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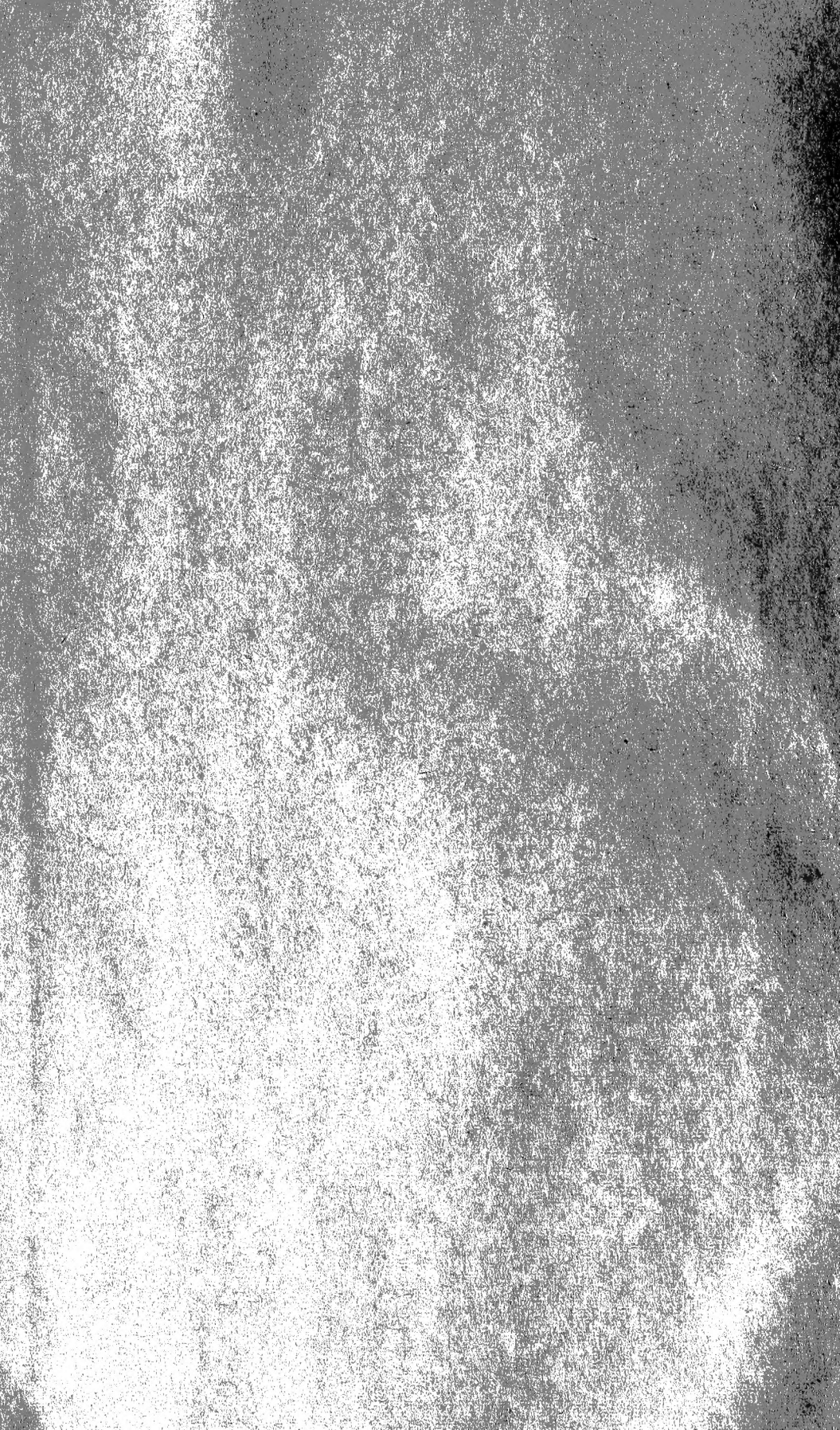
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ILLINOIS BIOLOGICAL
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VOLUME XVII

PUBLISHED BY THE UNIVERSITY OF ILLINOIS

URBANA, ILLINOIS

EDITORIAL COMMITTEE

JOHN THEODORE BUCHHOLZ
FRED WILBUR TANNER
HARLEY JONES VAN CLEAVE

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PUBLISHED BY THE UNIVERSITY OF ILLINOIS
UNDER THE AUSPICES OF THE GRADUATE SCHOOL
URBANA, ILLINOIS

EDITORIAL COMMITTEE

JOHN THEODORE BUCHHOLZ
FRED WILBUR TANNER
HARLEY JONES VAN CLEAVE

COMPARATIVE STUDIES ON TREMATODES
(GYRODACTYLOIDEA)
FROM THE GILLS OF NORTH AMERICAN
FRESH-WATER FISHES

WITH FIVE PLATES

BY
JOHN DARY MIZELLE

CONTRIBUTION FROM THE ZOOLOGICAL LABORATORY OF THE
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INTRODUCTION

This investigation was begun originally in the fall of 1933 as a general survey of the parasites of the Centrarchidae of Champaign County, Illinois. After two years of collecting, an attempt was made to identify the monogenetic trematodes, all of which had been preserved in Bouin's solution, before proceeding with the work on the other helminth parasites collected. Due to coagulation of adherent mucus and subsequent adhesion of specimens to the inner surfaces of vials, no Gyrodactyloidea were found in the fluid poured from containers in which specimens had originally been placed. New material was collected and the identification of parasites from living and freshly prepared mounts was undertaken together with the problem of perfecting a suitable technique requisite for research on this group of trematodes. As the work progressed the Monogenea were found to offer such a fertile field for investigation that on March 1, 1936, the problem was restricted to monogenetic forms only and expanded to include hosts of the piscine families Centrarchidae, Serranidae, Cyprinidae, and Poeciliidae from various localities throughout the State of Illinois without restriction to any particular county. A few distribution records from Oklahoma have been made and included in this presentation.

Some of the research covered by this monograph has been briefly presented in three previous papers (Mizelle 1936, 1937, and 1938).

MATERIALS AND METHODS

Due to a lack of time for examination of a large number of fishes collected from several localities on the same date, freezing was resorted to as a means of host preservation. On examination of the branchial material so treated, many of the monogenetic forms present were found free from the host tissues in the containers used for examination. Further work on the efficacy of freezing as a method for the removal of ectoparasitic trematodes from gill tissue resulted in the discovery of an optimum time of exposure ranging anywhere from six to seventy-two hours. In addition to the removal action, freezing also has the simultaneous effects of killing the parasites in a relaxed condition and of breaking up the mucus, both of which facilitate examination and preservation. Exposure for a shorter period than the above-stated minimum fails to break up the mucus to an optimum degree, while over-exposure distorts the specimens.

After freezing, the fishes were thawed in tap water, the gills removed, placed in stoppered homeopathic vials about two-thirds full of tap water, and vigorously shaken between thumb and forefinger for approximately fifty consecutive times. The liquid containing the parasites was then poured into Syracuse watch glasses and alternately diluted and decanted until clear enough for reliable examination with a widefield binocular microscope. The parasites were collected with a capillary pipette equipped with a rubber bulb and transferred to clear water to insure further removal of mucus. Experiments with fifty sets of gills taken from four species of sunfishes, namely, *Helioperca macrochira* (Rafinesque), *Allotis humilis* (Girard), *Xenotis megalotis* (Rafinesque), and *Apomotis cyanellus* (Rafinesque), have shown this method to be effective in removing ninety-two per cent of the gill trematodes present.

For making permanent mounts, the specimens were transferred from watch glasses to slides coated with Mayer's albumen. These were placed on inverted stender dishes in a finger bowl. Alcohol was poured into the container to a level below the top of the stender dishes, the top of the bowl was covered, and the apparatus set in an incubator. It was found that exposure for a period of from one to five minutes (depending upon the amount of water transferred with the parasite to the slide) at a temperature of about fifty-five degrees centigrade was sufficient to coagulate the albumen and securely attach the specimens to the surfaces of the slides. After attachment, the specimens were fixed in either Gilson's or Bouin's fluid and treated subsequently for removal of mercuric salts or picric acid. Specimens were stained in either Ehrlich's acid haemotoxylin, borax carmine, or a mixture of Ehrlich's acid haemotoxylin and Delafield's haemotoxylin in a saturated aqueous solution of potassium alum. It was later discovered that Mayer's albumen was unnecessary and that removal by pipette of the major portion of glycerine and water in which a parasite had been placed on a slide, caused adherence of specimens to the glass surface. Additional adherence was secured by immersing the preparations in fixatives (Gilson's or Bouin's) contained in Coplin jars. Inconsistencies in staining together with poor differentiation and obscuring of structures possessing critical taxonomic value, viz., anchors, bars, hooks, and copulatory apparatus, caused the final abandonment of staining procedures (Mizelle, 1937). Thereafter the specimens were mounted, unstained in balsam. Because of small size and the tendency of the anchors to become entangled in debris and in the cuticula of other specimens, it was found practically impossible to handle these parasites in containers during the ordinary technical processes requisite for mounting. Either of the above procedures for fixation of speci-

mens to slides works very well, but the latter is preferred by the present author because of a shortening of the time element.

The term *haptor* for attachment organs as proposed by Price (1934a) is adopted. The following terms are used as proposed by Mueller (1936): *anchors* for the large hooks of the haptor; *wings* for the membranous structures arising from the convex surfaces of the anchor shafts; *bars* for the chitinous structures connecting the bases of a pair of anchors; and *hooks* for the smaller marginal armature of the haptor. The term *copulatory complex* is used for the ensemble of the male copulatory structures such as the cirrus, accessory piece, cirral thread, and cirral fin when present in combinations of two or more. *Buccal canal* is proposed for the anterior portion of the digestive tube between the pharynx and the opening to the outside.

In forms with nonarticulate bars, the anchor pairs are designated dorsal and ventral, since their shafts curve toward and their points project from the dorsal and ventral haptoral surfaces. In forms with the bars articulate with each other, both pairs of anchors lie on the ventral side of the haptor, and while the designation of the roots is the same, the respective anchors and bars are designated anterior and posterior instead of ventral and dorsal. For ease of reference the two roots comprising the bases of the anchors are designated with regard to the surfaces of the haptor. The root nearest the surface is thus designated the *superficial root* and the other the *deep root*. Mueller (1936) designated the roots of the anchor bases with reference to the anchor points and classified them as internal and external. In his system the inner and outer roots correspond respectively to the roots designated as superficial and deep by the present writer.

The haptoral hooks are numbered consecutively from ventral to dorsal surfaces beginning near the anterior central portion of the haptor and proceeding posteriorly on the ventral side and then anteriorly on the dorsal surface (see figs. 173-174). The two pairs of hooks on the dorsal surface are numbered six and seven, number six being the more posterior. The hooks of pair number five are usually situated nearer the ventral than the dorsal surface. They may lie between the bars or between the distal ends of the ventral anchor shafts.

Descriptions of forms in this work have been made on living specimens as well as on stained and unstained mounts. Sections were made of *Cleidodiscus robustus* Mueller, 1934, and *Cleidodiscus capax* Mizelle, 1936. Measurements do not follow surfaces of curved structures, but have been made across the arcs formed by them. For example, an anchor length consists of a measurement extending from the region of junction

(curved portion) of the shaft and point to the tip of the more distant root of the anchor base.

All measurements, except those of the anchors, hooks, bars, and cirri were taken on freshly killed specimens temporarily mounted in a solution of equal parts of glycerine and water, on glass slides without cover-glasses. Measurements of the anchors, hooks, bars, and cirri were made with coverglasses on the preparations. Each mean measurement given in this work is a calculated average derived from measurements taken from twenty different specimens.

After considerable research on this group of parasites (Tetraonchinae and Dactylogyrinae) a modification of the relative importance and treatment of different structures was made with reference to their taxonomic value. In the first part of the work the haptor hooks were measured individually, but no figures of these structures were given. In later parts of the investigation the hook measurements are usually represented by minima and maxima for the total number of hooks present, and descriptions for these are supplemented (except *Actinocleidus fergusonii* n. sp.) by one or more figures to illustrate the extent of differentiation of parts. In similar manner the cirrus descriptions have been supplemented by measurements which were omitted in the earlier portion of the investigation. It should be pointed out that species described herein are arranged according to genera and not with reference to chronological completion of descriptions. Since the general internal structure in the subfamilies Tetraonchinae and Dactylogyrinae is very similar, figures of whole specimens are not given for all the species described. Structures considered to possess critical taxonomic value are figured for all the forms described in this work.

Type material (cotypes) of forms described herein have been deposited in the U. S. National Museum Helminthological Collection.

ORDER MONOGENEA CARUS, 1863

HISTORICAL REVIEW

The group Trematoda, named by Rudolphi in 1808, as an order, originally included the following genera: *Monostomata* Zeder, *Amphistomata* Rudolphi, *Distoma* Retzius, and *Polystoma* Zeder. In 1858, van Beneden proposed the term monogénèses for trematodes which develop without metamorphosis and digénèses for those which develop with metamorphosis, the former category generally consisting of ectoparasites and the latter exclusively of endoparasites. In 1863, Carus proposed the terms Monogenea and Digenea, respectively, to replace the two terms of van

Beneden. In 1892, Monticelli divided the order Trematoda into the suborders Heterocotylea, Aspidocotylea, and Malacocotylea. The suborder Heterocotylea coincides with the Monogenea (Pratt, 1900). The Aspidocotylea and Malacocotylea are divisions of the Digenea. Odhner (1912) divided the Monogenea of Carus into the Polyopisthocotylea and Monopisthocotylea, respectively, on the basis of the presence or absence of a genito-intestinal canal.

According to Fuhrmann (1928), as set forth in Kükenthal's *Handbuch der Zoologie*, the Monogenea and Digenea of Carus are accepted as orders and the order Trematoda Rudolphi, is elevated to the status of class. The order Monogenea Carus, as given by Fuhrmann, embraces three suborders, Monopisthodiscinea, Monopisthocotylinea, and Polyopisthocotylinea. The suborder Monopisthodiscinea is divided into four families, Progyrodactylidae Johnston and Tiegs, 1922, Gyrodactylidae Cobbold, 1877, Dactylogyridae Bychowsky, 1933, and Calceostomatidae (Parona and Perugia, 1890). The suborder Monopisthocotylinea contains three families, Udonellidae Taschenberg, 1879, Monocotylidae Taschenberg, 1879, and Tristomidae van Beneden, 1858, while the suborder Polyopisthocotylinea is divided into five families, namely, Polystomidae van Beneden, 1858, Microcotylidae Taschenberg, 1879, Octocotylidae van Beneden and Hesse, 1863, Onchocotylidae Cerfontaine, 1899, and Dicliphoridae Cerfontaine, 1894.

Price (1937a) prefers the divisions Monopisthocotylea (= Monopisthodiscinea and Monopisthocotylinea) and Polyopisthocotylea (= Polyopisthocotylinea) of Odhner to those of Fuhrmann and designates the superfamilies Gyrodactyloidea Johnston and Tiegs, 1922, and Capsaloidea Price, 1937, respectively, to replace the suborders Monopisthodiscinea and Monopisthocotylinea of Fuhrmann. Price's classification is followed in the present publication.

KEY TO THE SUBORDERS OF MONOGENEA CARUS

- Genito-intestinal canal wanting; haptor with or without a large sucking disc.
 Monopisthocotylea Odhner
 Genito-intestinal canal present; haptor with separate suckers.....
 Polyopisthocotylea Odhner

KEY TO THE SUPERFAMILIES OF MONOPISTHOCOTYLEA ODHNER, 1912

- Posterior haptor armed; anchors with supporting bars.....
 Gyrodactyloidea Johnston and Tiegs
 Posterior haptor armed or unarmed; when armed, anchors without supporting
 bars..... Capsaloidea Price

SUPERFAMILY GYRODACTYLOIDEA JOHNSTON
AND TIEGS, 1922

GENERAL MORPHOLOGY OF THE GYRODACTYLOIDEA

Changes in classification, since the characterization of this superfamily by the above authors, have made it necessary to revise parts of their description. The description of the reproductive system, however, is taken from their monograph.

General anatomy.—The superfamily Gyrodactyloidea contains forms found in or on fishes, amphibians, and cephalopods. The species are characterized by the absence of anterior haptors and suckers of the ordinary type. A posterior haptor is present and consists of an armed disc which may or may not be distinctly set off from the body of the parasite. The haptor possesses hooks only (Isancistrinae), or hooks and anchors (one or two pairs) whose bases are connected by chitinous bars. The relationships of elements of haptoral armature vary greatly in different groups. Eye spots may be present or absent. In the pharyngeal region there are masses of glandular tissue which open to the outside by structures called *head organs* by Johnston and Tiegs (1922). An exception to this condition occurs in the family Calceostomatidae, in which these glands open by small ducts not concentrated in groups to form the so-called head organs.

Reproductive system.—“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 oötype, 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."

Digestive and excretory systems.—The mouth opens into a short buccal canal which empties into a muscular pharynx. An esophagus may or may not be present. The intestine may be saccate or bifurcate to form two crura which may or may not possess caeca. The crura may end blindly or be confluent with each other in the posterior body regions.

Johnston and Tiegs (1922) state, "Excretory ducts open either at the anterior end or, in some forms, probably at the posterior end." In the Dactylogyrinae and Tetraonchinae the present author is sure of excretory openings only in the anterior regions at about the level of the copulatory complex (see page 17).

KEY TO THE FAMILIES OF GYRODACTYLOIDEA

1. Viviparous.....Gyrodactylidae Cobbold
Oviparous.....2
2. Vitello-intestinal duct present.....Protogyrodactylidae Johnston and Tiegs
Vitello-intestinal duct wanting.....3
3. Anterior end of body expanded to form head lappets.....
.....Calceostomatidae (Parona and Perugia)
Anterior end of body not expanded to form head lappets.....
.....Dactylogyridae Bychowsky

THE NORTH AMERICAN FRESH-WATER GYRODACTYLOIDEA

REVIEW OF TAXONOMIC LITERATURE

Specific taxonomic investigations concerning the Gyrodactyloidea from North American fresh-water fishes have been meager.¹ Most important are the works of Mueller (1934, 1936, 1936a, 1937, 1937a, 1938), Mueller and Van Cleave (1932), Van Cleave (1921), Van Cleave and Mueller (1932 and 1934), and Price (1937a). In 1934 Mueller created the genera *Cleidodiscus* and *Urocleidus*; in 1936 he created the genera *Onchocleidus*, *Leptocleidus*, *Tetracleidus*, and *Aristocleidus*; and in 1937 he created the additional genera *Haplocleidus*, *Pterocleidus*, and *Actinocleidus*. The established genus *Ancyrocephalus* was made to include strictly marine forms (Mueller, 1936) and certain fresh-water Tetraonchinae of uncertain generic relationships.

¹The major portion of the work on the American fresh-water Gyrodactyloidea has dealt with control measures and identification only to genus. A literature review of this work will be found in the section of this publication dealing with economic importance.

The present author (Mizelle, 1936) described twelve species of Tetraonchinae from the gills of Illinois Centrarchidae and Serranidae. In 1937 he described three species of Dactylogyrinae from the blunt-nosed minnow, *Hyborhynchus notatus*, and at present has descriptions of four additional species of Tetraonchinae and one species of Dactylogyrinae in press. Another species of Tetraonchinae (*Actinocleidus fergusonii*) is originally described herein. The six last mentioned forms will be listed as new species in this publication. Including all the forms in the above taxonomic categories, the described species of North American fresh-water Gyrodactyloidea now total sixty-one. Three of these, namely, *Tetraonchus monenteron* (Wagener, 1857), *Dactylogyryrus anchoratus* (Dujardin, 1845), and *Gyrodactylus elegans* von Nordmann, 1832, were first described from another continent (Europe). Seven of these belong to the Gyrodactylinae (genus *Gyrodactylus*), six to the Dactylogyrinae (genus *Dactylogyryrus*), forty-seven to the Tetraonchinae, (12 *Cleidodiscus*, 11 *Oncocleidus*, 9 *Actinocleidus*, 3 *Haplocleidus*, 3 *Pterocleidus*, 3 *Urocleidus*, 2 *Tetraonchus*, 1 *Leptocleidus*, 1 *Aristocleidus*, 1 *Tetracleidus*, and 1 *Ancyrocephalus*), and one to the subfamily Lepidotrematinae, viz., *Lepidotetes collinsi* Mueller, 1936.

