverse section through anterior end.

Plate xv.

Figs. 32-34. *Empleurosoma pyriforme*.

32. Entire animal; 33. Anterior end; 34. Transverse section of intestine.

Figs. 35-37. *Lepidotrema therapon*.

35. Entire animal; 36. Anterior end; 37. Egg.

Plate xvi.

Figs. 38-42. *Lepidotrema therapon*.

38. Male reproductive organs; 39. Cirrus; 40. (a) Disc, ventral view; (b) Disc, lateral view; (c) Ventral major hook; (d) Dorsal major hook; (e) Basal supporting apparatus; (f) Toothed-disc (squamodisc); 41. Young animal; 42. Disc, to show arrangement of minor hooks. Those of dorsal side are blackened; those of other side not so.

Fig. 43. *L. tenue*.

Disc.

Fig. 44. *L. fuliginosum*.

Disc.

N.B. Figs. 42, 43, 44 are drawn in approximately identical positions, in order to show the relative positions of the minor hooks.

Plate xvii.

Figs. 45-49. *Lepidotrema therapon*.

45. Longitudinal vertical section through posterior region, to show the great accumulation of yolk; 46. Longitudinal vertical section through entire animal; 47. Transverse section of male and female reproductive organs; 48. Transverse section through anterior end, in region of pharynx; 49. Transverse section in region of shell-glands.

Figs. 50-51. *Lepidotrema fuliginosum*.

50. Reproductive organs; 51. Opening of vagina and transverse vitelline tubes into female duct.

Plate xviii.

Figs. 52-53. *Lepidotrema tenue*.

52. Entire animal; 53. Reproductive organs.

Figs. 54-55. *Flabellodiscus simplex*.

54. Reproductive organs; 55. Nervous system.

Plate xix.

Figs. 56-60. *Empleurodiscus angustus*.

56. Entire animal; 57. Transverse section in region of transverse yolk-duct; 58. Cirrus with "prostate" gland; 59. Egg; 60. Head end, showing partial projection of "head-organs."

Figs. 61-62. *Flabellodiscus simplex*.

61. Young form; 62. (adult) Transverse section through anterior end.

Figs. 63-64. *Empleurodiscus angustus*.

63. Toothed disc; 64. Posterior disc in actual attachment to gill-filament as viewed from ventral side, through the gill-tissue.

Plate xx.

Figs. 65-72. *Lepidotes fluviatilis*.

65. Entire animal; 66. Reproductive organs slightly diagrammatic; 67. Disc, ventral view; 68. Transverse section through head region; 69. Toothed disc; 70. Head of half-grown animal; 71. (adult) Transverse section through region posterior to testis; 72. Young animal (ventral view).

Plate xxi.

Fig. 73. *Lepidotes fluviatilis*.

Transverse section through region of cirrus.

Figs. 74, 78, 78a. *Lamellodiscus typicus*.

74. Disc; 78. Entire animal; 78a. Cirrus.

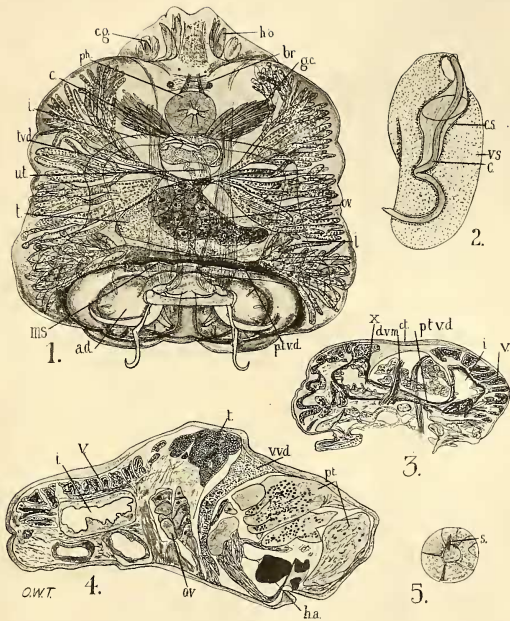
Figs. 75-77. *Calceostoma glandulosum*.

75. Transverse section in region of oviduct; 76. Transverse section of skin; 77. To show excretory openings in head region.