Price (1937a) lists forty-five Dactylogyrinae and nine Gyrodactylinae as foreign species (mostly European). Mueller (1936) gives six as the number of European species of fresh-water Tetraonchinae. According to the above information, the species of Gyrodactylinae are about evenly distributed between North America and Europe, whereas most of the Dactylogyrinae are found in Europe and most of the Tetraonchinae in North America.¹

KEY TO THE SUBFAMILIES OF GYRODACTYLIDAE COBBOLD, 1877

- Haptor with two anchors and 16 hooks.....Gyrodactylinae Monticelli
Haptor without anchors but with 15 hooks.....Isancistrinae Fuhrmann

KEY TO THE SUBFAMILIES OF DACTYLOGYRIDAE BYCHOWSKY, 1933

1. Haptor with 2 pairs of anchors.....2
Haptor with 1 pair of anchors.....3
2. Haptor with a pair (dorsal and ventral) of accessory structures or squamodiscs
.....Diplectaninae Monticelli
Haptor without squamodiscs.....Tetraonchinae Monticelli
3. Haptor with a circle of heavy cuticularized, tubular structures.....
.....Bothitrematinae Price
Haptor without chitinized tubular structures.....Dactylogyrinae Bychowsky

¹After this publication went to press Mueller (1938) described additional species of Tetraonchinae and Dactylogyrinae.

GENERAL MORPHOLOGY OF THE NORTH AMERICAN FRESH-WATER
TETRAONCHINAE MONTICELLI, 1903

General anatomy.—The flattened body comprises two distinctly tandem regions, an anterior, very narrowly elliptical, body proper and a posterior, hexagonal or discoidal haptor.¹ The body surface is devoid of scales (except in some specimens of *Cleidodiscus robustus* Mueller, 1934). Internal monaxon spicules are very infrequently found in the body parenchyma, namely, in some specimens of *Cleidodiscus robustus* and *Cleidodiscus capax* Mizelle, 1936. A pair of lateral lobe-like projections (cephalic lobes) are generally present in the head region. Two pairs of eye spots are present, located dorsally near the anterior end, with one pair behind the other, those of the anterior pair being generally smaller. Each eye spot is composed of an aggregation of melanistic granules which are easily separated from each other by cover-glass pressure. A group of glandular cells occurs on each side of the body in the region of the pharynx. These glands open to the exterior by head organs situated on the anterolateral margins of the cephalic region.

Four anchors always present on the haptor, generally similar in shape (except genus *Aristocleidus* Mueller, 1936) and size (except genus *Haplocleidus* Mueller, 1937). Each anchor is differentiated into a base, which is usually bifurcate to form two roots; a shaft which may be solid or hollow; and a point which projects from the surface of the haptor. The shaft may be regularly recurved distally, merging imperceptibly with the point or sharply recurved to form a distinct internal angle at this locus. Membranous wings, so designated by Mueller (1936), arise from the convex surfaces of the anchor shafts. These have been found universally present in the species described in this investigation. However, these structures exhibit differential development and are often scarcely perceptible in some species. Two bars always present (except in the genera *Tetraonchus* and *Murraytrema*), each of which connects the bases of a pair of anchors. The bars generally exist as separate structures. *Actinocleidus* Mueller, 1937, is the only genus in which the bars are articulated with each other. Seven pairs of chitinous hooks (eight pairs in *Tetraonchus*) are generally present on the haptor. A hook may be a solid or a hollow, cylindrical, tapering rod ending distally in a sickle-shaped process and opposable piece, or a solid structure distinctly differentiated into a base, shaft, sickle-shaped termination and an opposable piece. Five pairs of hooks are located ventrally and two pairs dorsally (see figs. 173-174).

¹Due to contraction at death, the postero-lateral sides of a haptor, normally hexagonal, may be pulled together to the extent that the posterior side is obliterated and in such case the structure assumes a pentagonal shape. The junction of the haptor with the body is considered one side of the haptor. Body contraction at death may shorten or accentuate the peduncle so that relative separation of haptor from the body becomes a poor descriptive character.

Reproductive system.—The single testis, regular in outline, is located in the posterior half of the body and may be dorsal, posterior, or postero-dorsal to the ovary. The vas deferens passes forward, generally, on the left side of the body, and usually dilates to form a seminal vesicle immediately posterior to the cirrus base. Two prostate glands generally present, situated near the posterior end of the copulatory complex, and each connected with the cirrus by a single individual duct. The prostate glands are similar to those described by Goto (1894) for the genus *Epibdella*. The copulatory complex consists of a cirrus and one or more of the following chitinous structures: solid accessory piece, cirral thread, and cirral fin. This compound structure is situated in a vestibule immediately in rear of the esophageal bifurcation. The cirrus projects or empties ventrally through the vestibular pore.

The ovary is a nonlobed organ with spatial relationships with the testis as given above. It may be larger or smaller than or about the same size as the testis. Internally it is filled with relatively large, clear, nucleated eggs of different sizes, which are easily visible in living mounts. The eggs diminish in size toward the posterior portion of the ovary. The oviduct arises from the anterior portion of the ovary and passes forward near the midline of the body. Never more than one egg has been observed in the oviduct at a given time. The egg pore is situated ventrally near the vestibular pore. The single vagina (wanting in the genus *Urocleidus* and also in species of other genera) may occur on either lateral body margin. It is generally provided with a chitinous tube which connects it with a seminal receptacle, situated near the anterior end of the ovary. The vitellaria consist of innumerable minute follicles arranged in two lateral longitudinal bands extending from dorsal to ventral body surfaces. Anteriorly these bands may or may not be confluent immediately behind the pharynx near their anterior limits but are always broadly confluent posteriorly on or near the peduncle. Encroachment of the vitellaria on the midbody regions of old individuals may become so marked as to obscure the visibility of internal organs. Vitelline ducts enter the oötype one on each side just anterior to the ovary as described by Goto (1894) for the genus *Tristomum* Cuvier, 1817, and by MacCallum (1915) for *Ancyrocephalus teuthis*.

Digestive and excretory systems.—The mouth is located in the mid-ventral region near the level of the anterior eye spots. A short buccal canal passes posterodorsad to enter the well-developed pharynx. The short esophagus bifurcates (except in *Tetraonchus*) to form two lateral intestinal crura which unite posteriorly (except in *Murraytrema*) in the region of confluency of the vitellarial bands.

The excretory system consists of a maze of ramifying tubules pre-

sumably terminating in flame cells. Basically a single pair of lateral collecting ducts (one on each side) occurs in the posterior part of the anterior body half. Anteriorly each tube bifurcates to form two ducts. One of these passes laterally at an angle of about forty-five degrees and empties on the dorsolateral body surface, near the level of the copulatory complex. The other passes anteriorly and terminates lateral to the anterior eye spot.¹ Posteriorly the single duct referred to above bifurcates in the region of the ovary to form two tubes which pass posteriorly, turn mesiad in the region of confluency of the vitellarial bands and unite to form a short tube. This structure unites with its bilateral mate to form a single duct which terminates near or on the peduncle. Especially large solenocytes have been observed in some species between the level of the ovary and the base of the copulatory complex. Flame cell numbers and patterns have not been worked out for the group.

Note.—The status of most of the following genera is uncertain at the present time. The genera *Onchocleidus*, *Tetracleidus*, *Aristocleidus*, *Haplocleidus*, *Pterocleidus*, and *Urocleidus* are probably synonymous.

KEY TO THE GENERA OF NORTH AMERICAN
FRESH-WATER TETRAONCHINAE
(Excluding *Tetraonchus* and *Murraytrema*)

1. Cirrus relatively simple.....2
Cirrus in a large coil.....*Leptocleidus* Mueller
2. Anchors similar in shape.....3
Anchors dissimilar in shape.....*Aristocleidus* Mueller
3. Anchors similar in size.....4
Anchors markedly dissimilar in size.....*Haplocleidus* Mueller
4. Bars nonarticulate.....5
Bars articulate with each other.....*Actinocleidus* Mueller
5. Vagina present.....6
Vagina wanting.....*Urocleidus* Mueller
6. Vagina on right body margin.....7
Vagina on left body margin.....*Cleiaodiscus* Mueller
7. Anchor shafts without spurs.....8
Anchor shafts with spurs.....*Pterocleidus* Mueller
8. Accessory piece present.....*Tetracleidus* Mueller
Accessory piece wanting.....*Onchocleidus* Mueller

¹The present author (Mizelle, 1936) observed what he interpreted to be excretory pores in the anterior and posterior regions of these parasites as mentioned by Johnston and Tiegs (1922). Further observations have failed to reveal these structures consistently, so that it seems best to avoid any detailed discussion of them at the present time.

Genus *Cleidodiscus* Mueller, 1934

Diagnosis.—Tetraonchinae with intestine bifurcate but confluent posteriorly. Vagina present on the left body margin about midway the length. Copulatory complex consisting of a cirrus and accessory piece. Accessory piece well developed, always present and articulated to the cirrus base. Haptor distinct, discoidal, pentagonal, or hexagonal in shape. Two separate bars present, each of which connects the bases of members of a pair of anchors. Each of the fourteen hooks present is structurally differentiated into a base, shaft, sickle-shaped termination, and opposable piece. Parasitic on the gills of fresh-water fishes. Type species, *Cleidodiscus robustus* Mueller, 1934.

Cleidodiscus robustus Mueller, 1934

Figs. 1, 13-21

Hosts and Localities: Bluegill Sunfish (*Helioperca macrochira*), Illinois River, Havana, Ill.; Chautauqua Lake, Havana, Ill.; Horseshoe Lake, Cairo, Ill.; Lake Decatur, Decatur, Ill.; Lake Senachwine, Henry, Ill.—Green Sunfish (*Apomotis cyanellus*), Embarrass River, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9090.¹

Synonym: *Cleidodiscus incisor* Mizelle, 1936.

General anatomy.—Relatively large parasites whose surfaces often possess chitinoid scale-like structures. The parenchyma of old individuals very frequently contains monaxon spicules. Average length 1.414 mm. (0.615-2.296 mm.), average width at level of cephalic lobes 0.132 mm. (0.106-0.246 mm.), average greatest body width 0.216 mm. (0.121-0.410 mm.), average width of peduncle at junction with haptor 0.060 mm. (0.041-0.106 mm.). Haptor distinct, discoidal, and broader than long, average width 0.111 mm. (0.092-0.148 mm.), average length 0.106 mm. (0.082-0.139 mm.). Ventral bar similar in shape to dorsal bar but slightly longer. Average length of ventral bar 0.028 mm. (0.025-0.032 mm.), average length of dorsal bar 0.027 mm. (0.024-0.029 mm.). Anchors similar in shape, bases bifurcate, superficial roots about same length as knob-like deep roots. Wings present on anchor shafts but often so delicate as to be scarcely perceptible. Shafts of both pairs of anchors hollow and regularly recurved, making junction with the points without formation of an angle. Ventral anchors slightly longer than dorsal anchors, bases of the two pairs of anchors approximately the same width. Average length of ventral anchors 0.026 mm. (0.021-0.030 mm.), average width 0.012 mm. (0.010-0.017 mm.), average length of dorsal anchors 0.024 mm. (0.019-0.027 mm.), average width of dorsal anchors

¹These specimens were deposited as cotypes of *C. incisor*, which is now a synonym of *C. robustus*.

0.012 mm. (0.009-0.017 mm.). Hook bases ovate and very short as compared with lengths of shafts. Hooks of pair number one slightly shorter than rest of hooks. The arrangement of the hooks is characteristic of North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm.
1	0.015	0.013-0.017
2	0.017	0.015-0.020
3	0.019	0.016-0.023
4	0.019	0.017-0.023
5	0.016	0.014-0.017
6	0.019	0.017-0.021
7	0.019	0.017-0.023

Anterior eye spots smaller and usually closer together than the members of the posterior pair.

Reproductive system.—Gonads near middle of body, testis ovate and located posterior to ovary. Vas deferens passes forward on left side of body and expands to form a conspicuous seminal vesicle just posterior to cirrus base. Only one prostate gland has been observed. It is bulb-shaped, located posterior to the cirrus base and contains a coarsely granular yellowish fluid. It empties into cirrus base by a single duct arising from the anterior end. Copulatory complex well developed and situated in a relatively large vestibule. Cirrus a simple, curved, chitinous tube; accessory piece a blade-like chitinous structure with a knob near the middle, which serves as a site for attachment of muscles. Contractile elements arise on posterior surface of knob of accessory piece and insert on base of cirrus. On contraction of these structures the cirrus and accessory piece separate distally and the cirrus is projected ventrally, for a short distance, through the pore of the vestibule. Retraction mechanism of the cirrus not understood.

Ovary ovate in shape, smaller than testis, and situated anterior to it. Egg pore located on ventral surface on right of copulatory complex. Vagina present on left side, near junction of first and second thirds of body length; vaginal canal short, with a row of spines encircling the base at its junction with the large pyriform seminal receptacle. Vitellaria and vitelline ducts as described in the general morphology of North American fresh-water Tetraonchinae. Shell gland a cluster of glandular cells surrounding the oötype.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American Fresh-water Tetraonchinae. Average diameter of pharynx 0.076 mm. (0.046-0.123 mm.).

Systematic position.—In the present investigation this parasite has been taken only from the bluegill and green sunfishes. It occurs in mixed infestations on the former host with *Pterocleidus acer* (Mueller, 1936), *Haploleidus dispar* (Mueller, 1936), *Actinocleidus fergusonii* n. sp., and *Onchocleidus mucronatus* Mizelle, 1936, and in mixed infestations on the latter host with *Cleidodiscus diversus* n. sp., *Actinocleidus longus* n. sp., *Onchocleidus cyanellus* n. sp., and an undescribed member of the genus *Actinocleidus* Mueller, 1937. This form was described by the present author (Mizelle, 1936) as *Cleidodiscus incisor*. Study of Mueller's type specimens revealed it to be a synonym of *Cleidodiscus robustus*.

One hundred per cent infestation with *C. robustus* was recorded for: nineteen bluegill sunfish from Chautauqua Lake, Havana, Ill., in May, 1936; thirty-one bluegills from the Illinois River, Havana, Ill., in May, and June, 1936; six bluegills from Horseshoe Lake, Cairo, Ill., in June, 1936; twenty-three bluegill sunfish from Lake Decatur, Decatur, Ill., in June, July, and August, 1936. Fourteen bluegills from Lake Senachwine, Henry, Ill., were found only fifty per cent infested with this gill parasite in June, 1936. The green sunfish is only occasionally infested with this helminth.

Cleidodiscus capax Mizelle, 1936

Figs. 7, 67-75

Hosts and Localities: White Crappie (*Pomoxis annularis*), Lake Decatur, Decatur, Ill.; Illinois River, Havana, Ill.—Black Crappie (*Pomoxis sparoides*), Lake Senachwine, Henry, Ill.; Illinois River, Havana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9079.

General anatomy.—Relatively large gill parasites devoid of surface scales but often possessing internal monaxon spicules in the parenchyma. Average length 1.603 mm. (0.959-2.050 mm.), average width at level of cephalic lobes 0.161 mm. (0.115-0.205 mm.), greatest body width average 0.301 mm. (0.180-0.410 mm.), average width of peduncle at junction with haptor 0.096 mm. (0.082-0.107 mm.). Haptor distinct, discoidal in outline and broader than long, average width 0.158 mm. (0.115-0.180 mm.), average length 0.106 mm. (0.090-0.123 mm.). Ventral bar heavier and slightly longer than dorsal bar. Average length of ventral bar 0.032 mm. (0.028-0.034 mm.), average length of dorsal bar 0.030 mm. (0.024-0.036 mm.). Anchors similar in shape, bases often nonbifurcate, obscuring the two roots which are always evident in young individuals. Wings of anchor shafts often so delicate as to be scarcely perceptible. Shafts of both pairs of anchors solid and regularly recurved without formation of an angle at the point of junction with their respective points. Ventral anchors larger than dorsal anchors, bases of ventral anchors markedly wider than bases of dorsal anchors. Average length of ventral anchors 0.032 mm. (0.026-0.038 mm.), average width 0.027 mm. (0.019-0.036 mm.), average length

of dorsal anchors 0.031 mm. (0.026-0.038 mm.), average width 0.023 mm. (0.019-0.029 mm.). Hook bases ovate and very short as compared with lengths of shafts. Hooks of pair number one shorter than the rest of the hooks. The arrangement of the hooks is characteristic of North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm
1	0.014	0.013-0.017
2	0.016	0.013-0.019
3	0.017	0.014-0.019
4	0.018	0.015-0.019
5	0.016	0.013-0.019
6	0.017	0.013-0.019
7	0.017	0.013-0.019

The anterior eye spots are smaller and invariably farther apart than members of the posterior pair.

Reproductive system.—Gonads situated near the middle of the body, testis ovate and situated posterior to ovary. Vas deferens passes forward on left side of body and expands to form a fusiform seminal vesicle near the cirrus base. Prostate glands two in number, larger one somewhat fusiform in shape and filled with a finely granular colorless fluid, smaller one subpyriform in outline and filled with a coarsely granular yellowish fluid. Copulatory complex well developed and situated in a relatively small vestibule. Cirrus a curved chitinous tube reciprocally coiled about the accessory piece. Accessory piece a curved chitinous rod. A conspicuous knob which serves as a site for muscular attachment occurs on the anterior portion of the accessory piece. Contractile elements arise on posterior portion of this knob and insert on the cirrus base. On contraction of these structures the anterior portion of the accessory piece remains *in situ*, the portion of the accessory piece posterior to the knob bends in an elbow fashion and the cirrus is projected through the vestibular pore for a distance equal to about one half its length. The terminal portion of the accessory piece serves as a guide for the cirrus. Presumably, the retraction of the cirrus is accomplished by straightening of the accessory piece.

Ovary ovate, smaller than testis and situated anterior to it. Egg pore on ventral surface, on right of copulatory complex base. Vagina present on left body margin, anterior to middle of body proper; vaginal canal a long chitinous tube connecting vagina with the well-developed seminal receptacle. Vitellaria and vitelline ducts as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland a cluster of glandular cells surrounding the oötype.

Digestive and excretory systems.—The digestive and excretory sys-

tems are as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.139 mm. (0.082-0.164 mm.).

Systematic position.—This parasite has been found to occur in heavy infestations on the gills of the black crappie from Lake Senachwine, Henry, Ill. Another form, *Cleidodiscus vanleavei* Mizelle, 1936, also occurs on the same host, but the two species have not been recovered from the same host specimen. *Cleidodiscus capax* occurs in smaller numbers on the gills of the white crappie, in mixed infestations with *Cleidodiscus longus* Mizelle, 1936, *Cleidodiscus uniformis* Mizelle, 1936, and *Cleidodiscus vanleavei*. In size, this form closely approximates that of *Cleidodiscus robustus* Mueller, 1934, but the anchors, bars, copulatory complex, and vagina are morphologically different from corresponding structures in *C. robustus*. *C. capax* occurs only on the black and white crappies, whereas *C. robustus* has been taken from the pumpkinseed, bluegill, green sunfish, "sunfish," and "bass" (Mueller, 1936). Tetraonchid parasites of crappies (black and white) have not been found to occur on other hosts in this investigation. One hundred per cent infestation with *C. capax* was recorded for: forty-eight white crappies from Lake Decatur, Decatur, Ill., in May, June, July, and August, 1936; sixteen black crappies from Lake Senachwine, Henry, Ill.; and five black crappies from the Illinois River, Havana, Ill., in June, 1936.

Cleidodiscus longus Mizelle, 1936

Figs. 4, 49-56

Hosts and Localities: White Crappie (*Pomoxis annularis*), Lake Decatur, Decatur, Ill.; Salt Fork of the Big Vermilion River, south of Oakwood, Ill.; Boomer Creek, Stillwater, Okla.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9080.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.626 mm. (0.492-0.713 mm.), average width at level of cephalic lobes 0.087 mm. (0.066-0.107 mm.), greatest body width average 0.106 mm. (0.098-0.123 mm.), average width of peduncle at junction with haptor 0.064 mm. (0.038-0.086 mm.). Haptor distinct, hexagonal in shape, and broader than long, average width 0.110 mm. (0.076-0.123 mm.), average length 0.100 mm. (0.057-0.114 mm.). Ventral bar with notched ends, relatively straight, heavier and slightly longer than dorsal bar which is bent in middle to present a sagged appearance. Average length of ventral bar 0.038 mm. (0.032-0.042 mm.), average length of dorsal bar 0.037 mm. (0.028-0.042 mm.). Anchors similar in shape, bases bifurcate, superficial roots longer than deep roots. Wings on anchor shafts clearly discernible. Distal portion

of each anchor shaft markedly dilated and containing a cavity which extends into basal portion of each point. Anchor points and shafts unite to form an internal angle at locus of junction. Ventral anchors larger than dorsal anchors. Average length of ventral anchors 0.043 mm. (0.038-0.051 mm.), average width 0.028 mm. (0.019-0.032 mm.), average length of dorsal anchors 0.037 mm. (0.031-0.046 mm.), average width 0.017 mm. (0.013-0.023 mm.). Bases of ventral anchors conspicuously wider than bases of dorsal anchors. Hook bases of pair number five ovate and shorter than their respective shafts, bases of other hooks elongate-ovate and about same length as their shafts. Hooks of pair number five noticeably shorter than rest of hooks. The arrangement of the hooks is characteristic of North American Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm.
1	0.017	0.015-0.019
2	0.020	0.017-0.023
3	0.021	0.019-0.023
4	0.019	0.017-0.023
5	0.014	0.009-0.017
6	0.019	0.015-0.021
7	0.021	0.017-0.023

The anterior eye spots are smaller and invariably farther apart than members of the posterior pair.

Reproductive system.—Gonads located anteriorly in posterior half of body, testis elongate and located posterior to ovary. Vas deferens arises from anterior end of testis, passes forward on left side of body without evident dilatation to form a seminal vesicle. Two prostate glands present, larger one elongate-saccate in outline and filled with a finely granular colorless fluid, the smaller one saccate and containing a coarsely granular yellowish fluid. Each prostate gland empties into base of cirrus by a single individual duct. Copulatory complex well developed and situated in a slender vestibule. Cirrus a long chitinous whip-like tube attenuated distally to a fine thread. Accessory piece consists of a chitinous structure with a deep groove which serves as a guide for the cirrus. Contractile elements originate on the accessory piece near its midportion and insert on the base of the cirrus. On contraction of these elements, the portion of the accessory piece distal to the muscular attachments remains *in situ*, the proximal portion bends in elbow fashion and the cirrus is projected through the vestibular pore, beyond the body surface, for a distance equal to about one-half its length. Presumably, the straightening of the accessory piece retracts the cirrus.

Ovary ovate, from one to two times as large as testis and situated anterior to it. Uterine pore located on ventral surface at right of copula-

tory complex base. Vagina present on left margin near the middle of the body; vaginal canal a chitinous tube emptying mesially into a well-defined seminal receptacle. The vitellaria and vitelline ducts are as described in the general morphology for the North American fresh-water Tetraonchinae. Shell gland, a group of glandular cells surrounding the oötype.

Digestive and excretory systems.—The digestive and excretory systems exist as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.033 mm. (0.030-0.036 mm.).

Systematic position.—This species of gill parasite has been recovered only from the white crappie in this investigation. It occurs in mixed infestations with *Cleidodiscus vancleavei* Mizelle, 1936, *Cleidodiscus capax* Mizelle, 1936, and *Cleidodiscus uniformis* Mizelle, 1936. *Cleidodiscus longus* possesses a copulatory complex similar to but longer than that of *C. uniformis*. The vaginae of the two species are almost identical. The chief differences are the dissimilarities of bars and anchors of these two species. The bases of the two pairs of anchors of *C. longus* are markedly different in width, whereas the widths of the two pairs of anchors of *C. uniformis* are almost identical. Average width of ventral anchors of *C. longus* 0.028 mm., average width of dorsal anchors 0.017 mm. Average width of ventral anchors of *C. uniformis* 0.017 mm., average width of dorsal anchors 0.016 mm. *C. longus* possesses anchors whose shafts are markedly dilated distally while the anchors of *C. uniformis* are never more than slightly dilated. Each anchor shaft of *C. longus* meets its respective point to form an internal angle, but the shafts of *C. uniformis* are uniformly recurved without formation of an angle at this point.

The bars of the two species are different and constant in shape. *C. uniformis* is the closest morphological relative of *C. longus*.

Forty-eight white crappies from Lake Decatur, Decatur, Ill., in May, June, July, and August, 1936, were infested one hundred per cent with this gill parasite. Only one host was taken from the Salt Fork of the Big Vermilion River south of Oakwood, Ill., July, 1936. Five hosts from Boomer Creek, Stillwater, Okla., were infested one hundred per cent with this species.

Cleidodiscus uniformis Mizelle, 1936

Figs. 12, 85-93

Hosts and Localities: White crappie (*Pomoxis annularis*), Lake Decatur, Decatur, Ill.; Salt Fork of the Big Vermilion River, south of Oakwood, Ill.; Boomer Creek, Stillwater, Okla.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9081.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.583 mm. (0.398-0.738 mm.), average width at level of cephalic lobes 0.080 mm. (0.065-0.114 mm.), greatest body width average 0.097 mm. (0.075-0.147 mm.), average width of peduncle at junction with haptor 0.062 mm. (0.034-0.092 mm.). Haptor distinct, hexagonal in shape and broader than long, average width 0.107 mm. (0.076-0.127 mm.), average length 0.093 mm. (0.062-0.114 mm.). Ventral bar about size of dorsal bar, but straighter and with anterior surface raised in the midportion. Dorsal bar slightly bent ventrally in the middle and with obliquely truncate ends. Average length of ventral bar 0.036 mm. (0.029-0.038 mm.), average length of dorsal bar 0.036 mm. (0.030-0.040 mm.). Anchors similar in shape and size, bases bifurcate, superficial roots longer than deep roots. Wings clearly evident on all four anchor shafts. Anchors hollow distally, regularly recurved without formation of an angle at junction with points. Hollow portion of shaft continued into base of anchor point. Bases of dorsal and ventral anchors not markedly different in width. Average length of ventral anchors 0.032 mm. (0.026-0.034 mm.), average width 0.017 mm. (0.013-0.019 mm.), average length of dorsal anchors 0.032 mm. (0.026-0.036 mm.), average width 0.016 mm. (0.013-0.018 mm.). Hook bases ovate to elongate-ovate in shape. Hooks of pairs numbers one and five shorter than other hooks. The arrangement of the hooks is as described in the general morphology of the North American fresh-water *Tetraonchinae* possessing fourteen haptoral hooks (see pages 9, 15, and 62).

<i>Hook pair</i>	<i>Average length in mm.</i>	<i>Range in mm.</i>
1	0.015	0.011-0.017
2	0.019	0.015-0.021
3	0.020	0.015-0.023
4	0.021	0.015-0.023
5	0.015	0.010-0.017
6	0.021	0.015-0.023
7	0.020	0.015-0.023

Spatial relationships between members of the pairs of eye spots variable, anterior pair smaller.

Reproductive system.—Gonads situated anteriorly in the second half of body, testis ovate, slightly smaller than, and located dorsoposterior to ovary. Vas deferens arises from anterior end of testis, passes forward near midline of body and enters cirrus base without evident dilatation to form a seminal vesicle. Two prostate glands present, larger one irregularly saccate and filled with a finely granular fluid, smaller one elongate and containing a coarsely granular, yellowish fluid. Copulatory complex well developed and situated in a slender vestibule. Cirrus a long chitinous whip-like tube attenuated distally to a fine thread. Accessory piece a

chitinous structure with a deep groove which serves as cirrus guide. Muscular elements originate about midway on accessory piece and insert on base of cirrus. On contraction of these elements the portion of the accessory piece anterior to the attachment remains *in situ*, the portion of the accessory piece posterior to the attachment bends in elbow fashion and the cirrus is projected ventrally, through the vestibular pore, for a distance equal to about one-half its length.

Ovary ovate, slightly larger than testis and situated anteroventrally to it. Egg pore located on ventral surface on right of vestibular pore. Vagina present on left margin in anterior body half, vaginal canal a relatively long chitinous tube terminating at the well-developed seminal receptacle. Vitellaria and vitelline ducts are as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—The digestive and excretory systems exist as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.034 mm. (0.030-0.048 mm.).

Systematic position.—This parasite, from Illinois localities, has been found to occur in mixed infestations with *Cleidodiscus vanceleveii* Mizelle, 1936, *Cleidodiscus capax* Mizelle, 1936, and *Cleidodiscus longus* Mizelle, 1936. It has been recovered only from the gills of the white crappie. The vagina of this species is almost identical with that of *C. longus*. Whereas the shafts of *C. longus* are markedly dilated to form an internal angle at the junction with the points, the converse condition exists in the anchors of *C. uniformis*. The anchor shafts of *C. uniformis* are never more than slightly dilated, hollow and regularly recurved without formation of an angle at the locus mentioned above for *C. longus*. The ventral anchor bases of *C. longus* are much wider than are the dorsal anchor bases. The dorsal and ventral anchor bases of *C. uniformis* are almost identical in width. Average width of ventral anchor bases of *C. longus* 0.028 mm., average width of dorsal anchor bases 0.017 mm.; average width of ventral anchor bases of *C. uniformis* 0.017 mm., average width of dorsal anchor bases 0.016 mm. In addition to the above differences, the bars of the two species are constantly different in shape. *C. longus* is the nearest morphological relative of *C. uniformis*.

Forty-eight white crappies from Lake Decatur, Decatur, Ill., in May, June, July, and August, 1936, were one hundred per cent infested with this parasite. Only one host was taken from the Salt Fork of the Big Vermilion River south of Oakwood, Ill., July, 1936. Five hosts from Boomer Creek, Stillwater, Okla., were infested one hundred per cent with this species.

Cleidodiscus vancleavei Mizelle, 1936

Figs. 5, 31-39

Hosts and Localities: White and Black Crappies (*Pomoxis annularis* and *P. sparoides*), Lake Decatur, Decatur, Ill.; Salt Fork of the Big Vermilion River, south of Oakwood, Ill.; Boomer Creek, Stillwater, Okla.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9082.

Synonyms: *Onchocleidus formosus* Mueller, 1936; *C. formosus* (Mueller, 1936) Price, 1937.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.563 mm. (0.399-0.681 mm.), average width at level of cephalic lobes 0.068 mm. (0.042-0.089 mm.), greatest body width average 0.070 mm. (0.057-0.089 mm.), average width of peduncle at junction with haptor 0.047 mm. (0.036-0.067 mm.). Haptor distinct, hexagonal in shape and broader than long, average width 0.104 mm. (0.089-0.124 mm.), average length 0.086 mm. (0.074-0.105 mm.). Dorsal bar notched at each end and with a median spine on the posterior border. Ends of ventral bar variable in shape, median posterior spine present. Average length of ventral bar 0.024 mm. (0.019-0.029 mm.), average length of dorsal bar 0.025 mm. (0.019-0.029 mm.). Anchors similar in shape, bases slightly bifurcate, superficial roots longer than deep roots, wings clearly evident. Each anchor shaft solid, junction with point marked by an internal angle. Ventral anchors slightly longer than dorsal anchors. Bases of dorsal and ventral anchors not noticeably different in width. Average length of ventral anchors 0.039 mm. (0.033-0.044 mm.), average width 0.019 mm. (0.013-0.023 mm.), average length of dorsal anchors 0.036 mm. (0.029-0.042 mm.), average width 0.017 mm. (0.015-0.019 mm.). Hook bases of pair number five ovate and shorter than shafts, bases of remaining hooks elongate. Bases of pair number one about same length as their shafts, bases of remaining hooks longer than their respective shafts. Hooks of pair number five noticeably shorter than the other hooks. The arrangement of the hooks is characteristic of North American Tetraonchinae possessing fourteen haptor hooks (see pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm.
1	0.018	0.013-0.019
2	0.020	0.017-0.023
3	0.019	0.015-0.023
4	0.022	0.019-0.025
5	0.013	0.011-0.015
6	0.021	0.017-0.025
7	0.024	0.019-0.027

The anterior eye spots are smaller and farther apart than members of the posterior pair.

Reproductive system.—Gonads situated anteriorly in posterior body

half, testis relatively small and located posterior to ovary. Vas deferens dilated near cirrus base to form a tubular seminal vesicle. Two prostate glands, one containing a finely granular colorless fluid, the other filled with a coarsely granular faintly yellowish fluid. Copulatory complex well developed and situated in a small vestibule. Cirrus a short chitinous tube, base relatively large, shaft tapered to a point distally. Accessory piece a chitinous structure of variable shape. It encloses the base of the cirrus and usually makes one complete turn around the cirrus shaft. Operation of copulatory complex not observed.

Ovary ovate, much larger than testis and situated anterior to it. Egg pore on ventral surface anterior to base of copulatory complex. Vagina on left margin near midlength of body; vaginal canal short, emptying mesially into a transparent seminal receptacle. Vitellaria and vitelline ducts exist as described in the general morphology of the North American fresh-water Tetraonchinae. Nature of shell gland not determined.

Digestive and excretory systems.—The digestive and excretory systems are as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.025 mm. (0.023-0.028 mm.).

Systematic position.—This parasite, from Illinois localities, has been recovered from the gills of the white crappie, in mixed infestations with *Cleidodiscus capax* Mizelle, 1936, *Cleidodiscus longus* Mizelle, 1936, and *Cleidodiscus uniformis* Mizelle, 1936. It has been recovered from the gills of the black crappie in pure infestations. *C. capax* also occurs on the black crappie, but in this investigation these two parasites have not been recovered from the same host specimen. While the general morphology of *Cleidodiscus vanleavei* is similar to that of the rest of the members of the genus, the characteristic copulatory complex, together with the presence of spines on both the dorsal and ventral bars distinguish it immediately from all related forms. In May, June, July, and August, 1936, forty-eight white crappies from Lake Decatur, Decatur, Ill., were found one hundred per cent infested with this helminth. Only one host (white crappie) was taken from the Salt Fork of the Big Vermilion River. Six black crappies from Lake Decatur in June, 1936, were infested only fifty per cent with this parasite.

Mueller (1936a) described this parasite from the gills of the black crappie from Lake Okeechobee, Clewiston, Fla., as *Onchocleidus formosus*. The sinistral vagina and the copulatory complex with the accessory piece articulated to the cirrus base, definitely places this form in the genus *Cleidodiscus* Mueller, 1934. Mueller's specimens of *O. formosus* have been compared with specimens of *C. vanleavei*, and forms showing variation in the ventral bar and accessory piece identical

with Mueller's figures have been taken from the black and white crappies in Illinois and Oklahoma.

Cleidodiscus bedardi Mizelle, 1936

Figs. 6, 57-66

Host and Localities: Long-Eared Sunfish (*Xenotis megalotis*), Embarrass River, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9083.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.412 mm. (0.285-0.495 mm.), average width at level of cephalic lobes 0.056 mm. (0.047-0.067 mm.), greatest body width average 0.080 mm. (0.057-0.103 mm.), average width of peduncle at junction with haptor 0.057 mm. (0.038-0.065 mm.). Haptor distinct, subdiscoidal in shape and broader than long, average width 0.087 mm. (0.059-0.100 mm.), average length 0.058 mm. (0.051-0.067 mm.). Ventral bar noticeably larger than dorsal bar and variable in shape. Both bars bent near middle, dorsal bar always bent posteriorly, ventral bar may be bent either anteriorly or posteriorly. Average length of ventral bar 0.031 mm. (0.027-0.036 mm.), average length of dorsal bar 0.024 mm. (0.023-0.025 mm.). Anchors similar in shape, bases bifurcate, superficial roots slightly longer than deep roots. Anchor shafts solid, suggestion of internal angle at junction of shaft and point. Ventral anchor slightly longer than dorsal anchors. Ventral anchor bases not conspicuously wider than dorsal anchor bases. Average length of ventral anchors 0.027 mm. (0.023-0.034 mm.), average width 0.012 mm. (0.009-0.015 mm.), average length of dorsal anchors 0.024 mm. (0.021-0.032 mm.), average width 0.011 mm. (0.009-0.015 mm.). Hooks not conspicuously different in length. Bases of hooks ovate, bases of pair number five shorter than shafts, bases of other hooks about same length as their respective shafts. The arrangement of hooks is as described in the general morphology of the North American Tetraonchinae possessing fourteen haptor hooks (see pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm
1	0.013	0.011-0.015
2	0.014	0.011-0.015
3	0.014	0.013-0.015
4	0.014	0.013-0.015
5	0.012	0.009-0.013
6	0.015	0.013-0.016
7	0.014	0.013-0.015

Anterior eye spots smaller and generally farther apart than members of posterior pair.

Reproductive system.—Gonads located in posterior body half, testis ovate, situated dorsoposterior to and much smaller than ovary. Vas deferens passes forward generally on left side of body as a slightly undulant tube dilated near cirrus base to form a fusiform seminal vesicle. Only one prostate gland observed; it is saccate and contains a coarsely granular yellowish fluid. Copulatory complex well developed and situated in a relatively large vestibule. Cirrus a simple curved chitinous tube tapered distally to a fine point. Accessory piece a solid chitinous rod with a chelate termination. Operation of cirrus not observed.

Ovary subspherical, much larger than, and situated anteroventrally to the testis. Egg pore on ventral surface on right of copulatory complex. Vagina present on left margin near midlength of body; vaginal canal short, emptying into a small seminal receptacle lying parallel to the lateral margin of body. A pseudovagina (Fig. 64) occurs immediately anterior to the vagina. Vitellaria and vitelline ducts exist as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland a thickened portion of the oviduct.

Digestive and excretory systems.—The digestive and excretory systems are as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.025 mm. (0.021-0.032 mm.). A large solenocyte occurs in the region of the seminal receptacle.

Systematic position.—This parasite, from Illinois localities, occurs in mixed infestations with *Actinocleidus articularis* (Mizelle, 1936), *Onchocleidus distinctus* Mizelle, 1936, *Pterocleidus acuminatus* (Mizelle, 1936), an undescribed species of *Cleidodiscus* Mueller, 1934, and an undescribed member of the genus *Haplocleidus* Mueller, 1937. *Cleidodiscus bedardi* has been taken only from the gills of the long-eared sunfish from the Embarrass River south of Urbana, Ill. It is immediately recognizable by the striking difference in the size of the dorsal and ventral bars, the ventral being much larger; the presence of a pseudovagina; and a chelate accessory piece. The anchors are relatively small with deeply bifurcate bases. These structural details taken together are radically different from those of any other described member of the genus *Cleidodiscus*.

One hundred per cent infestation was recorded for one hundred twenty-five long-eared sunfish, from the Embarrass River in April, May, June, July, and August, 1936.

Cleidodiscus diversus sp. nov.

Figs. 141-147

Host and Localities: Green Sunfish (*Apomotis cyanellus*), Embarrass River, Urbana, Ill.; Boomer Creek, Stillwater, Okla.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9139.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.340 mm. (0.205-0.394 mm.), greatest body width (near peduncle) average 0.061 mm. (0.052-0.085 mm.). Haptor distinct, hexagonal and broadly connected to peduncle. Ventral bar variable in shape, heavier and slightly longer than dorsal bar which is bent in middle to present a sagged appearance. Average length of ventral bar 0.029 mm. (0.025-0.034 mm.), average length of dorsal bar 0.021 mm. (0.019-0.023 mm.). Anchors similar in size and shape, bases bifurcate; wings on anchor shafts clearly discernible. Anchor points and shafts unite to form an internal angle at locus of junction. Average length of ventral anchors 0.025 mm. (0.021-0.032 mm.), average length of dorsal anchors 0.025 mm. (0.022-0.029 mm.). Each of the fourteen hooks is differentiated into a base, shaft, sickle-shaped termination, and opposable piece. Hook lengths 0.013-0.019 mm. Hook bases elongate-ovate and about same length as shafts. The arrangement of the hooks is characteristic of North American fresh-water Tetraonchinae possessing fourteen haptor hooks (see pages 9, 15, and 62). The anterior eye spots are smaller and generally farther apart than members of the posterior pair.

Reproductive system.—Gonads located anteriorly in posterior half of body; vas deferens arises from anterior end of testis, passes forward as a slightly undulant tube. Copulatory complex well developed and situated in a relatively large vestibule. Cirrus a short chitinous tube with a large base and tapered shaft, length 0.034 mm. (0.027-0.043 mm.). Accessory piece a doubly recurved chitinous structure with a knob near the midportion and with a forked termination. Operation of cirrus not observed.

Ovary ovate; egg pore located on ventral surface near vestibular pore. Vagina present on left margin near the middle of the body. The vitellaria and vitelline ducts are as described in the general morphology for the North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—The digestive and excretory systems exist as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.021 mm. (0.017-0.027 mm.)