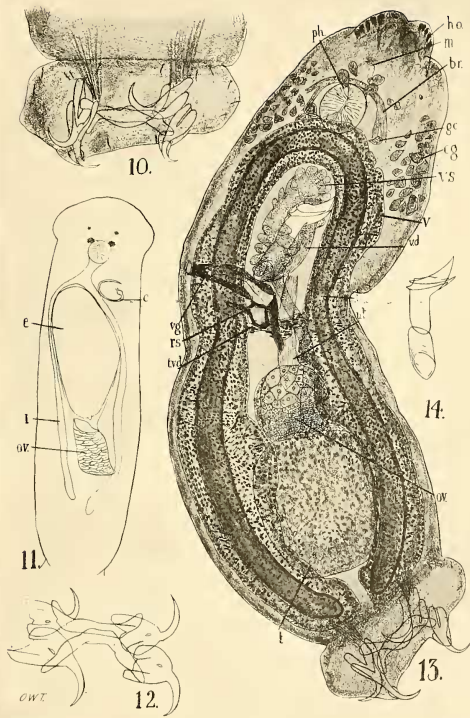
Plate xxii.

Figs. 79-86. *Calceostoma glandulosum*.

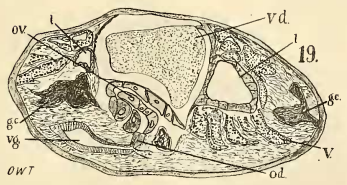
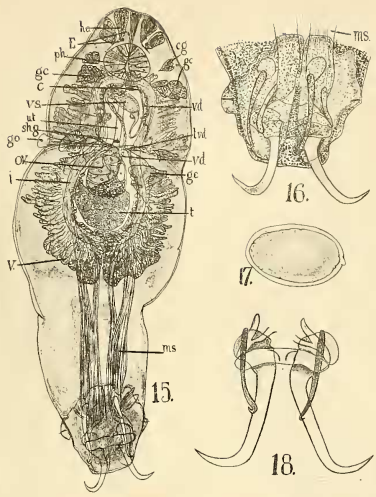
79. Entire animal; 80. Head in side view; 81. Reproductive organs; 82. A small portion of the cephalic glands; 83. To show the articulation of the hooks; 84. Two minute hooks; 85. Hook apparatus of disc; 86. Disc, ventral view.



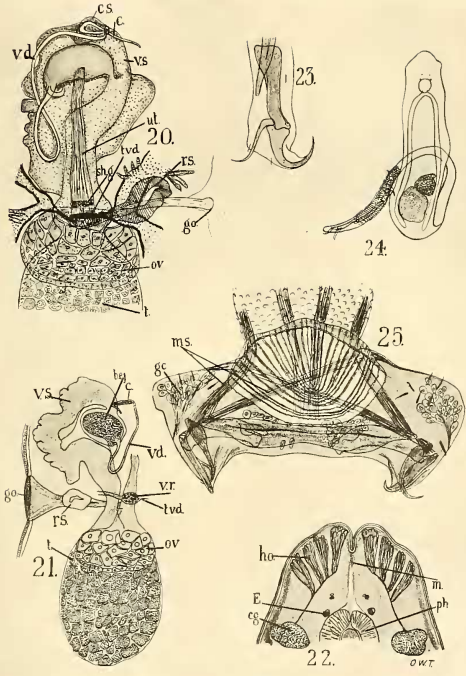
Gyrodactyloid Trematodes from Australian Fishes.



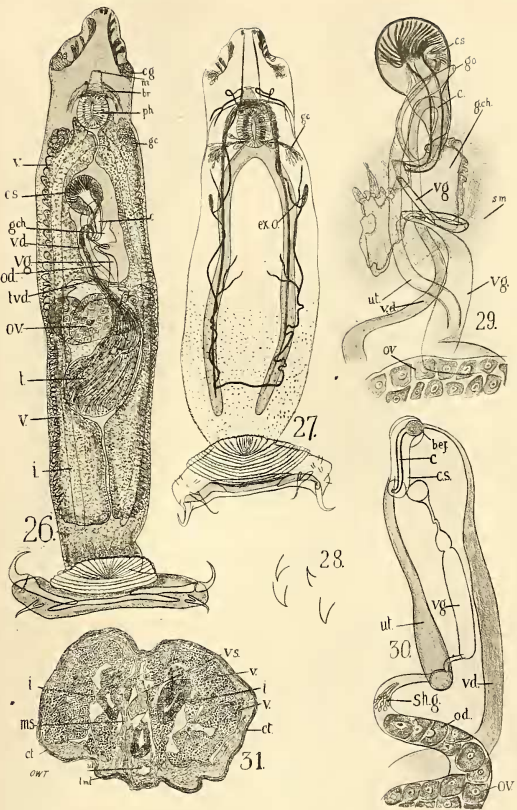
Gyrodactyloid Trematodes from Australian Fishes.