Systematic position.—*Cleidodiscus diversus* occurs in mixed infestations with *Cleidodiscus robustus* Mueller, 1934, *Onchocleidus cyanellus* n. sp., *Actinocleidus longus* n. sp., and an undescribed member of the genus *Actinocleidus* Mueller, 1937. *C. diversus* possesses anchors similar to those of *Cleidodiscus bedardi* Mizelle, 1936, and a copulatory complex like that of *Actinocleidus fergusonii*, n. sp. The former species occurs on

the long-eared sunfish, the latter on the bluegill, and *C. diversus* on the green sunfish. One hundred per cent infestation with this parasite is recorded for twenty-six green sunfish from the Embarrass River in May, 1937.

Genus *Onchocleidus* Mueller, 1936

Diagnosis.—Tetraonchinae with intestine bifurcate but confluent posteriorly. Vagina present or absent; when present it lies on the right body margin near the midlength. Copulatory complex weakly developed, cirrus a slender chitinous tube, at times with a fin or cirral thread around the shaft, at times corkscrew-like in nature. Accessory piece may be wanting but when present its base is not articulated with the cirrus base. Haptor generally distinct, hexagonal or pentagonal in shape. Fourteen hooks present, each of which may be solid and differentiated into a base, shaft, sickle-shaped termination and opposable piece, but generally exists as a solid or hollow cylindrical structure with a sickle-shaped termination and opposable piece distally. Parasitic on the gills of fresh-water fishes. Type species, *O. ferox* (Mueller, 1934).

Onchocleidus principalis Mizelle, 1936

Figs. 3, 76-84

Hosts and Localities: Kentucky Bass (*Micropterus pseudaplites*) and Small-Mouth Bass (*Micropterus dolomieu*), Salt Fork of the Big Vermilion River, Homer, Ill. Large-Mouth Bass (*Aplites salmoides*), Lake Senachwine, Henry, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9085.

Synonym: *Onchocleidus contortus* Mueller, 1937.

General anatomy.—Relatively small parasites devoid of body scales and internal spicules. Average length 0.467 mm. (0.369-0.631 mm.), average width at level of cephalic lobes 0.079 mm. (0.066-0.108 mm.), greatest body width average 0.096 mm. (0.070-0.127 mm.), average width of peduncle at junction with haptor 0.057 mm. (0.028-0.070 mm.). Haptor distinct, hexagonal in shape and broader than long, average width 0.098 mm. (0.078-0.125 mm.), average length 0.066 mm. (0.051-0.082 mm.). Ventral bar relatively straight and heavier than dorsal bar. Dorsal bar with midportion noticeably curved posteriorly, slightly shorter than ventral bar and with a notch on posterior margin near each end. Average length of ventral bar 0.036 mm. (0.032-0.042 mm.), average length of dorsal bar 0.035 mm. (0.030-0.044 mm.). Anchors similar in shape, wings slightly visible. Shaft and point of each anchor solid and relatively regularly recurved without formation of a distinct internal angle at their junction. Ventral anchors slightly longer than dorsal anchors. Average length of ventral anchors 0.033 mm. (0.028-0.038 mm.), average width 0.018 mm. (0.015-0.021 mm.), average length of dorsal anchors 0.031

mm. (0.027-0.034 mm.), average width 0.015 mm. (0.013-0.017 mm.). Bases of ventral anchors larger but not conspicuously wider than bases of the dorsal anchors. Each of the fourteen hooks differentiated into a base, shaft, sickle-shaped termination and opposable piece. Hook bases elongate, bases of pair number one about same length as their shafts, bases of pair number five shorter than their shafts, bases of remaining hooks slightly longer than their shafts. Hooks of pairs numbers one and five shorter than other hooks. The arrangement of the hooks is as described in the general morphology of the North American fresh-water *Tetraonchinae* possessing fourteen haptor hooks (see pages 9, 15, and 62).

<i>Hook pair</i>	<i>Average length in mm.</i>	<i>Range in mm</i>
1	0.017	0.013-0.019
2	0.020	0.019-0.023
3	0.020	0.019-0.023
4	0.021	0.019-0.024
5	0.015	0.013-0.019
6	0.020	0.019-0.025
7	0.021	0.019-0.025

Anterior eye spots smaller and about the same distance apart as members of the posterior pair. In life, a refractile area is present immediately in front of each anterior eye spot.

Reproductive system.—Gonads located in posterior body half, testis ovate and situated dorsal to ovary. Vas deferens passes forward on left side of body and expands into a relatively large fusiform seminal vesicle just posterior to cirrus base. Two prostate glands present, larger one tubular and filled with a finely granular hyaline fluid, smaller gland an elongate bulb-like structure containing a coarsely granular yellowish fluid. Each prostate empties into base of cirrus by a single individual duct. Copulatory complex weakly developed and situated in a relatively small vestibule. Cirrus a chitinous corkscrew-like tube emptying ventrally through the vestibular pore. Accessory piece a solid chitinous structure about three-fifths the length of cirrus and with a forked termination which is often complete to form a ring through which the cirrus passes. Operation of cirrus not observed.

Ovary ovate and about two to three times as large as the testis. Egg pore located on the ventral surface at right of cirrus base. Vagina present on right margin about midway the body length; vaginal canal an undulant, lightly chitinized tube, often with one or two loose coils; seminal receptacle conspicuous. The vitellaria and vitelline ducts are as described in the general morphology of the North American fresh-water *Tetraonchinae*.

Digestive and excretory systems.—The digestive system agrees with

the description given for the North American fresh-water Tetraonchinae. Average diameter of the pharynx 0.029 mm. (0.025-0.034 mm.). Excretory system as described for the North American fresh-water Tetraonchinae, but an additional pair of ducts occur at level of seminal receptacle. One of these ducts is present on each side of the body and passes toward the lateral body margins. Openings for these structures have not been observed. Two very large solenocytes are present, one is located at the level of the ovary and the other near the posterior end of the seminal vesicle.

Systematic position.—This parasite is singular in that each of the fourteen hooks is differentiated into a base, shaft, sickle-shaped termination and opposable piece. While this character is common to the genus *Cleidodiscus* Mueller, 1934, the possession of other characters as vagina on right margin, and accessory piece not articulated to the cirrus base definitely places it in the genus *Onchocleidus* Mueller, 1936. The bars, anchors, vaginal tube, and hooks are distinctive.

Mueller (1937) described this parasite as *Onchocleidus contortus* from the large-mouth bass in Florida. The distal portion of the accessory piece of *O. principalis* was originally described (Mizelle, 1936) as forming a ring through which the cirrus projected. Mueller (1937) distinguished *O. contortus* from *O. principalis* by the forked termination of the accessory piece. This structural variation of the accessory piece was earlier recognized by the present author. Specimens of these two species have been compared and found to be identical. Hosts, for this species, have been found one hundred per cent infested.

Onchocleidus interruptus Mizelle, 1936

Figs. 2, 103-108

Host and Localities: Yellow Bass (*Morone interrupta*), Lake Decatur, Decatur, Ill.; Lake Senachwine, Henry, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9088.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.407 mm. (0.285-0.508 mm.), average width at level of cephalic lobes 0.073 mm. (0.067-0.080 mm.), greatest body width average 0.085 mm. (0.066-0.104 mm.), average width of peduncle at junction with haptor 0.057 mm. (0.046-0.070 mm.). Haptor distinct, hexagonal in shape and broader than long, average width 0.097 mm. (0.086-0.133 mm.), average length 0.078 mm. (0.066-0.095 mm.). Ventral bar slightly longer than dorsal bar and with a cavity in its posterior midportion. Both bars slightly bent in the middle. Average length of ventral bar 0.033 mm. (0.029-0.044 mm.), average length of

dorsal bar 0.030 mm. (0.027-0.036 mm.). Anchors similar in shape, bases bifurcate superficial roots longer than deep roots. Anchor wings clearly perceptible. Each anchor shaft solid and uniting with its point to form an internal angle at junction. Ventral anchors longer than dorsal anchors. Average length of ventral anchors 0.045 mm. (0.040-0.052 mm.), average width 0.024 mm. (0.019-0.032 mm.), average length of dorsal anchors 0.040 mm. (0.036-0.050 mm.), average width 0.014 mm. (0.013-0.021 mm.). Bases of ventral anchors noticeably wider than bases of dorsal anchors. Each hook, except pair number five, consists of an elongate chitinous body with an opposable piece and sickle-shaped termination. Each hook of pair number five is differentiated into a base, shaft, sickle-shaped termination, and opposable piece. Hooks of pair number one longer, and hooks of pair number five conspicuously shorter than rest of hooks. The arrangement of hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62).

<i>Hook pair</i>	<i>Average length in mm.</i>	<i>Range in mm.</i>
1	0.032	0.028-0.040
2	0.024	0.021-0.025
3	0.024	0.021-0.027
4	0.023	0.019-0.032
5	0.013	0.011-0.015
6	0.026	0.021-0.032
7	0.029	0.027-0.034

The spatial relationships between members of the two pairs of eye spots variable, anterior pair smaller.

Reproductive system.—Gonads situated anteriorly in the posterior body half, testis ovate, from four to six times as large as ovary and located posterior to it. Vas deferens dilated immediately posterior to cirrus base to form a conspicuous seminal vesicle. Two prostate glands present, large one saccate, filled with a finely granular, colorless fluid, smaller one botuliform and containing a coarsely granular yellowish fluid. Copulatory complex weakly developed and enclosed within a slender vestibule. Cirrus a short, straight, chitinous tube attenuated distally, expanded terminally, and with a cirral thread around the shaft. Accessory piece solid, with a key-hole effect distally through which one of the loops of the cirral thread passes. Operation of copulatory complex not fully understood.

Ovary subspherical, much smaller than testis and situated anterior to it. Egg pore on ventral surface on right of copulatory complex. Vagina and seminal receptacle wanting in this species. Vitellaria and vitelline ducts are as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—The digestive and excretory systems are as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.028 mm. (0.023-0.032 mm.).

Systematic position.—This parasite has been collected only from the gills of the yellow bass. It is the only monogenetic form recorded from this host. *Onchocleidus interruptus* is easily recognized by the massive testis and the characteristic bars and anchors. The shafts of the ventral anchors are noticeably bent in the direction of the points. The copulatory complex resembles that of *Onchocleidus distinctus* Mizelle, 1936, a form which occurs on the long-eared sunfish. Sixty-five hosts from Lake Decatur in May, June, July, and August, 1936, and eight hosts from Lake Senachwine in June, 1936, were infested one hundred per cent with *O. interruptus*.

Onchocleidus mucronatus Mizelle, 1936

Figs. 9, 22-30

Hosts and Localities: Bluegill Sunfish (*Helioperca macrochira*), Orange-spotted Sunfish (*Allois humilis*), Pumpkinseed Sunfish (*Eupomotis gibbosus*), Hybrid between Bluegill and Pumpkinseed Sunfishes and Hybrid between Orange-spotted and Pumpkinseed Sunfishes, Lake Senachwine, Henry, Ill.—Bluegill Sunfish, Lake Decatur, Decatur, Ill.; Boomer Creek, Stillwater, Okla.—Orange-spotted Sunfish, Salt Fork of the Big Vermilion River, Homer, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9087.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.503 mm. (0.426-0.820 mm.), average width at level of cephalic lobes 0.051 mm. (0.041-0.098 mm.), greatest body width average 0.065 mm. (0.051-0.131 mm.), average width of peduncle at junction with haptor 0.042 mm. (0.019-0.075 mm.). Haptor distinct, hexagonal or pentagonal in shape and broader than long, average width 0.101 mm. (0.070-0.148 mm.), average length 0.098 mm. (0.076-0.139 mm.). Each bar possesses a spine projecting from middle of posterior margin. Average length of ventral bar 0.022 mm. (0.019-0.024 mm.), average length of dorsal bar 0.024 mm. (0.021-0.025 mm.). Wings on anchor shafts delicate. Anchors similar in shape, bases slightly bifurcate, superficial roots longer than deep roots. Anchor shafts solid and unite with anchor points to form an internal angle at junction. Anchors approximately same size. Average length of ventral anchors 0.057 mm. (0.051-0.067 mm.), average width 0.014 mm. (0.009-0.019 mm.), average length of dorsal anchors 0.057 mm. (0.051-0.074 mm.), average width 0.012 mm. (0.009-0.019 mm.). Each hook, except pair number five, has an elongate chitinous body, a sickle-shaped termination, and opposable piece. Each hook of pair number five possesses a base,

shaft, sickle-shaped termination and opposable piece. Hooks of pairs numbers one and seven with apparent cavity, members of pair number two often with slight cavity. Hooks of pair number one noticeably longer and hooks of pair number five conspicuously shorter than other hooks. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm.
1	0.035	0.030-0.043
2	0.026	0.023-0.032
3	0.030	0.025-0.037
4	0.032	0.028-0.038
5	0.013	0.010-0.015
6	0.033	0.028-0.038
7	0.031	0.028-0.044

Anterior eye spots smaller and usually farther apart than members of the posterior pair.

Reproductive system.—Gonads located in posterior half of body, testis subspherical, located posterior to, and from two to three times as large as ovary. Vas deferens passes forward generally making one loop in front of vaginal canal and dilates posterior to cirrus base to form an elongate seminal vesicle. Two prostate glands present, larger one banana-shaped, containing a finely granular colorless fluid, smaller one saccate and filled with a coarsely granular yellowish fluid. Each prostate gland empties into cirrus base by a single individual duct. Copulatory complex weakly developed and enclosed within a slender vestibule. Cirrus a chitinous tube with a cirral thread around the shaft. Accessory piece a solid chitinous structure with a key-hole effect distally through which the cirrus projects. Muscular elements arise on accessory piece and insert on base of cirrus; on contraction of these elements the accessory piece remains *in situ*, and the cirrus is projected ventrally, through the vestibular pore, a short distance beyond the body surface. Retraction of cirrus not fully understood.

Ovary subspherical, about one-third to one-half the size of testis and situated anterior to it. Egg pore on ventral surface near vestibular pore. Vagina on right body margin near midlength; vaginal canal a short zigzag, chitinous tube emptying into a small bag-like seminal receptacle. Vitellaria and vitelline ducts as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland a cluster of cells surrounding the ootype.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American fresh-water

Tetraonchinae. Average diameter of pharynx 0.027 mm. (0.024-0.039 mm.).

Systematic position.—This species occurs in mixed infestations with *Cleidodiscus robustus* Mueller, 1934, *Haplocleidus dispar* (Mueller, 1936), *Pterocleidus acer* (Mueller, 1936) and *Actinocleidus fergusonii* n. sp. on the bluegill sunfish. Superficially the copulatory complex is similar to that of *H. dispar*. Each bar of *O. mucronatus* possesses a spine on the posterior middle region, a condition seldom found in the genus. Specimens of *O. mucronatus* from Lake Senachwine were almost twice the size of those from the same host, viz., the bluegill sunfish, from Lake Decatur. One hundred per cent infestation with this parasite is recorded for: nineteen bluegills from Lake Chautauqua, Havana, Ill., in May, 1936; five hybrids between the bluegill and pumpkinseed sunfishes from Lake Senachwine, Henry, Ill., in June, 1936; six hybrids between the orange-spotted and pumpkinseed sunfishes from Lake Senachwine, Henry, Ill., in June, 1936; four orange-spotted sunfish from the Salt Fork of the Big Vermilion River, Homer, Ill., in April, 1936; and one bluegill sunfish from the Illinois State Natural History Survey pond, Urbana, Ill., in July, 1936. Twelve bluegills from Lake Senachwine in June, 1936, were infested seventy-five per cent.

Onchocleidus distinctus Mizelle, 1936

Figs. 8, 109-117

Host and Locality: Long-eared Sunfish (*Xenotis megalotis*), Embarrass River, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9086.

General anatomy.—Relatively small parasites devoid of body scales and internal spicules. Average length 0.476 mm. (0.344-0.590 mm.), average width at level of cephalic lobes 0.065 mm. (0.048-0.072 mm.), greatest body width average 0.070 mm. (0.050-0.095 mm.), average width of peduncle at junction with haptor 0.046 mm. (0.032-0.057 mm.). Haptor distinct, hexagonal or pentagonal in shape and broader than long, average width 0.078 mm. (0.064-0.110 mm.), average length 0.070 mm. (0.057-0.086 mm.). Ventral bar slightly shorter than dorsal bar. Average length of ventral bar 0.024 mm. (0.021-0.027 mm.), average length of dorsal bar 0.026 mm. (0.023-0.029 mm.). Anchors similar in shape, bases slightly bifurcate, superficial roots longer than deep roots. Anchor wings weakly developed. Distal portion of each anchor shaft slightly dilated and hollow. Internal angle at junction of each anchor shaft and point. Ventral anchors slightly longer than dorsal anchors. Average length of ventral anchors 0.035 mm. (0.032-0.038 mm.), average width

0.016 mm. (0.013-0.019 mm.), average length of dorsal anchors, 0.034 mm. (0.030-0.036 mm.), average width 0.013 mm. (0.011-0.015 mm.). Bases of ventral anchors not conspicuously wider than bases of the dorsal anchors. Each of the fourteen hooks consists of an elongate cylindrical body with a sickle-shaped termination and opposable piece distally. Body of each hook of pair number five, which lies between the shafts of ventral anchors, shows a tendency toward differentiation into a base and shaft. Hooks of pairs numbers one, six, and seven possess hollow bodies, hooks of pair number two often have slightly hollow bodies, rest of hook bodies solid. Hooks of pair number one larger and hooks of pair number five conspicuously smaller than rest of hooks. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm.
1	0.032	0.027-0.036
2	0.026	0.023-0.030
3	0.026	0.023-0.029
4	0.028	0.023-0.030
5	0.010	0.009-0.012
6	0.029	0.025-0.032
7	0.030	0.027-0.034

Anterior eye spots smaller and almost invariably farther apart than members of posterior pair.

Reproductive system.—Gonads located anteriorly in the posterior body half, testis ovate, smaller than ovary and situated posterior to it. The vas deferens arises from anterior end of testis, passes forward on left side of body and expands into a fusiform seminal vesicle near cirrus base. Two prostate glands present, each tubular in shape, smaller one about three-fourths the size of larger, and filled with a finely granular colorless fluid, larger one containing a coarsely granular yellowish fluid. Copulatory complex weakly developed and situated in a relatively small vestibule. Cirrus a small chitinous tube with a cirral thread around the shaft. Accessory piece a partial sleeve, open proximally and complete distally, and enclosing cirrus. Contractile elements arise on inner surface of accessory piece and insert on base of cirrus. On contraction of these structures the accessory piece remains *in situ*, and the cirrus is projected ventrally through the vestibular pore, for a short distance beyond the body surface. Retraction of the cirrus not understood.

Ovary ovate, larger than testis and situated anterior to it. Egg pore on ventral surface near vestibular pore. Vagina on right margin near termination of first body half; vaginal canal a chitinized tube emptying

mesially into a small seminal receptacle. Vitellaria and vitelline ducts are as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—The digestive system is as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.023 mm. (0.019-0.028 mm.). The excretory system is common to the North American fresh-water Tetraonchinae. Two especially large solenocytes are present immediately anterior to the level of the ovary; a third flame cell is present in the region of the seminal receptacle.

Systematic position.—This parasite occurs in mixed infestations with *Cleidodiscus bedardi* Mizelle, 1936, *Actinocleidus articularis* (Mizelle, 1936), *Pterocleidus acuminatus* (Mizelle, 1936), an undescribed species of the genus *Cleidodiscus* Mueller, 1934, and an undescribed species of *Haplocleidus* Mueller, 1937. It has been recovered only from the long-eared sunfish. The cirrus superficially resembles the cirrus of *Onchocleidus minus* Mueller, 1936. The accessory piece is wanting in *O. minus* but is present in *Onchocleidus distinctus*. The vaginal canal, bars, and slightly dilated and hollow anchors, are conspicuously different from any other described member of the genus. One hundred per cent infestation is recorded for one hundred twenty-five hosts taken from the Embarrass River during the months of April, May, June, July, and August, 1936.

Onchocleidus cyanellus sp. nov.

Figs. 135-140

Host and Locality: Green Sunfish (*Apomotis cyanellus*), Embarrass River, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9142.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.572 mm. (0.328-0.738 mm.), greatest body width average 0.096 mm. (0.067-0.114 mm.). Haptor distinct, hexagonal in shape and broader than long. Each bar possesses a spine projecting from middle of posterior margin. Average length of ventral bar 0.024 mm. (0.021-0.027 mm.), average length of dorsal bar 0.025 mm. (0.021-0.029 mm.). Wings on anchor shafts delicate. Anchors similar in shape, bases slightly bifurcate, superficial roots noticeably longer than deep roots. Anchor shafts solid and unite with anchor points to form an internal angle at junction. Anchors approximately same size. Average length of ventral anchors 0.052 mm. (0.048-0.057 mm.), average length of dorsal anchors 0.053 mm. (0.049-0.059). Each hook has an elongate chitinous body with a sickle-shaped termi-

nation and opposable piece distally. Hooks of pair number five show a tendency toward differentiation into a base, shaft, sickle-shaped termination and opposable piece. Length of hooks of pair number five 0.008-0.013 mm., length of rest of hooks 0.024-0.032 mm. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62). Anterior eye spots smaller and usually farther apart than members of the posterior pair.

Reproductive system.—Gonads located in posterior half of body; vas deferens passes forward as a slightly undulant tube. Copulatory complex weakly developed and enclosed within a slender vestibule. Cirrus a chitinous tube with a cirral thread around the shaft, length 0.035 mm. (0.032-0.040 mm.); accessory piece vestigial. Operation of cirrus not observed.

Ovary subspherical; egg pore on ventral surface near vestibular pore. Vagina on right body margin near midlength. Vitellaria and vitelline ducts as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—Digestive and excretory systems are as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.024 mm. (0.018-0.036 mm.).

Systematic position.—This species occurs in mixed infestations with *Cleidodiscus diversus* n. sp., *Cleidodiscus robustus* Mueller, 1934, *Actinocleidus longus* n. sp., and an undescribed member of the genus *Actinocleidus* Mueller, 1937. The anchors and bars resemble those of *Onchocleidus mucronatus* Mizelle, 1936. The copulatory complex is different from the foregoing species and the zigzag vaginal tube characteristic of *O. mucronatus* is wanting. One hundred per cent infestation is recorded for twenty-six green sunfish from the Embarrass River in May, 1937.

Genus *Actinocleidus* Mueller, 1937

Diagnosis.—Tetraonchinae with intestine bifurcate but confluent posteriorly. Vagina present on left body margin near the midlength. Copulatory complex consisting of a cirrus and accessory piece. Accessory piece well developed, always present, and articulated to the cirrus base. Haptor distinct, discoidal in shape, and has both pairs of anchors on the ventral surface. The bars connecting the anchor bases are articulated with each other in their midregions. Each of the fourteen hooks present is differentiated into a base, shaft, sickle-shaped termination and opposable piece. Parasitic on the gills of fresh-water fishes. Type species, *Actinocleidus oculatus* (Mueller, 1934).

Actinocleidus articularis (Mizelle, 1936)

Figs. 10, 40-48

Host and Locality: Long-eared Sunfish (*Xenotis megalotis*), Embarrass River, Urbana, Illinois.

Location: Gills.

Specimen: U.S.N.M. Helm. Coll. No. 9084.

General anatomy.—Relatively small gill parasites with internal spicules and surface scales wanting. Average length 0.470 mm. (0.360-0.615 mm.), average width at level of cephalic lobes 0.062 mm. (0.049-0.082 mm.), greatest body width average 0.068 mm. (0.049-0.079 mm.), average width of peduncle at junction with haptor 0.041 mm. (0.028-0.067 mm.). Haptor distinct, disc-like in shape and broader than long, average width 0.072 mm. (0.061-0.086 mm.), average length 0.055 mm. (0.047-0.057 mm.). Anterior bar noticeably bent posteriorly in mid-portion with a notch present near each end on posterior margin. Posterior bar modified to form a plate-like structure, anterior end of which articulates with posterior surface of anterior bar. Average length of anterior bar 0.037 mm. (0.032-0.042 mm.), average length of posterior bar 0.022 mm. (0.019-0.025 mm.). Anchors similar in shape and size, bases nonbifurcate, deep roots vestigial. Anchor wings moderately developed. Anchor shafts solid and regularly recurved without formation of an angle at junction with hollow points. Average length of anterior anchors 0.033 mm. (0.032-0.038 mm.), average width 0.010 mm. (0.009-0.013 mm.), average length of posterior anchors 0.032 mm. (0.028-0.038 mm.), average width 0.010 mm. (0.008-0.011 mm.). Bases of hooks subspherical in shape and very short as compared with shafts. Hooks of pair number one slightly shorter than rest of hooks. Arrangement of the hooks is as described in the general morphology of the North American fresh-water Tetraonchinae with fourteen haptor hooks (See pages 9, 15, and 62).

Hook pair	Average length in mm.	Range in mm.
1	0.011	0.009-0.015
2	0.014	0.013-0.015
3	0.015	0.013-0.019
4	0.015	0.013-0.017
5	0.014	0.013-0.015
6	0.015	0.013-0.019
7	0.014	0.013-0.015

Anterior eye spots smaller and usually farther apart than members of the posterior pair.

Reproductive system.—Gonads situated in posterior half of body, testis ovate, about same size as ovary and located dorsoposterior to it.

Vas deferens arises from anterior end of testis and passes forward as an undulant tube and dilates slightly to form a tubular seminal vesicle near cirrus base. Two prostate glands present, smaller one somewhat bulbular in shape and filled with a finely granular colorless fluid, larger one bulbular in shape and containing a coarsely granular yellowish fluid. Copulatory complex well developed and situated in a moderate-sized vestibule. Cirrus a chitinous tube with a large base and a doubly recurved shaft which ends in a forked termination. Accessory piece a chitinous structure of an aviform shape. Operation of copulatory complex not observed.

Ovary ovate in outline, about same size as testis and located antero-ventrally to it. Egg pore located on ventral surface on right of copulatory complex. Vagina present on left margin near midlength of body; vaginal canal a short chitinous tube emptying into a transparent seminal receptacle which lies at anterior end of ovary. Vitellaria and vitelline ducts as described in the general morphology of North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.025 mm. (0.021-0.028 mm.).

Systematic position.—This species, from Illinois localities, occurs in mixed infestations with *Onchocleidus distinctus* Mizelle, 1936, *Cleidodiscus bedardi* Mizelle, 1936, *Pterocleidus acuminatus* (Mizelle, 1936), an undescribed species of *Cleidodiscus* Mueller, 1934, and an undescribed species of the genus *Haploleidus* Mueller, 1937. *Actinocleidus oculatus* (Mueller, 1934), structurally stands closer to this species than does any other member of the genus. *Actinocleidus articularis* is readily distinguishable from *A. oculatus* by the presence of hollow anchor points, a doubly recurved cirrus, and an aviform accessory piece. The former species has been taken only from the long-eared sunfish, whereas the latter is common only to the pumpkinseed sunfish (*Eupomotis gibbosus*). One hundred twenty-five long-eared sunfish taken from the Embarrass River south of Urbana, Ill., in the months of April, May, June, July, and August, 1936, were infested one hundred per cent with this parasite.

Actinocleidus longus sp. nov.

Figs. 166-172

Host and Localities: Green Sunfish (*Apomotis cyanellus*), Embarrass River, Urbana, Ill.; Boomer Creek, Stillwater, Okla.

Location: Gills.

Specimen: U.S.N.M. Helm. Coll. No. 9140.

General anatomy.—Relatively small gill parasites with internal spicules and surface scales wanting. Average length 0.444 mm. (0.336-0.573 mm.), greatest body width average 0.069 mm. (0.055-0.095 mm.). Haptor distinct, disc-like in shape and broader than long. Anterior bar noticeably bent posteriorly in midportion, and articulated with central portion of posterior bar. Average length of anterior bar 0.044 mm. (0.036-0.049 mm.), average length of posterior bar 0.031 mm. (0.027-0.040 mm.). Anchors similar in shape and size, bases nonbifurcate, deep roots vestigial. Anchor wings well developed. Anchor shafts hollow and regularly recurved without formation of an angle at junction with hollow points. Average length of anterior anchors 0.036 mm. (0.034-0.038 mm.), average length of posterior anchors 0.037 mm. (0.032-0.042 mm.). Bases of hooks subspherical in shape and very short as compared with shafts, hook lengths 0.013-0.017 mm. Arrangement of the hooks is as described in the general morphology of the North American fresh-water Tetraonchinae with fourteen haptor hooks (see pages 9, 15, and 62). Anterior eye spots smaller and usually farther apart than members of the posterior pair.

Reproductive system.—Gonads situated in posterior half of body; vas deferens arises from anterior end of testis and passes forward as an undulant tube. Copulatory complex well developed and situated in a moderate-sized vestibule. Cirrus a chitinous tube with a moderately large base, and attenuated to form a hair-like tube in the middle, but moderately enlarged distally. Accessory piece whip-like and much shorter than the cirrus. Operation of copulatory complex not observed.

Ovary ovate in outline; egg pore located on ventral surface near vestibular pore. Vagina present on left margin near midlength of body. Vitellaria and vitelline ducts as described in the general morphology of North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.026 mm. (0.021-0.029 mm.).

Systematic position.—This species occurs in mixed infestations with *Cleidodiscus diversus* n. sp., *Cleidodiscus robustus* Mueller, 1934, *Onchocleidus cyanellus* n. sp., and an undescribed species of *Actinocleidus* Mueller, 1937. This species has been collected only from the green sunfish. It possesses a copulatory complex somewhat similar to that of *Cleidodiscus longus* Mizelle, 1936, from the white crappie, and anchors, hooks, and bars resembling those of *Actinocleidus articularis* (Mizelle, 1936). One hundred per cent infestation with this parasite is recorded for twenty-six green sunfish from the Embarrass River in May, 1937.

Actinocleidus fergusonii sp. nov.

Figs. 148-153

Host and Localities: Bluegill Sunfish (*Helioperca macrochira*), Lake Senachwine, Henry, Ill.; Boomer Creek, Stillwater, Okla.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9141.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.379 mm. (0.330-0.444 mm.), greatest body width average 0.056 mm. (0.045-0.083 mm.). Haptor distinct, subdiscoidal in shape and broader than long. Anterior bar bent posteriorly in the middle; posterior bar modified to articulate with anterior bar. Average length of anterior bar 0.029 mm. (0.025-0.033 mm.), average length of posterior bar 0.019 mm. (0.012-0.025 mm.). Anchors similar in shape, nonbifurcate, superficial roots elongate, deep roots vestigial. Anchor shafts hollow and regularly recurved without formation of angle at junction with hollow points. Anchors similar in size and shape. Average length of anterior anchors 0.025 mm. (0.023-0.027 mm.), average length of posterior anchors 0.023 mm. (0.021-0.025 mm.). Hooks not conspicuously different in length. Hook lengths 0.009-0.015 mm. Hook bases subspherical and much shorter than hook shafts. The arrangement of hooks as described in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptor hooks (see pages 9, 15, and 62). Anterior eye spots smaller and generally farther apart than members of the posterior pair.

Reproductive system.—Gonads located in posterior body half, testis ovate, situated dorsoposterior to and about same size as ovary. Vas deferens passes forward as a slightly undulant tube. Copulatory complex well developed and situated in a moderately large vestibule. Cirrus a simple curved chitinous tube with large base, and tapered distally to a fine point, average length 0.023 mm. (0.021-0.028 mm.). Accessory piece with two curves and with a knob near the middle. Operation of cirrus not observed.

Ovary subspherical, and situated anteroventrally to testis. Egg pore on ventral surface on right of copulatory complex. Vagina present on left margin near midlength of body. Vitellaria and vitelline ducts exist as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—The digestive and excretory systems are as described in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.017 mm. (0.012-0.025 mm.).

Systematic position.—This parasite, from Illinois localities, occurs in

mixed infestations with *Cleidodiscus robustus* Mueller, 1934, *Onchocleidus mucronatus* Mizelle, 1936, *Pterocleidus acer* (Mueller, 1936) and *Haplocleidus dispar* (Mueller, 1936). This species is closely related to *Actinocleidus gracilis* Mueller, 1937. The cirrus of *Actinocleidus fergusonii* is sickle-shaped whereas the cirrus of *A. gracilis* is an undulant tube. Only slight infestation of the bluegill sunfish is recorded for this parasite.

Genus *Pterocleidus* Mueller, 1937

Diagnosis.—Tetraonchinae with intestine bifurcate but confluent posteriorly. The vagina, when present, is located on the right body margin near the midlength. Copulatory complex consisting of a cirrus, cirral thread, and accessory piece or a cirrus and cirral fin. The accessory piece, when present is never articulated with the cirrus base. Haptor distinct, pentagonal or hexagonal in shape. Each anchor shaft possesses a spur-like projection near the origin of the anchor point. The bars connecting the anchor bases are not articulated with each other. Each haptor hook generally consists of a solid or hollow shaft terminating distally in a sickle-shaped structure and opposable piece. Parasitic on the gills of fresh-water fishes. Type species *Pterocleidus acer* (Mueller, 1936).

Pterocleidus acuminatus (Mizelle, 1936)

Figs. 11, 94-102

Host and Locality: Long-Eared Sunfish (*Xenotis megalotis*), Embarrass River, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9089.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.495 mm. (0.338-0.640 mm.), average width at level of cephalic lobes 0.066 mm. (0.052-0.095 mm.), greatest body width average 0.093 mm. (0.066-0.118 mm.), average width of peduncle at junction with haptor 0.053 mm. (0.038-0.068 mm.). Haptor distinct, hexagonal or pentagonal in shape and slightly broader than long, average width 0.078 mm. (0.064-0.104 mm.), average length 0.077 mm. (0.068-0.098 mm.). Ventral bar smaller than dorsal bar, both bars with a gentle posterior slope in the midregions. Average length of ventral bar 0.025 mm. (0.019-0.027 mm.), average length of dorsal bar 0.026 mm. (0.022-0.029 mm.). Anchors similar in size and shape, bases slightly bifurcate, superficial roots longer than deep roots. Anchor shafts solid, junction with points forms an internal angle. Spurs on anchor shafts well developed. Anchor wings clearly discernible. Average length of ventral anchors 0.047 mm. (0.040-0.051 mm.), average width 0.014 mm. (0.011-0.017 mm.), average length of dorsal anchors 0.048 mm.

(0.040-0.053 mm.), average width 0.013 mm. (0.010-0.017 mm.). Each hook consists of an elongate, solid chitinous body with a sickle-shaped termination and opposable piece distally. Hooks of pairs numbers one, six, and seven larger and pair number five noticeably smaller than rest of hooks. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62).

<i>Hook pair</i>	<i>Average length in mm.</i>	<i>Range in mm.</i>
1	0.026	0.021-0.029
2	0.020	0.015-0.023
3	0.022	0.015-0.025
4	0.025	0.019-0.029
5	0.012	0.009-0.015
6	0.026	0.020-0.029
7	0.027	0.023-0.029

Anterior eye spots smaller and almost invariably farther apart than members of the posterior pair.

Reproductive system.—Gonads located anteriorly in posterior body half, testis ovate, posterior to, and about same size as ovary. Vas deferens passes forward on left side of body and dilates to produce a spindle-shaped seminal vesicle immediately posterior to cirrus base. Two prostate glands present, banana-shaped, and about of equal size. One of the prostate glands contains a finely granular colorless hyaline fluid, the other contains a coarsely granular yellowish fluid. Each prostate gland empties into cirrus base by a single individual duct. Copulatory complex weakly developed and enclosed within a slender vestibule. Cirrus a cork-screw-like chitinous tube with a moderate-sized base. Accessory piece a ploughshare-shaped structure lying along side of cirrus proximally and complete distally to form a ring through which the cirrus passes. Operation of cirrus not observed.

Ovary ovate, about size of testis and situated anterior to it. Egg pore located on ventral surface near vestibular pore. Vagina present on right body margin near midlength; vaginal canal a chitinized tube often making one or two loops before emptying mesially into the seminal receptacle. Vitellaria and vitelline ducts as described in the general morphology of the North American fresh-water Tetraonchinae. Shell gland not observed.

Digestive and excretory systems.—The digestive and excretory systems exist as described for the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.026 mm. (0.019-0.030 mm.). Two large flame cells present, one at level of seminal receptacle, the other one at level of copulatory complex.

Systematic position.—This species occurs in mixed infestations with *Cleidodiscus bedardi* Mizelle, 1936, *Actinocleidus articularis* (Mizelle, 1936), *Onchocleidus distinctus* Mizelle, 1936, and an undescribed member of *Haplocleidus* Mueller, 1937, and undescribed member of *Cleidodiscus* Mueller, 1934. The cirrus of *Pterocleidus acuminatus* resembles that of *Onchocleidus principalis* Mizelle, 1936, but the anchors possess spur-like structures which are characteristic of the genus *Pterocleidus*. *P. acuminatus* has been collected only from the long-eared sunfish. The bars, anchors, vagina and vaginal tube of this species are distinctive in themselves. One hundred twenty-five hosts from the Embarrass River in April, May, June, July, and August, 1936, were infested one hundred per cent with this parasite.

Genus *Urocleidus* Mueller, 1934

Diagnosis.—Tetraonchinae with intestine bifurcate but confluent posteriorly. Vagina and seminal receptacle lacking. Copulatory complex weakly developed and consisting of an accessory piece and cirrus. Accessory piece not articulated to cirrus base. Haptor subdiscoidal, pentagonal, or hexagonal in shape. Each of the fourteen hooks present may be solid or hollow, with a sickle-shaped structure and opposable piece distally; or consist of a base, shaft, sickle-shaped structure, and opposable piece. Parasitic on the gills of fresh-water fishes. Type species *Urocleidus aculeatus* (Van Cleave and Mueller, 1932).

Urocleidus umbraensis sp. nov.

Figs. 159-165

Host and Locality: Top Minnow (*Fundulus notatus*), Embarrass River, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9146.

General anatomy.—Relatively small parasites devoid of surface scales and internal spicules. Average length 0.546 mm. (0.508-0.623 mm.), greatest body width average 0.123 mm. (0.090-0.140 mm.). Haptor distinct, subdiscoidal to hexagonal in shape and broadly connected to the short peduncle. Ventral bar variable in shape, length 0.025 mm. (0.023-0.027 mm.), average length of dorsal bar 0.023 mm. (0.021-0.026 mm.). Anchors similar in shape, bases slightly bifurcate, superficial roots longer than deep roots, wings clearly evident. Each anchor shaft with a small cavity proximally, regularly recurved without formation of angle at junction with points. Bases of ventral anchors wider than dorsal anchor bases. Average length of ventral anchors 0.023 mm. (0.021-0.025 mm.), average length of dorsal anchors 0.022 mm. (0.019-0.024 mm.). Each hook

consists of a slender shaft, sickle-shaped termination and opposable piece. Hook lengths 0.010-0.013 mm. The arrangement of the hooks is as described for the North American fresh-water Tetraonchinae possessing fourteen haptoral hooks (see pages 9, 15, and 62). Anterior eye spots smaller and farther apart than members of the posterior pair.

Reproductive system.—Gonads situated anteriorly in posterior body half; vas deferens passes forward as a slightly undulant tube. Copulatory complex weakly developed and situated in a small vestibule. Cirrus a curved chitinous tube, tapered distally, length 0.025 mm. (0.019-0.030 mm.). Accessory piece a chitinous structure of variable shape. Operation of copulatory complex not observed.

Egg pore on ventral surface anterior to base of copulatory complex. Vagina and seminal receptacle lacking. Vitellaria and vitelline ducts exist as described in the general morphology of the North American fresh-water Tetraonchinae. Nature of shell gland not determined.

Digestive and excretory systems.—The digestive and excretory systems are as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.032 mm. (0.029-0.038 mm.).

Systematic position.—This species has been collected only from the gills of *Fundulus notatus* and is the only monogenetic fluke recorded for this host. *Urocleidus umbraensis* multiplies readily on hosts confined in aquaria. Hosts from natural waters present a low infestation with this parasite.

Genus *Dactylogyrus* Diesing, 1850

Synonym: *Gyrodactylus* Monticelli, 1892, in part.

Diagnosis.—Dactylogyridae with intestine bifurcate but usually confluent posteriorly. Vagina present or absent. Copulatory complex well developed. Haptor moderately developed. One pair of anchors present with bases connected by one or two chitinous bars. Fourteen hooks present on haptor. Four eye spots of approximately the same size in head region. Parasitic on the gills of fishes. Type species, *Dactylogyrus auriculatus* (v. Nordmann, 1832) Diesing, 1850.

Dactylogyrus bychowskyi Mizelle, 1937

Figs. 118-122

Host and Localities: Blunt-Nosed Minnow (*Hyborhynchus notatus*), Embarrass River and Drainage Ditch, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9143.