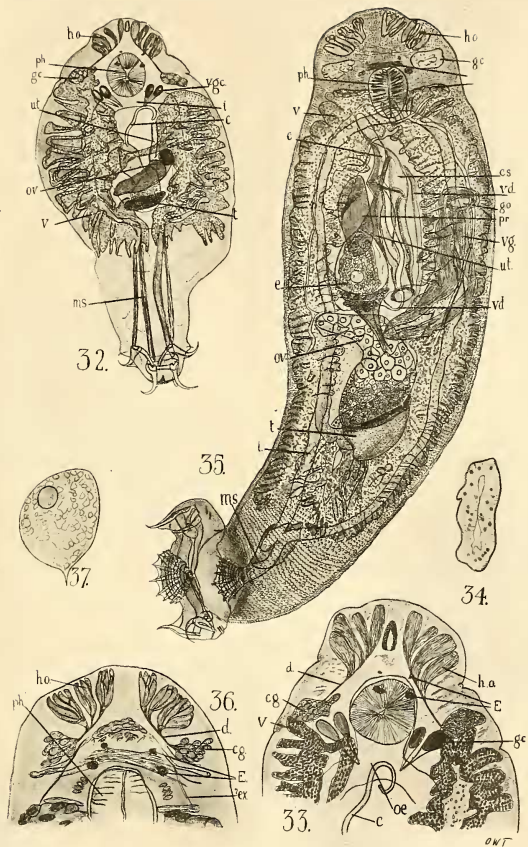
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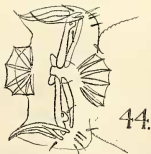
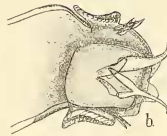
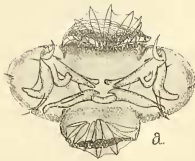
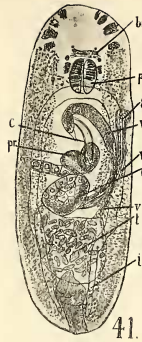
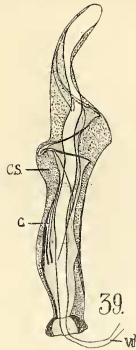
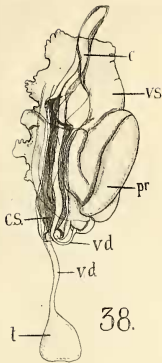
Gyrodactyloid Trematodes from Australian Fishes.



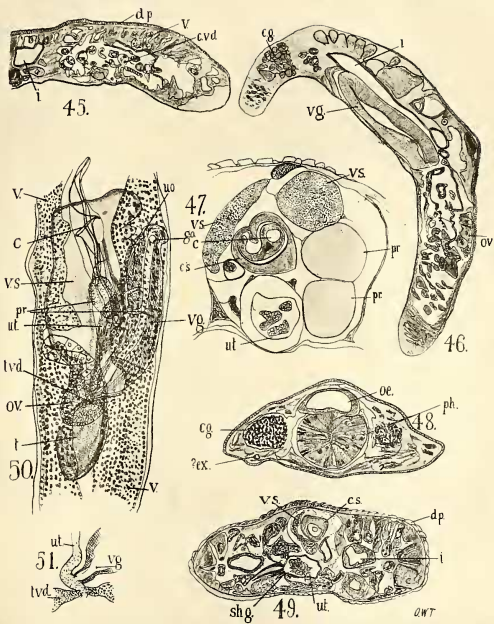
Gyrodactyloid Trematodes from Australian Fishes.



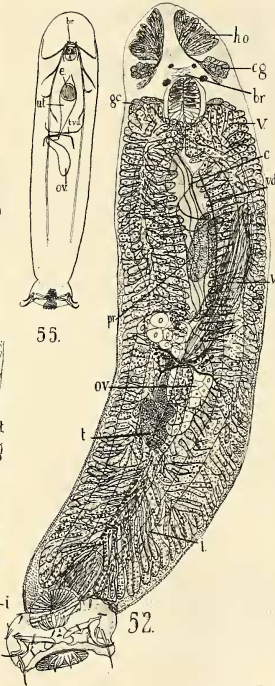
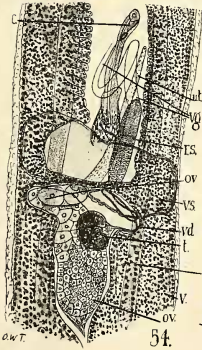
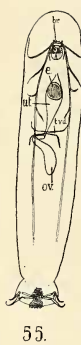
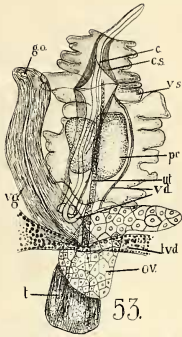
Gyrodactyloid Trematodes from Australian Fishes.