General anatomy.—Relatively small gill trematodes of a somewhat

fusiform nature. Average length 0.381 mm. (0.285-0.615 mm.), average width at level of cephalic lobes 0.057 mm. (0.040-0.086 mm.), greatest body width average 0.079 mm. (0.049-0.108 mm.), average width of peduncle at junction with haptor 0.044 mm. (0.030-0.067 mm.). Haptor distinct, knob-like, at times assuming a subpentagonal shape and broader than long; average width 0.072 mm. (0.050-0.095 mm.), average length 0.059 mm. (0.048-0.068 mm.). The single pair of anchors is located dorsally with their superficial bases connected by a solid chitinous bar. Bases of anchors bifurcate, superficial root noticeably longer than deep root. Anchor shafts (solid in fresh preparations, small cavity in permanent mounts) make junction with points to form a distinct internal angle. Wings on anchor shafts clearly visible. Average length of anchors 0.048 mm. (0.038-0.057 mm.), average width of anchor bases 0.020 mm. (0.015-0.028 mm.). A ventral bar or "ventrales Chitinstuck" or "Chitin-klammer" of German workers, has not been observed in this species. Average length of dorsal bar 0.021 mm. (0.017-0.025 mm.). Each of the fourteen hooks present is differentiated into a base, shaft, sickle-shaped termination and opposable piece. Hook bases ovate and very short as compared with length of shafts. Hooks of pairs numbers one and five slightly shorter than rest of hooks. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptoral hooks (see pages 9, 15, and 62).

<i>Hook pair</i>	<i>Average length in mm.</i>	<i>Range in mm.</i>
1	0.015	0.013-0.017
2	0.017	0.015-0.019
3	0.017	0.015-0.019
4	0.018	0.015-0.021
5	0.014	0.011-0.017
6	0.017	0.013-0.021
7	0.017	0.015-0.019

Eye spots four in number, approximately equal in size and with members of each pair about the same distance apart.

Reproductive system.—Gonads located near middle of body, testis ovate, situated dorsoposterior to and smaller than ovary. Vas deferens passes forward near the median line of the body as a slightly undulant tube. Seminal vesicle lies near the copulatory complex base and consists of an elongate dilatation of the vas deferens. Two prostate glands present near copulatory complex base, one bulbular in shape, the other botuliform, each emptying into cirrus base by a single individual duct. Copulatory complex well developed and situated in a relatively large vestibule. Cirrus an elongate hollow chitinous tube tapering to a point distally and with a digitiform projection arising from the base. Average length of cirrus

0.044 mm. (0.038-0.051.). Accessory piece a solid chitinous blade-like structure with a knob present about half-way its length. Proximal portion of accessory piece articulated with base of cirrus.

Ovary ovate, larger than testis and with spatial relationships as given above. Egg pore located on ventral surface in the region of the copulatory complex. Vagina present on right body margin in posterior portion of anterior body half. Vaginal tube chitinous and connected with a small clear ovate seminal receptacle. Vitellaria and vitelline ducts as given in the general morphology of the North American fresh-water Tetraonchinae.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.038 mm. (0.029-0.048 mm.).

Systematic position.—*Dactylogyrus bychowskyi* possesses a copulatory apparatus similar to that of *Dactylogyrus amphibothrium* Wagener, 1857, but is different from the latter species in the possession of a digitiform process on the cirrus base. The anchors, hooks, and bars of the two species differ in shape and size relationships. *D. amphibothrium* is found on *Acerina cernua* whereas *D. bychowskyi* occurs on *Hyborhynchus notatus*.

Dactylogyrus bifurcatus Mizelle, 1937

Figs. 123-128

Host and Localities: Blunt-Nosed Minnow (*Hyborhynchus notatus*), Embarrass River and Drainage Ditch, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9144.

General anatomy.—Relatively small gill trematodes of a somewhat fusiform nature. Average length 0.343 mm. (0.254-0.492 mm.), average width at level of cephalic lobes 0.051 mm. (0.038-0.065 mm.), greatest body width average 0.070 mm. (0.049-0.095 mm.), average width of peduncle at junction with haptor 0.038 mm. (0.019-0.042 mm.). Haptor distinct, subdiscoidal in shape and broader than long, average width 0.062 mm. (0.049-0.087 mm.), average length 0.044 mm. (0.023-0.057 mm.). The single pair of anchors is located dorsally with their superficial bases connected by a solid chitinous bar. Bases of anchors bifurcate, superficial root longer than deep root. Anchor shafts (solid in fresh preparations, small cavity in permanent mounts) regularly recurved without formation of an angle at junction of shafts and anchors. Wings on anchor shafts clearly visible. Average length of anchors 0.033 mm. (0.028-0.034 mm.), average width of anchor bases 0.012 mm. (0.008-0.013 mm.). Ends of ventral bar slightly bent posteriorly with a short median projection on anterior border and about the same length as dorsal

bar. Average length of dorsal bar 0.017 mm. (0.015-0.023 mm.). Each of the fourteen hooks present is differentiated into a base, shaft, sickle-shaped termination and opposable piece. Hook bases elongate and nearly as long as the shafts. Hooks of pair number one slightly shorter than the rest of the hooks. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptoral hooks (see pages 9, 15, and 62).

<i>Hook pair</i>	<i>Average length in mm.</i>	<i>Range in mm.</i>
1	0.016	0.013-0.019
2	0.018	0.015-0.021
3	0.019	0.015-0.023
4	0.018	0.015-0.021
5	0.017	0.015-0.019
6	0.018	0.013-0.019
7	0.017	0.015-0.019

Eye spots four in number, about the same size and with members of the two pairs about the same distance apart.

Reproductive system.—Gonads situated near middle of body, testis globular, located posterior to and much larger than ovary. Vas deferens passes forward near median line of body as a slightly undulant tube. Seminal vesicle near copulatory complex and consists of an elongate dilatation of vas deferens. The single prostate gland which lies near the copulatory complex base is bulbular in shape. Copulatory complex well developed and situated in a small vestibule. Cirrus a short curved chitinous tube tapering to a point distally. Average length of cirrus 0.029 mm. (0.027-0.030 mm.). Accessory piece a solid chitinous structure bifurcate distally and with the proximal portion articulated to cirrus base.

Ovary ovate, smaller than testis and with spatial relationships as given above. Egg pore located on ventral surface in region of copulatory complex. The vagina and seminal receptacle have not been observed in this species. Vitellaria and vitelline ducts as given in the general morphology of the North American fresh-water Tetraonchinae.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.022 mm. (0.019-0.027 mm.).

Systematic position.—The morphology of *Dactylogyrus bifurcatus* conforms with the general generic morphology, but differs from other members of the genus by the possession of a short distally bifurcate accessory piece.

Dactylogyrus simplex Mizelle, 1937

Figs. 129-134

Host and Localities: Blunt-Nosed Minnow (*Hyborhynchus notatus*), Embarrass River and Drainage Ditch, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9145.

General anatomy.—Relatively small gill trematodes of a general fusiform shape. Average length 0.324 mm. (0.189-0.443 mm.), average width at level of the cephalic lobes 0.045 mm. (0.038-0.057 mm.), greatest body width average 0.062 mm. (0.044-0.076 mm.), average width of peduncle at junction with haptor 0.036 mm. (0.023-0.048 mm.). Haptor distinct, irregularly discoidal in shape, and broader than long, average width about 0.056 mm. (0.042-0.074 mm.), average length about 0.038 mm. (0.029-0.048 mm.). The single pair of anchors is located dorsally with their superficial bases connected by a solid chitinous bar. Bases of anchors bifurcate, superficial root longer than deep root. Anchor shafts solid and regularly recurved without formation of an angle at junction of shafts and points. Wings on anchor shafts clearly discernible. Average length of anchors 0.028 mm. (0.027-0.034 mm.), average width of anchor bases 0.012 mm. (0.008-0.017 mm.). Ends of ventral bar bent posteriorly with a short median projection on the anterior border and about same length as dorsal bar. Average length of dorsal bar 0.019 mm. (0.017-0.021 mm.). Each of the fourteen hooks present is differentiated into a base, shaft, sickle-shaped termination, and opposable piece. Hook bases elongate and nearly as long as the shafts. Hooks of pair number one slightly shorter than rest of hooks. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptor hooks (see pages 9, 15, and 62).

<i>Hook pair</i>	<i>Average length in mm.</i>	<i>Range in mm.</i>
1	0.015	0.011-0.017
2	0.017	0.015-0.019
3	0.018	0.015-0.023
4	0.017	0.015-0.023
5	0.016	0.011-0.021
6	0.016	0.013-0.017
7	0.017	0.014-0.023

Eye spots four in number, approximately equal in size and with members of each pair about the same distance apart.

Reproductive system.—Gonads situated in first portion of posterior body half. Testis globular, located posterior to and much larger than ovary. Vas deferens passes forward near median line of body as a slightly undulant tube. Seminal vesicle lies near copulatory complex and

consists of a dilatation of vas deferens. Two prostate glands present near copulatory complex base, one bulbular in shape, the other elongate, each emptying into cirrus base by a single individual duct. Copulatory complex well developed and situated in a large vestibule. Cirrus a hollow, sickle-shaped, chitinous tube, tapering to a point distally. Average length of cirrus 0.024 mm. (0.019-0.029 mm.). Accessory piece a solid chitinous structure with a knob present near the midlength. The proximal portion of the accessory piece is articulated with the base of the cirrus.

Ovary ovate, smaller than testis and with spatial relationships as given above. Egg pore located on ventral surface in region of copulatory complex. The vagina and seminal receptacle are not clearly discernible in this form. Vitellaria and vitelline ducts as given in the general morphology of the North American fresh-water Tetraonchinae.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.022 mm. (0.019-0.025 mm.).

Systematic position.—*Dactylogyrus simplex* is closely related morphologically to *Dactylogyrus anchoratus* (Dujardin, 1845); *Dactylogyrus intermedius* Wegener, 1909; and *Dactylogyrus macracanthus* Wegener, 1909. *Dactylogyrus simplex* differs from these three related species in the shape and size relationships of the copulatory complex, anchors, bars, and hooks. *D. anchoratus* occurs on *Carassius carassius*, *Carassius auratus*, and *Cyprinus carpio*; *D. intermedius* on *Carassius carassius*; *D. macracanthus* on *Tinca tinca*; and *D. simplex* on *Hyborhynchus notatus*.

Dactylogyrus atromaculatus sp. nov.

Figs. 154-158

Host and Locality: Creek Chub (*Semotilus atromaculatus*), Embarrass River, Urbana, Ill.

Location: Gills.

Specimens: U.S.N.M. Helm. Coll. No. 9148.

General anatomy.—Relatively small gill trematodes of a somewhat fusiform nature. Average length 0.526 mm. (0.385-0.656 mm.), greatest body width average 0.089 mm. (0.080-0.103 mm.). Haptor hexagonal or subdiscoidal, and well set off from the body. The single pair of anchors is located dorsally with their superficial bases connected by a solid chitinous bar. Bases of anchors bifurcate, superficial root noticeably longer than deep root. Anchor shafts solid and regularly recurved without formation of internal angle at junction with points. Wings on anchor shafts clearly visible. Average length of anchors 0.033 mm. (0.029-0.040 mm.). A ventral bar, "ventrales Chitinstück" or "Chitinklammer" of German workers, has not been observed for this species. Length of

dorsal bar about length of anchors. Each of the fourteen hooks present is differentiated into a base, shaft, sickle-shaped termination and opposable piece. Hook bases elongate-ovate and shorter than the shafts. Hooks similar in shape and size, lengths 0.017-0.025 mm. The arrangement of the hooks is as given in the general morphology of the North American fresh-water Tetraonchinae possessing fourteen haptorial hooks (see pages 9, 15, and 62). Eye spots four in number, approximately equal in size and with members of each pair about the same distance apart.

Reproductive system.—Gonads located near middle of body, testis ovate; vas deferens passes forward near the median line of the body as a slightly undulant tube. Copulatory complex well developed and situated in a relatively large vestibule. Cirrus an elongate hollow chitinous tube tapered distally. Average length of cirrus 0.037 mm. (0.025-0.042 mm.). Accessory piece a solid chitinous blade-like structure with an enlargement near the midlength. Proximal portion of accessory piece articulated with base of cirrus.

Egg pore located on ventral surface in the region of the copulatory complex. Vagina not clearly distinguishable. Vitellaria and vitelline ducts as given in the general morphology of the North American fresh-water Tetraonchinae.

Digestive and excretory systems.—Digestive and excretory systems as given in the general morphology of the North American fresh-water Tetraonchinae. Average diameter of pharynx 0.031 mm. (0.029-0.038 mm.).

Systematic position.—This species differs from other described species of *Dactylogyrus* by the nature of the copulatory complex. The anchors are similar to those of *Dactylogyrus simplex* Mizelle, 1937. A vestigial bar is lacking in *Dactylogyrus atromaculatus* n. sp., whereas one is present in *D. simplex*. *D. atromaculatus* has been collected only from the gills of the creek chub. It occurs in mixed infestations with an undescribed species of *Dactylogyrus*.

ECONOMIC IMPORTANCE

Trematodes are found abundantly in and on both marine and fresh-water fishes. That they cause serious damage to the host is demonstrated by the work of several authors. The results of Cross (1935) on four-year-old yellow perch (*Perca flavescens*) show that fish with light infestations averaged eighteen per cent longer and one hundred twenty per cent heavier than fish with heavy infestations. This work included observations on myxosporidian, cestode, nematode, and copepod parasites,

in addition to the ectoparasitic and endoparasitic trematodes.¹ Bangham (1927) found that larval cestodes (*Proteocephalus ambloplites*) sterilized one hundred fifty small-mouth bass breeders in an Ohio hatchery. Out of three hundred ninety-one fish (*Platygobio gracilis*) Hubbs (1927) found sixty-eight individuals with abnormalities which he attributed to infestation with parasites, chiefly *Proteocephalus* and several species of trematode metacercariae.² The abnormal fish showed an increase in the number of scales, a retention of larval characters, and an average growth retardation of 4.5 mm. in length. In the production of abnormalities, Hubbs considered *Proteocephalus* more important than trematodes, but in a few cases he attributed relative damage to the latter since some abnormally developed individuals harbored heavy infestations of trematodes and only a few specimens of *Proteocephalus*. Van Haitsma (1931) noted death of four out of a lot of nine ducks, which he was inclined to attribute to infestation with *Cotylurus flabelliformis* (Faust). The same author (1931a) observed two experimentally infested suckers whose death he was sure was due to penetration with cercariae of *Diplostomulum flexicaudum* (Cort and Brooks). Van Haitsma (1931a) quoted Blochman as having had the same experience with several fish placed in a tank with eight specimens of *Lymnaea stagnalis* shedding furcocercous cercariae (*Cercaria fissicauda*). Szidat (1927) cited *Diplostomulum spathaceum* (Rud.) as being responsible for the death of thousands of *Acerina cernua* and *Leuciscus rutilus*. McCoy (1928) reported death of seven sunfish (*Eupomotis gibbosus*) by penetration of large numbers of *Cercaria hamata* Miller. Ferguson (unpublished data) in 1936 noted the death of several blunt-nosed minnows (*Hyborhynchus notatus*) experimentally infested with variable numbers of an unidentified furcocercous cercaria from *Physa integra*.

Bangham (1928) is of the opinion that "The internal flukes are probably the least harmful of the bass parasites, but those which are external often do considerable damage to the gills, skin, and fins of the host—especially where they are found in ponds where many bass are confined." Hofer (1904) and Plehn (1924) considered *Gyrodactylus* as destructive to the skin and gills of various species of European fishes. Roth (1922) mentioned this organism as the etiological agent of a contagious disorder of carp, goldfishes, and other fish in aquaria and natural waters. Atkins (1901) recorded *Gyrodactylus elegans* von Nordmann in hatchery ponds and also in the wild waters of Maine. Cooper in 1915 reported *Gyrodactylus medius* Kathariner, on the small-mouth black bass of Canada. Van Cleave (1921) doubted the identity of Cooper's species and

¹Only one specific parasite was mentioned, namely *Triacnophorus nodulosus* (cysts).

²The genus *Proteocephalus* was the only identification made. Hubbs dealt only with endoparasites.

believed it different from any described form. In the same publication Van Cleave described *Gyrodactylus fairporti* in an epidemic from the common bullhead (*Ameiurus melas*) and the European carp (*Cyprinus carpio*) at Fairport, Iowa. Pratt (1929) recorded ectoparasitic helminth infestations on the gills of rainbow trout in the New York Hatchery at Cold Spring Harbor, and mentioned that the parasites were numerous enough in many cases to cause marked damage to the affected hosts. He did not determine the species, but his figure indicated it to be a species of *Gyrodactylus*. Ward (1918) noted the occurrence of *Gyrodactylus* in several localities attacking lake trout and small-mouth bass in the Eastern United States and Canada. Moore (1922) reported it as the causative agent of disease in fish hatcheries in New York, affecting trout primarily, and stated that its range was probably widespread. In 1924 Embury reported *Gyrodactylus* as responsible for considerable loss of trout in New Jersey where measures were undertaken to control its ravages. Hess (1928) noted serious losses in hatcheries among "fry" three to six weeks old by an unidentified species of *Dactylogyus*. MacCallum (1915) found that members of the family Microcotylidae caused the death of ninety per cent of the angel and butterfly fishes in the tanks of the New York Aquarium. Guberlet, Hansen, and Kavanagh (1927) reported a daily mortality of one to two per cent for rainbow trout fingerlings (*Salmo irideus shasta*) infested with *Gyrodactylus elegans*, in a hatchery near Seattle, Washington, from November 15 to December 20, 1925. Two individuals (observed by the present author) out of a lot of sixteen black crappies (*Pomoxis sparoides*) transported by automobile from Lake Senachwine near Henry, Illinois, showed signs of suffocation and loss of balance on arrival at the laboratory at Urbana, Illinois. These two fish died approximately six hours later in one of the Illinois State Natural History Survey aquaria. On examination they were found heavily infested with *Cleidodiscus capax* Mizelle. The rest of the fish presented no particular symptoms of disease, and when examined at a later date were found to harbor only light infestations of the same species of parasite. It has been observed that yellow bass (*Morone interrupta*), which often harbor several hundreds of *Onchocleidus interruptus* Mizelle, on their gills, die soon after removal from the net when placed in containers filled with aerated water of the same temperature as that from which they were taken. Death of these hosts was prevented by cooling the water in containers before placing the fish therein. During the spring of 1937 an epidemic among blunt-nosed minnows (*Hyborhynchus notatus*) by *Dactylogyus bychowskyi* Mizelle, was observed. Over three hundred hosts in an aquarium at the University of Illinois died during the epidemic. Steel colored minnows (*Notropis whipplii*) in the same tank were not affected.

The flukes were found to infest the gills of the hosts exclusively. As many as two hundred parasites were recovered from one fish in this epidemic, whereas twenty-five fish examined a few hours after removal from neighboring streams, namely the Drainage Ditch and Embarrass River, harbored an average of five parasites each. It has not as yet been determined whether these phenomena are due wholly to infestation with the specific gill trematodes mentioned. Van Cleave (1921) and Mueller and Van Cleave (1932) are in accord with Bangham (1928) in stating that infestations with ectoparasites are more apt to become serious in aquaria and artificial enclosures rather than in natural waters. The same idea was expressed by MacCallum (1915), but after his publication had gone to press he had occasion to examine several fish from the open sea, two of which were snappers (*Priacanthus cruentatus*), whose death he was certain was due to infestation with *Diplectana*. The present writer has not recorded a single epidemic of tetraonchid ectoparasites among infested sunfishes kept in aquaria for maximum intervals of four weeks. Records of epidemics or serious outbreaks of oviparous *Gyrodactyloidea* are not as numerous as for viviparous forms. Members of the genus *Gyrodactylus*, have been observed to harbor as many as two generations within a single parent.

The nature of damage by ectoparasitic trematodes to fish hosts is varied. MacCallum (1915) attributed the damage of *Microcotyle* to be of a double nature, namely the production of an anemia and suffocation. This author says that species of this genus (*Microcotyle*) fasten themselves to the gills of fishes and that such attachment causes irritation which induces an outflow of mucus covering the gills, thus preventing access of water to the respiratory surfaces. Due to the feeding habits of these parasites, a depletion of the host's blood supply occurs which renders it exsanguine, producing death. MacCallum (1927) recorded that in 1926 Miss Ida Mellen noted the destruction of the cornea of the Pacific puffer (*Spheroides annulatus*), the spade fish (*Chaetodipterus faber*), and several species of angel fishes of the genera *Angelichthys* and *Pomacanthus* by *Epibdella melleni* MacCallum. Tubangui (1931), in regard to *Ancyrocephalus manilensis* Tubangui, stated that the infested organs were much congested and showed numerous punctiform hemorrhages, produced no doubt by the hooks of the parasite. Pratt (1929) mentioned a shriveling of the gills which rendered them functionless in heavy infestations of *Gyrodactylus* on rainbow trout. Van Cleave (1921) considered direct damage to the general body surfaces of fishes by *Gyrodactylus fairporti* Van Cleave, only one mode of parasitic attack and that additional damage was possibly done by bacteria, protozoa, and fungi, whose invasion of the host was made possible by removal of skin and scales by the armature of ectoparasitic helminths.

The present author in examining over one thousand individuals belonging to species of Tetraonchinae and Dactylogyrinae described herein, found infestations restricted to branchial tissues. This site of parasitic attack is in accord with the findings of MacCallum (1915) for the Octocotylidae, Microcotylidae, and *Diplectana*. The principal damage to fish hosts by the observed members of Tetraonchinae is accomplished presumably by an irritative or toxic action resulting from the insertion of the haptor. Each point of haptoral attachment on the branchial filaments of the black and white crappies (*P. sparoides* and *P. annularis*) by *Cleidodiscus capax* Mizelle, and of the bluegill sunfish (*Helioperca macrochira*) by *Cleidodiscus robustus* Mueller, generally present an enlarged circumscribed area denoting an apparent condition of hypertrophy or hyperplasia. These areas become thickly covered with mucus which prevents contact of the branchial surface with the water, recalling the condition of suffocation mentioned by MacCallum (1915) for members of the genus *Microcotyle*.

A knowledge of the specific etiological agent together with its complete life history is indispensable to the successful control of a disease. Until recently the incompleteness of such information concerning the North American Gyrodactyloidea Johnston and Tiegs, has been astonishing. MacCallum (1915 and 1927) described a number of species from marine fishes. Van Cleave (1921) described *Gyrodactylus fairporti* from Fairport, Iowa. Hess (1928 and 1930) recorded the presence of undetermined species of *Dactylogyrus* and *Gyrodactylus* on goldfishes and an undetermined species of *Ancyrocephalus* from several species of native fishes in Indiana and central New York. Stafford (1905), Cooper (1915), Ward (1918), Bangham (1926), and Guberlet, Hansen, and Kavanagh (1927) have given records of one or more instances of the occurrence of Gyrodactyloidea on fresh-water fishes, but have left doubts as to the identity of the forms with which they dealt, and in several instances made identification only to genus. In 1928 Bangham made no attempt to identify species of gill parasites of the large-mouth black bass (*Aplites salmoides*). In 1933 the same author in his publication on the parasites of the spotted bass (*Micropterus pseudaplites*), which also included a summary of parasites of the small and large-mouth basses from Ohio streams, did not record a single ectoparasitic trematode for the spotted or Kentucky bass, and only one unidentified species of *Ancyrocephalus* for the other hosts. Since 1931 taxonomic work on this group has been relatively prolific (see page 13).

In regard to life histories of the Monogenea, only three are completely known. Of the Gyrodactyloidea, the life history of *Gyrodactylus elegans* von Nordmann was studied by Kathariner in 1904. The life history of *Epibdella melleni* MacCallum, belonging to the Capsaloidea, was pub-

lished by Jahn and Kuhn in 1932. Zeller (1872a) published the life history of *Diplozoon paradoxum*, a member of Polyopisthocotylea. Zeller also published (1872) a description of the life history of *Polystomum integerrimum*, but this work has been doubted by many authors including Stunkard (1917). Hess (1928) gave a very superficial account of the life history of an unidentified species of *Dactylogyrus* which he found infesting the gills of the small and large-mouth black basses, common sunfish, goldfish, carp, and "other fishes."

In discussing possibilities of controlling endoparasites, different authors have suggested destruction of a unit in the chain of hosts utilized by a particular species, as a means of extermination of the etiological agent. Chandler (1920) suggested the killing of the snail host (which harbors intermediate stages of trematode parasites) in order to stamp out certain trematode diseases. Linton (1911) advocated the shooting of water birds as a measure for ridding fish of yellow grub or metacercariae of *Clinostomum*. Baker (1922) pointed out the danger of such practices by showing the relationships of Mollusca in food chains of aquatic organisms. In addition Baker called attention to the fact that agents such as copper sulphate used to kill snails were highly toxic to algae and other microscopic life on which higher animals depend for food.

Methods for extermination of monogenetic trematodes must of necessity differ radically from those used for digenetic forms because of a difference in life histories. In the light of our present knowledge, an intermediate host is not utilized by monogenetic flukes. Infection is accomplished by contact (MacCallum, 1927), (Guberlet, Hansen, and Kavanagh, 1927) and when fish are subjected to crowded conditions, ectoparasitic trematodes often increase in numbers that effect a high mortality of the hosts as pointed out by MacCallum (1915), Van Cleave (1921), Guberlet, Hansen, and Kavanagh (1927), and others.

Various methods have been proposed for destruction of these trematodes. Hubner (1895) recommended an exposure of infested fish to a one-fourth of one per cent solution of salicylic acid for thirty minutes. Hofer (1904) also recommended the treatment of Hubner and in addition advocated a bath of one part of potassium permanganate to one hundred thousand parts of water. Plehn (1924) proposed an exposure of diseased fish for ten minutes to a two per cent solution of hydrogen peroxide and subjection to a one to eight thousand acetic acid bath from one to one and one-half hours as being specific for ectoparasites closely related to *Discocotyle salmonis* Schaffer. Davis (1929) found the acetic acid treatment ineffective. Laird and Embury (1931) also found the acetic acid bath of no benefit and determined treatment with a bath of copper sulphate and of saturated sodium chloride solution, as used by European fish culturists for one to one and one-half minutes (Davis

1929), to be worthless. Through an indirect communication, the present author learned that Jahn successfully treated fish for *Epibdella melleni* by doubling the concentration of salt in sea water. Laird (1927) reported successful destruction of gill parasites by spraying the branchial tissue with a twenty per cent solution of Zonite. Laird and Embody (1931) recommended a two minute immersion of fish in a solution of Zonite made of one ounce of the chemical to ten to twelve quarts of water. Guberlet, Hansen, and Kavanagh (1927) found gyrodactyliasis, or fin disease of fish, very difficult to control. After a number of experiments with various chemicals they concluded that exposure to a four and one-half to five per cent solution of common salt for one and one-half to two and one-half minutes to be the safest and most effective treatment for the disease. Hess (1930) found that immersion of the host for two hours in a solution of potassium permanganate (one pound to thirty-two thousand gallons of water) was absolutely specific for undetermined species of *Gyrodactylus* and *Dactylogyrus* on goldfishes. He also recommended spraying the surface of ponds with one pound of the dissolved chemical to twenty-five thousand to forty thousand gallons of water, depending on the amount of organic matter present, capable of reducing potassium permanganate. Hess observed that old fish withstood stronger solutions of this chemical better than did the younger individuals. Because of reduction of potassium permanganate by organic matter in hatchery ponds, this method becomes impractical due to the inability to correctly estimate the amount of organic material in the water. Water capacity of hatchery ponds must also be known for intelligent use of the anthelmintic.

Fish culturists and conservation agencies responsible for rearing and distributing fishes have given practically no attention to the dangers of transporting gill parasites into new regions. Except for a few of the large species, the gyrodactylids are so small as to escape field inspections. Furthermore, detailed information as to the species involved and the specific action of each on the host has been generally lacking. Doubtless the inconsistencies encountered by several authors, with various anthelmintics recommended by other workers, were in part due to the fact that they dealt with ectoparasites other than those for which particular chemicals were found specific. Control measures aimed at a generalized treatment for ectoparasitic trematodes would probably be as meaningless as a generalized therapy for the multitude of human diseases. It is recommended that fishes infested with monogenetic trematodes be subjected to therapy one hundred per cent effective for removal of such parasites, before placing them in new environments as aquaria, fish hatcheries, or natural waters. New hosts for etiological agents of disease generally suffer high mortality until a physiological balance with the organism is established.

DISCUSSION

In a recent publication Mueller (1937) mentioned two systems of numbering the hooks on haptors of fresh-water species of North American Tetraonchinae. Contentions regarding the order of these structures are not of a serious nature, and only for the sake of future workers in this field are the following comparisons and deductions set forth. It must be remembered that any arbitrary system of numbering that deals with haptoral hooks in this group of parasites cannot be regarded as having unquestionable value. A natural system of numbering these hooks must be attained through embryological studies. In the absence of such studies, all systems of numbering must be regarded as highly artificial, derived solely as a matter of convenience, and discarded when basic information is produced. Information concerning the embryology of North American Tetraonchinae is as yet wanting.

Haptoral hooks, in North American fresh-water species of Tetraonchinae (*Tetraonchus* and *Murraytrema* not studied) and *Dactylogyrinae*, are distributed on both dorsal and ventral sides of the haptor, five pairs being on the ventral and two pairs on the dorsal side.¹ In 1936 Mueller numbered the hooks consecutively around the margin of the haptor, beginning with the anterior central (ventral) pair of hooks as number one. Since the two dorsal pairs of hooks are variable in their positional relationships (in different species) with the five pairs of ventral hooks, the earlier proposed system of numbering (Mueller 1936) becomes very confusing. Discrepancies naturally occur in the older system of numbering because of this fluctuation in the linear positions of the two pairs of hooks mentioned. For instance, the most anterior dorsal hook is labelled number six by Mueller for *Onchocleidus minus* (1936, p. 59, pl. 13, fig. 13), two for *O. similis* (*ibid.*, fig. 10), four for *O. ferox* (*ibid.*, fig. 12) and number five for *P. acer* and *H. dispar* (*ibid.*, figs. 9 and 11), whereas in the new system of numbering (Mizelle, 1936) each anterior dorsal hook consistently becomes number seven for each species. Since the hooks involved (all except number one) are generally identical in structure in a given species, with varying size relationships in different species together with variable spatial relationships with each other, the stable character of ventral and dorsal distribution must be resorted to if any degree of regularity is to be attained. In the later proposed system of numbering (Mizelle, 1936) Mueller's starting point is utilized for hooks of the first pair, but instead of zigzagging in some cases from one surface of the haptor to the other and in other cases going consecutively from

¹In 1936 the present author described a variation of this arrangement for one species, viz., *Actinocleidus articularis* (Mizelle, 1936). All fourteen hooks were thought to occur on the same side of the haptor. In subsequent work, the hook arrangement of all species in this genus has been found to agree with that existing in the other North American Tetraonchinae (fresh-water) genera possessing fourteen haptoral hooks.

ventral to dorsal side with the exclusion of the hook pair in the region of the ventral anchors, the sequence is posteriorly around the ventral side of the haptor and then dorsally in an anterior direction (figs. 173-174). Hooks numbers six and seven always relate to those on the dorsal side of the haptor, number six being invariably the more posterior. The single pair of hooks whose position is in the region of the ventral anchors obviously becomes number five in the new system instead of seven in that of Mueller's.

Mueller (1937) cited *O. minus* and *Cleidodiscus robustus* as possessing the primitive hook arrangement, whereas in 1936 he referred to *Actinocleidus oculatus* as possessing it. The present writer has found the same basic hook arrangement present in all species examined. The species of *Dactylogyrus* described in this paper possess the same hook arrangement as the Tetraonchinae, and although the ventral pair of anchors has disappeared in this genus, a ventral chitinous structure is present in *D. simplex*, *D. bifurcatus*, and many other previously described species. This structure could very easily be interpreted to represent a remnant of the ventral bar that once connected the two members of the ventral pair of anchors. The genus *Haploleidus* Mueller, 1937, which is characterized by a marked difference in the size of the two pairs of anchors, strongly suggests an intermediate stage in the transition from a condition of four anchors to a condition of two anchors or one pair. The genus *Gyrodactylus* is assumed to be more specialized than either of the foregoing since only one pair of anchors is present without a vestige of the ventral bar; oviparity is replaced by viviparity; eye spots have disappeared in adults; and all the hooks (eight pairs) occur on the same side of the haptor.

The present writer is in general accord with Price (1937a) with reference to the possible invalidity of some of Mueller's recently created genera, viz., *Cleidodiscus*, *Urocleidus*, *Onchocleidus*, *Leptocleidus*, *Tetra-
cleidus*, *Aristocleidus*, *Haploleidus*, *Pterocleidus*, and *Actinocleidus*. Species of *Urocleidus* are not unlike those of *Onchocleidus* except for the absence of a vagina, a condition which sporadically occurs in several genera of Tetraonchinae. *Leptocleidus* possesses characters common to the genus *Cleidodiscus* with which it is probably synonymous. *Tetra-
cleidus* is distinguished from *Onchocleidus* (Mueller, 1936) by the presence of an accessory piece in the copulatory complex. This structure has been described for practically all species of *Onchocleidus*. *Aristocleidus* is also like *Onchocleidus* except for a difference of size and shape relationships of the dorsal and ventral anchors, a condition which occurs in other genera of this subfamily. *Haploleidus* was split off the genus *Onchocleidus* to include forms which possess dorsal anchors that are much larger than the ventral anchors. Recent research (Seamster, 1938)

has shown this condition to occur as a variation in *Cleidodiscus pricei* Mueller, 1936. *Pterocleidus* was also split off the genus *Onchocleidus* and made to include forms which possess a spur on each anchor shaft. This condition is thought to be of no more importance than occurrence of spines on the bars of *Onchocleidus mucronatus* Mizelle, *O. cyanellus* Mizelle, *Cleidodiscus vancleavei* Mizelle, and *C. robustus* Mueller. The genus *Actinocleidus* was taken from *Cleidodiscus* to embrace forms which have fused bars and both pairs of anchors on the same side of the haptor. This genus is held as valid. A revision of the North American fresh-water genera of Tetraonchinae is contemplated in the near future.

SUMMARY

A method has been perfected for removal of ninety-two per cent of the monogenetic flukes present on the gills of fresh-water fishes.

Successful attachment of small gyroductyloid parasites to glass slides, to prevent loss of such material during technical processes requisite for production of permanent mounts, has been accomplished.

Twenty-one species of monogenetic trematodes of the subfamilies Tetraonchinae and Dactylogyrynae have been described from the gills of Illinois fishes. A few host records are reported from Oklahoma.

A review of the detrimental effects of monogenetic trematodes to fish hosts, together with a review of control methods for these parasites, is given.

A thorough subjection of fish hosts, infested with monogenetic trematodes, to procedures requisite for one hundred per cent removal of all stages of such parasites, is recommended before transplanting them in new environments, as aquaria, fish hatcheries, or natural waters.

Chitinous parts as anchors, bars, hooks, and copulatory structures are relatively constant and serve for definite identification of species of fresh-water Gyrodactyloidea especially when host-parasite relationships are known.

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PLATES

All figures were drawn with the aid of a camera lucida (except 173 and 174 which are diagrammatic). The scale used is indicated on each plate.

PLATE I

- FIG. 1.—*Cleidodiscus robustus* Mueller, 1934.
 FIG. 2.—*Onchocleidus interruptus* Mizelle, 1936.
 FIG. 3.—*Onchocleidus principalis* Mizelle, 1936.
 FIG. 4.—*Cleidodiscus longus* Mizelle, 1936.
 FIG. 5.—*Cleidodiscus vancleavei* Mizelle, 1936.
 FIG. 6.—*Cleidodiscus bedardi* Mizelle, 1936.

Abbreviations

<i>CC</i>	Copulatory complex	<i>PH</i>	Pharynx
<i>CL</i>	Cephalic lobe	<i>SG</i>	Shell gland
<i>ES</i>	Eye spots	<i>SR</i>	Seminal receptacle
<i>GC</i>	Cephalic glands	<i>SV</i>	Seminal vesicle
<i>H</i>	Haptor	<i>T</i>	Testis
<i>HO</i>	Head organs	<i>UP</i>	Egg or uterine pore
<i>IC</i>	Intestinal crura	<i>UT</i>	Oviduct or uterus
<i>M</i>	Mouth	<i>V</i>	Vagina
<i>OV</i>	Ovary	<i>VD</i>	Vas deferens
<i>P₁</i>	Prostate containing finely granular hyaline fluid	<i>VDT</i>	Vitelline duct
<i>P₂</i>	Prostate containing coarsely granular yellowish fluid	<i>VIT</i>	Vitellaria

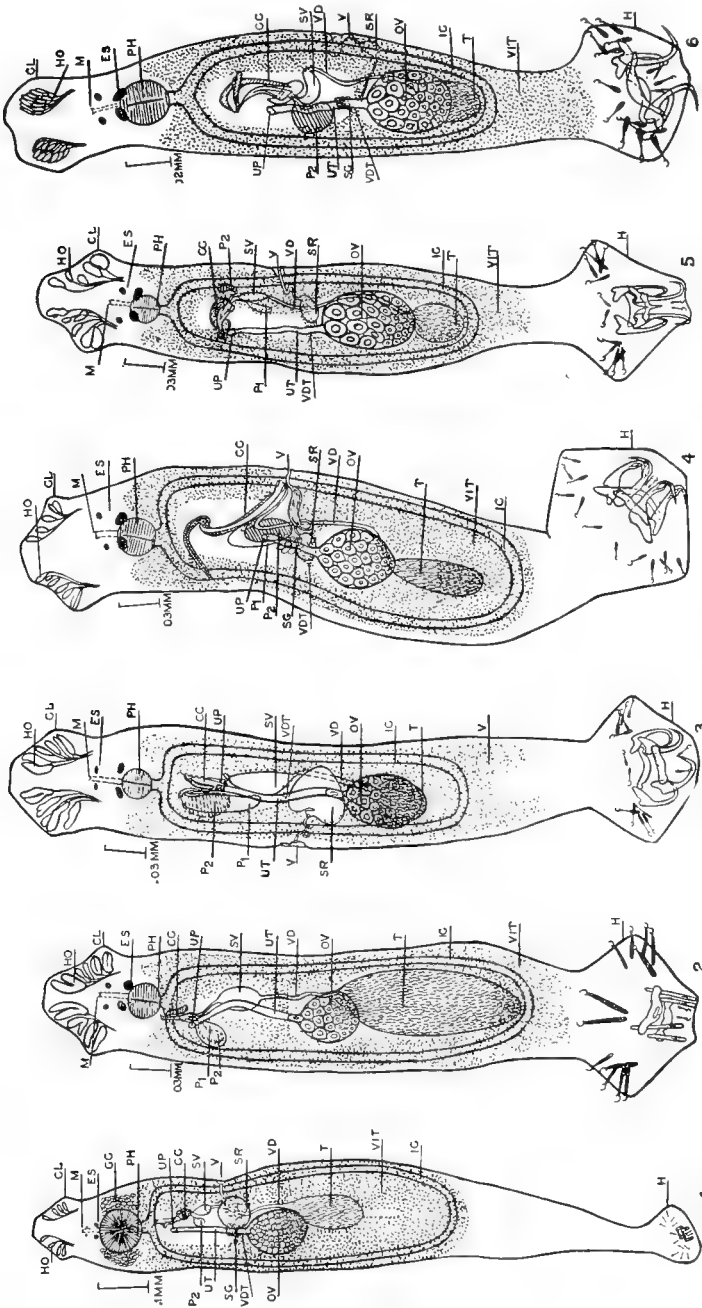


PLATE I

PLATE II

Abbreviations same as for Plate I

- FIG. 7.—*Cleidodiscus capax* Mizelle, 1936.
FIG. 8.—*Onchocleidus distinctus* Mizelle, 1936.
FIG. 9.—*Onchocleidus mucronatus* Mizelle, 1936.
FIG. 10.—*Actinocleidus articularis* (Mizelle, 1936).
FIG. 11.—*Pterocleidus acuminatus* (Mizelle, 1936).
FIG. 12.—*Cleidodiscus uniformis* Mizelle, 1936.