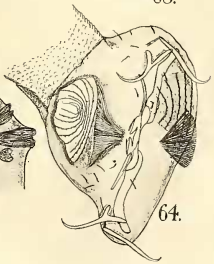
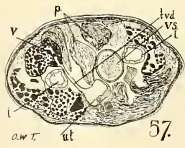
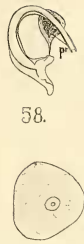
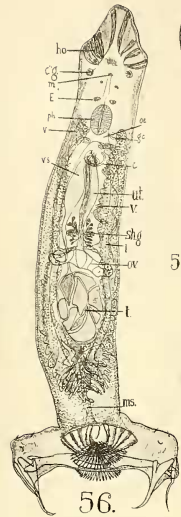
Gyrodactyloid Trematodes from Australian Fishes.



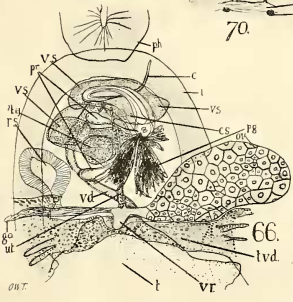
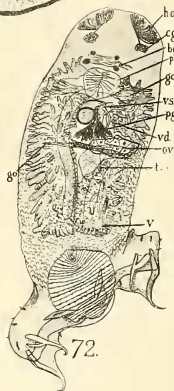
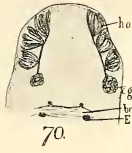
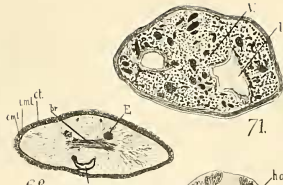
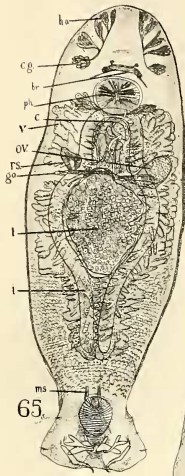
Gyrodactyloid Trematodes from Australian Fishes.



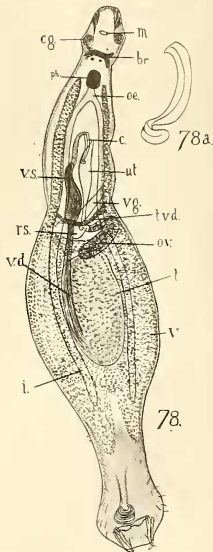
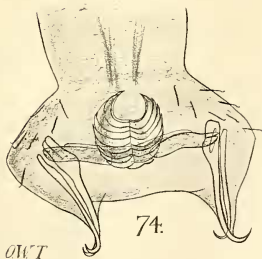
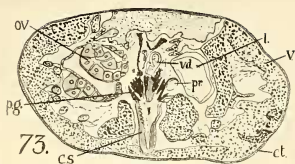
Gyrodactyloid Trematodes from Australian Fishes.



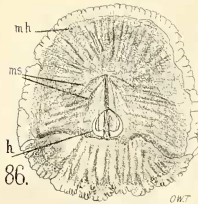
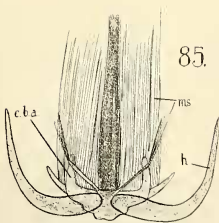
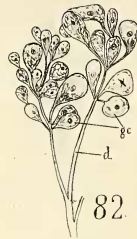
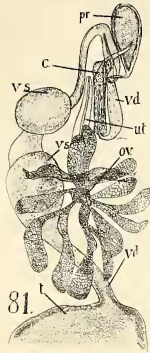
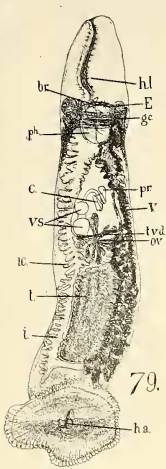
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