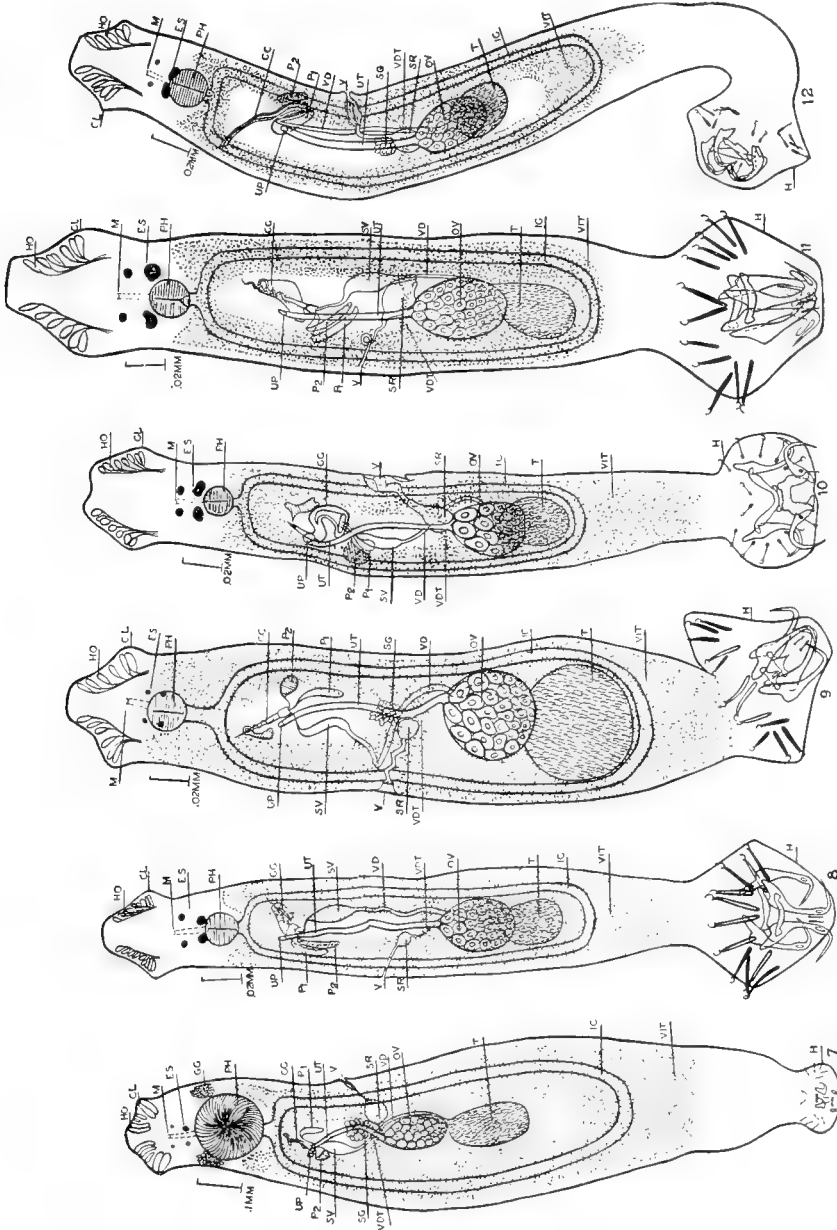


PLATE II

PLATE III

Cleidodiscus robustus Mueller, 1934

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|---------------------------------|--------------------------|
| FIG. 13.—Accessory piece. | FIG. 18.—Dorsal anchor. |
| FIG. 14.—Cirrus. | FIG. 19.—Ventral anchor. |
| FIG. 15.—Vagina. | FIG. 20.—Dorsal bar. |
| FIG. 16.—Vaginal tube or canal. | FIG. 21.—Ventral bar. |
| FIG. 17.—Seminal receptacle. | |

Onchocleidus mucronatus Mizelle, 1936

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|---------------------------|---------------------------------|
| FIG. 22.—Cirrus. | FIG. 27.—Ventral bar. |
| FIG. 23.—Accessory piece. | FIG. 28.—Vagina. |
| FIG. 24.—Dorsal anchor. | FIG. 29.—Vaginal tube or canal. |
| FIG. 25.—Ventral anchor. | FIG. 30.—Seminal receptacle. |
| FIG. 26.—Dorsal bar. | |

Cleidodiscus vanclaevei Mizelle, 1936

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|---------------------------|---------------------------------|
| FIG. 31.—Accessory piece. | FIG. 36.—Vaginal tube or canal. |
| FIG. 32.—Cirrus. | FIG. 37.—Seminal receptacle. |
| FIG. 33.—Dorsal anchor. | FIG. 38.—Dorsal bar. |
| FIG. 34.—Ventral anchor. | FIG. 39.—Ventral bar. |
| FIG. 35.—Vagina. | |

Actinocleidus articularis (Mizelle, 1936)

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|----------------------------|---------------------------------|
| FIG. 40.—Anterior anchor. | FIG. 45.—Vaginal tube or canal. |
| FIG. 41.—Anterior bar. | FIG. 46.—Seminal receptacle. |
| FIG. 42.—Posterior anchor. | FIG. 47.—Accessory piece. |
| FIG. 43.—Posterior bar. | FIG. 48.—Cirrus. |
| FIG. 44.—Vagina. | |

Cleidodiscus longus Mizelle, 1936

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|---|---------------------------------|
| FIG. 49.—Dorsal bar. | FIG. 53.—Vaginal tube or canal. |
| FIG. 50.—Ventral bar. | FIG. 54.—Seminal receptacle. |
| FIG. 51.—Cirrus and accessory
piece. | FIG. 55.—Dorsal anchor. |
| FIG. 52.—Vagina. | FIG. 56.—Ventral anchor. |

Cleidodiscus bedardi Mizelle, 1936

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|---------------------------|---------------------------------|
| FIG. 57.—Dorsal bar. | FIG. 62.—Ventral anchor. |
| FIG. 58.—Ventral bar. | FIG. 63.—Vagina. |
| FIG. 59.—Cirrus. | FIG. 64.—Pseudovagina. |
| FIG. 60.—Accessory piece. | FIG. 65.—Vaginal tube or canal. |
| FIG. 61.—Dorsal anchor. | FIG. 66.—Seminal receptacle. |

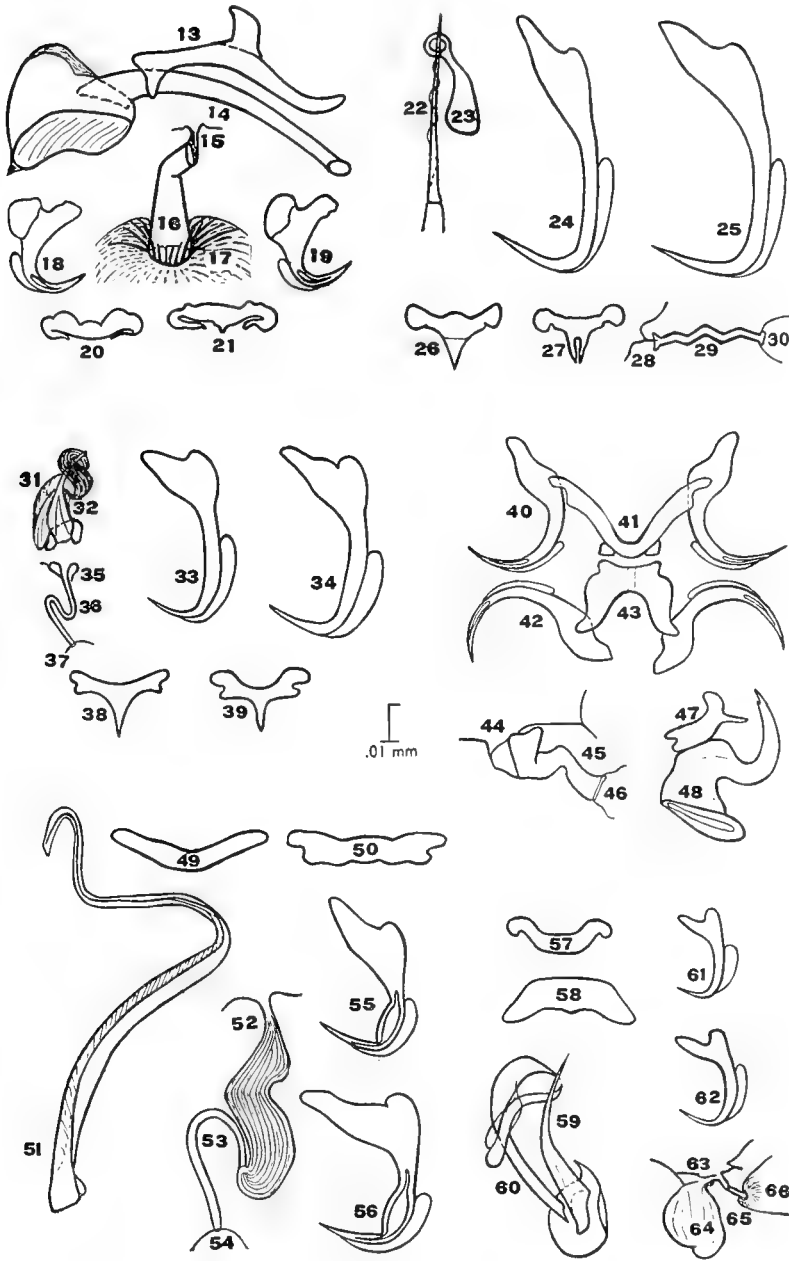


PLATE III

PLATE IV

Cleidodiscus capax Mizelle, 1936

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|---------------------------|---------------------------------|
| FIG. 67.—Accessory piece. | FIG. 72.—Vaginal tube or canal. |
| FIG. 68.—Cirrus. | FIG. 73.—Seminal receptacle. |
| FIG. 69.—Dorsal anchor. | FIG. 74.—Dorsal bar. |
| FIG. 70.—Ventral anchor. | FIG. 75.—Ventral bar. |
| FIG. 71.—Vagina. | |

Onchocleidus principalis Mizelle, 1936

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|---------------------------------|---------------------------|
| FIG. 76.—Dorsal anchor. | FIG. 81.—Accessory piece. |
| FIG. 77.—Ventral anchor. | FIG. 82.—Cirrus. |
| FIG. 78.—Vagina. | FIG. 83.—Dorsal bar. |
| FIG. 79.—Vaginal tube or canal. | FIG. 84.—Ventral bar. |
| FIG. 80.—Seminal receptacle. | |

Cleidodiscus uniformis Mizelle, 1936

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|---------------------------|---------------------------------|
| FIG. 85.—Dorsal bar. | FIG. 90.—Cirrus. |
| FIG. 86.—Ventral bar. | FIG. 91.—Vagina. |
| FIG. 87.—Dorsal anchor. | FIG. 92.—Vaginal tube or canal. |
| FIG. 88.—Ventral anchor. | FIG. 93.—Seminal receptacle. |
| FIG. 89.—Accessory piece. | |

Pterocleidus acuminatus (Mizelle, 1936)

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|---------------------------------|---------------------------|
| FIG. 94.—Dorsal bar. | FIG. 99.—Accessory piece. |
| FIG. 95.—Ventral bar. | FIG. 100.—Cirrus. |
| FIG. 96.—Vagina. | FIG. 101.—Dorsal anchor. |
| FIG. 97.—Vaginal tube or canal. | FIG. 102.—Ventral anchor. |
| FIG. 98.—Seminal receptacle. | |

Onchocleidus interruptus Mizelle, 1936

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|----------------------------|---------------------------|
| FIG. 103.—Dorsal anchor. | FIG. 106.—Ventral anchor. |
| FIG. 104.—Cirrus. | FIG. 107.—Dorsal bar. |
| FIG. 105.—Accessory piece. | FIG. 108.—Ventral bar. |

Onchocleidus distinctus Mizelle, 1936

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|----------------------------|----------------------------------|
| FIG. 109.—Dorsal bar. | FIG. 114.—Vagina. |
| FIG. 110.—Ventral bar. | FIG. 115.—Vaginal tube or canal. |
| FIG. 111.—Dorsal anchor. | FIG. 116.—Seminal receptacle. |
| FIG. 112.—Accessory piece. | FIG. 117.—Ventral anchor. |
| FIG. 113.—Cirrus. | |

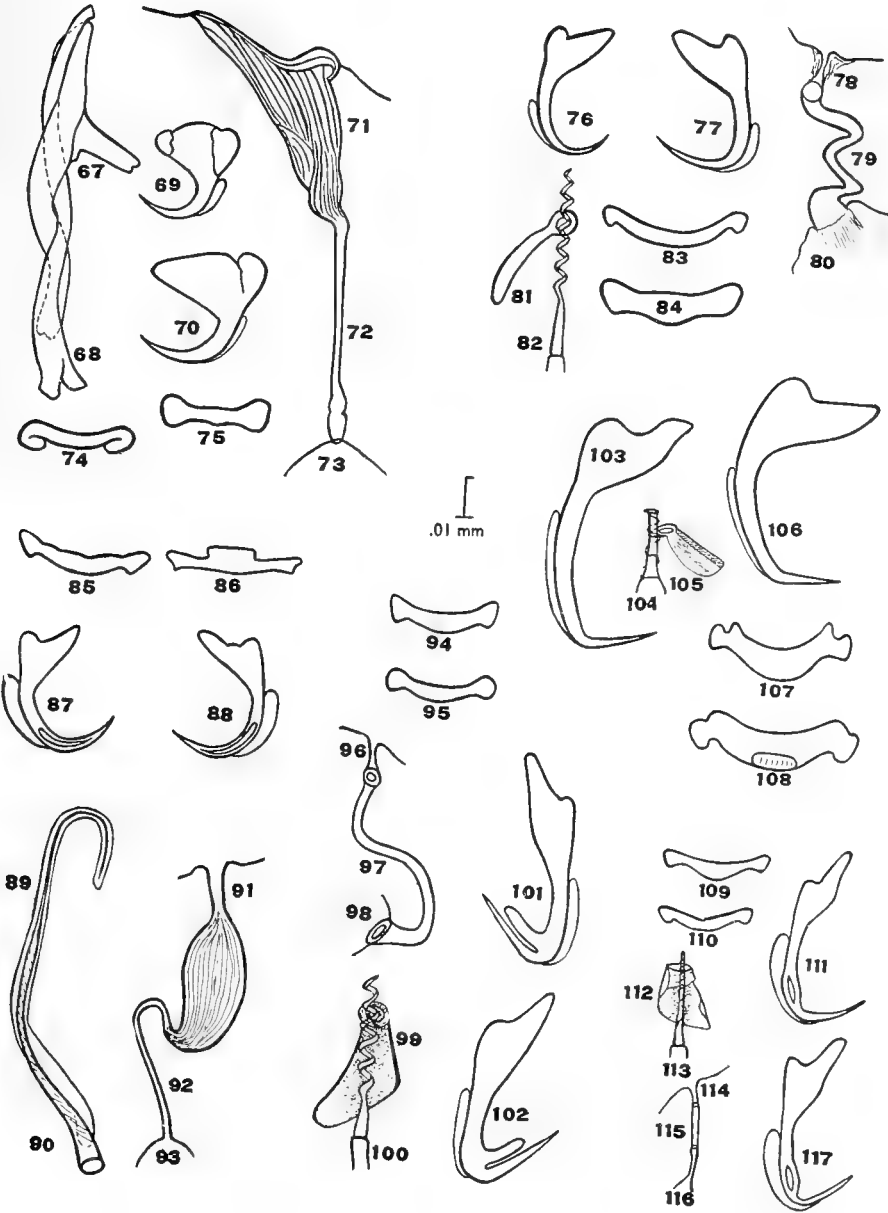


PLATE IV

PLATE V

Dactylogyrus bychowskyi Mizelle, 1937

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| FIG. 118.—Anchor. | FIG. 121.—Accessory piece. |
| FIG. 119.—Bar. | FIG. 122.—Hooks. |
| FIG. 120.—Cirrus. | |

Dactylogyrus bifurcatus Mizelle, 1937

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| FIG. 123.—Dorsal bar. | FIG. 126.—Cirrus. |
| FIG. 124.—Accessory piece. | FIG. 127.—Anchor. |
| FIG. 125.—“Ventral bar.” | FIG. 128.—Hooks. |

Dactylogyrus simplex Mizelle, 1937

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| FIG. 129.—Anchor. | FIG. 132.—“Ventral bar.” |
| FIG. 130.—Hooks. | FIG. 133.—Accessory piece. |
| FIG. 131.—Dorsal bar. | FIG. 134.—Cirrus. |

Onchocleidus cyanellus n. sp.

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| FIG. 135.—Ventral anchor. | FIG. 138.—Hook. |
| FIG. 136.—Copulatory complex. | FIG. 139.—Ventral bar. |
| FIG. 137.—Dorsal bar. | FIG. 140.—Dorsal anchor. |

Cleidodiscus diversus n. sp.

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| FIG. 141.—Dorsal anchor. | FIG. 145.—Dorsal bar. |
| FIG. 142.—Accessory piece. | FIG. 146.—Ventral bar. |
| FIG. 143.—Cirrus. | FIG. 147.—Hook. |
| FIG. 144.—Ventral anchor. | |

Actinocleidus fergusonii n. sp.

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| FIG. 148.—Anterior anchor. | FIG. 151.—Posterior bar. |
| FIG. 149.—Anterior bar. | FIG. 152.—Accessory piece. |
| FIG. 150.—Posterior anchor. | FIG. 153.—Cirrus. |

Dactylogyrus atromaculatus n. sp.

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| FIG. 154.—Cirrus. | FIG. 157.—Hook. |
| FIG. 155.—Accessory piece. | FIG. 158.—Anchor. |
| FIG. 156.—Bar. | |

Urocleidus umbraensis n. sp.

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| FIG. 159.—Dorsal anchor. | FIG. 163.—Dorsal bar. |
| FIG. 160.—Ventral anchor. | FIG. 164.—Ventral bar. |
| FIG. 161.—Accessory piece. | FIG. 165.—Hook. |
| FIG. 162.—Cirrus. | |

Actinocleidus longus n. sp.

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| FIG. 166.—Anterior anchor. | FIG. 170.—Hook. |
| FIG. 167.—Anterior bar. | FIG. 171.—Accessory piece. |
| FIG. 168.—Posterior anchor. | FIG. 172.—Cirrus. |
| FIG. 169.—Posterior bar. | |

FIGS. 173-174.—Side and ventral views of haptors to show arrangement of hooks.

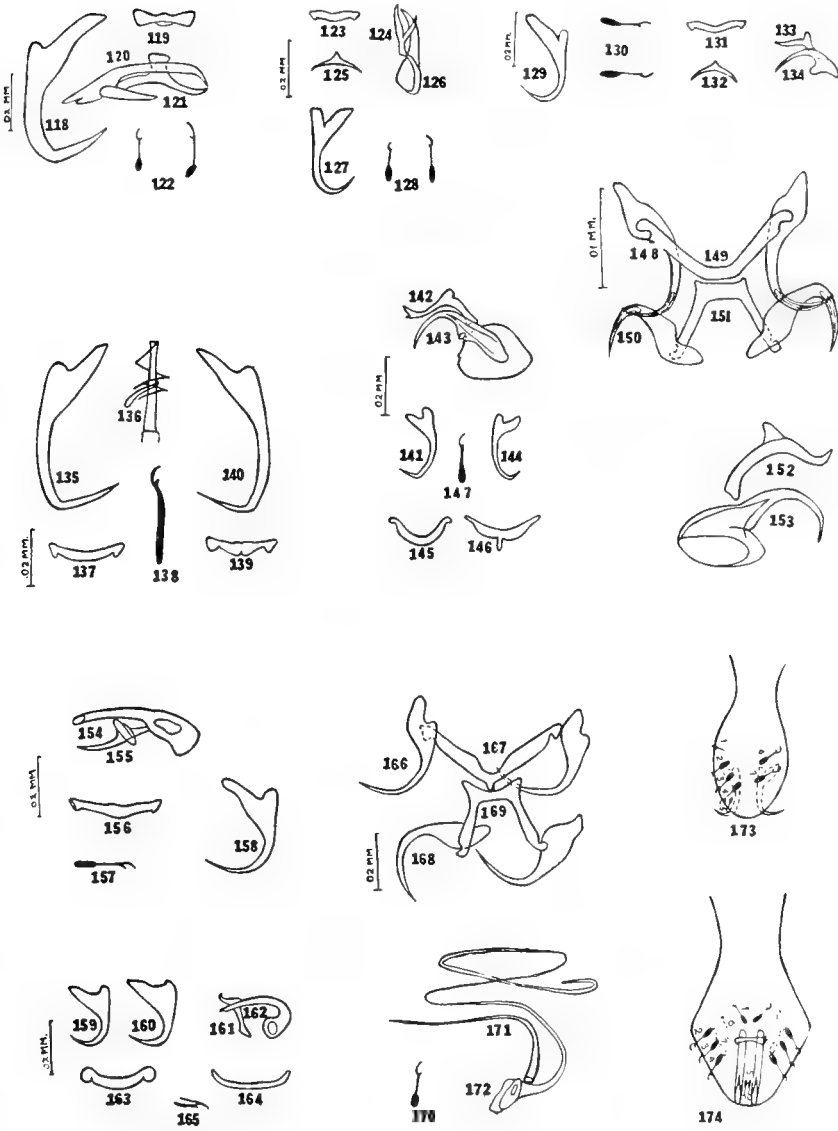


PLATE V





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