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STUDIES ON CESTODE PARASITES OF SHARKS AND SKATES[1]

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The cestode parasites of elasmobranch fishes present a great taxonomic problem partly because of the limited amount of work which has been done with them, and also because of the results of that work. A study of these parasites is almost impossible except where commercial fishing for elasmobranchs is carried on. Since these worms undergo autolysis much more rapidly than do any other groups of cestodes, observations of living worms must be made immediately and proper fixation methods must be instituted without delay. The external features of these helminths are quite distinctive while in many members of these groups, the internal characters seem monotonously similar. Thus Southwell (1930:178) wrote as follows of the Phyllobothriidae: "The similarity of the genitalia of the various species of this family is so great that it appears impossible to utilize these organs as a basis of classification except for the differentiation of species, and the same is true with regard to the vitelline glands and the musculature. The characters of the head, therefore, at present assume considerable importance for the purpose of classification." The majority of workers who have attempted to study the phyllobothriids have, knowingly or unknowingly, reached the same conclusions as Southwell. Hence, a great number of species have been described from external characters with only brief remarks concerning the internal anatomy. The external characters can be correlated with the internal anatomy for purposes of classification, but can not be used as the deciding taxonomic features since fixation alters the entire appearance of these worms, and this coupled with autolysis produces many strange results. Thus, Heller (1949) described a species of *Echeneibothrium* as *Anthobothrium cornucopia* van Ben. because the phyllidia did not show the characteristic loculi. In the same way, MacCallum described two new species, *Taenia rosaeformis* and *T. quadribothria,* in 1921 from specimens of a worm (recently described by Baer (1948) as *Rhinebothrium*

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rankini) which had been flattened under pressure. Structures such as the suckers of *Scyphophyllidium giganteum* (van Ben.) have never been reported, and the phyllidia of *Orygmatobothrium musteli* (van Ben.) have been described in a number of different ways. However, works of Zschokke (1888), Woodland (1927), Yamaguti (1934), Rees (1943, 1946, 1953) and Baer (1948) have made it possible to identify many species in spite of the condition of the preparations.

Since many taxonomic characters become lost or obscured following fixation, the following descriptions include data taken from both living specimens and prepared slides. In most cases, the total length which is recorded is that of specimens immediately upon removal from the host, and in the case of specimens over 40 mm. in length, was measured by suspending the helminths with the scolex downward. This length, of course, never was as great as the total length of the worms in saline, and was always greater than that of fixed specimens. Wherever possible, hook measurements and drawings were made from hooks isolated and oriented in polyvinyl-lacto-phenol.

In order to minimize distortion, especially of the scolex, specimens were stretched on glass plates and the fixative was pipetted onto them. Very small specimens and small free proglottids were first extended by swirling them in a minute quantity of saline in a 25 cc. Erlenmeyer flask and then hot fixative was added while the rotation of the flask was continued. Worcester's fluid, Lavdovsky's AFA, Carnoy 6:3:1, Maximow's modification of Zenker's fluid, and Kulschitzky's dichromate-sublimate fluid were used as fixatives. Kulschitzky's fluid is incomparable for histological studies on cestodes, but is not satisfactory for preparing toto-mounts.

Toto-mounts were stained with Galigher's standard alum haematoxylin, Mayer's alcoholic HCl carmine, or Celestin Blue. Initial clearing in methyl salicylate, followed by a brief wash in toluene before mounting in clarite or in HSR, proved advantageous in the moist atmosphere of the seacoast.

Most sections were cut at 13 micra, at which thickness reconstruction proved to be most simplified. However, the cells in some species tended to be so densely packed that sections had to be cut at 8 micra in order to interpret the anatomy. Heidenhain's azan stain was used routinely for histological purposes. Mallory's phosphotungstic acid-haematoxylin was used for confirmation.

Specimens from the Linton collection were in very poor condition and it was necessary to use the pyridine-permanganate-sulfite method of Riser (1950) in order to stain them.

Systematic Position

Woodland (1927) utilized basic morphological similarities in placing the tetrarhynchs and phyllobothriids as separate families in the Order Tetraphyllidea Carus, 1863. Although Dollfus (1942) was the only investigator to attack the system directly, pointing out that the basic motif of the tetrarhynchs tended to place them on the same taxonomic level as the Tetraphyllidea, this work has not been generally accepted. Dollfus (1942: 438) diagramed a phylogenetic tree in which he indicated that the tetrarhynchs diverged markedly from all the other groups, and in which he implied a close affinity between the Tetraphyllidea and Cyclophyllidea. In this latter instance, he indicated a very close relationship between the cyclophyllideans and proteocephalids, probably because of the convergent evolution of the organs of attachment. Fuhrmann (1931) stated that the Tetraphyllidea were the most primitive members of the sub-class Cestoda, and agreement on this point has been rather general (*vide* Wardle & McLeod, 1952). Riser (1949a:85) postulated a relationship between the Tetraphyllidea and Tetrabothriidae and Baer (1954) derived the latter from the former, raising the tetrabothriids to the rank of an order thus placing both groups as equal systematic units. These are the most important points concerning these parasites since Braun's (1900) work was published. The taxomonic history of these worms has been rather completely covered by Southwell (1925, 1930) and Wardle & McLeod (1952).

Basically, the cestodes diverge along two lines. One of these lines is characterized by a life-history involving three larval stages with the infective larvae not bearing embryonic hooks. The other line contains species in which two larval stages occur, and the infective larvae retain the embryonic hooks. In both lines, species appear in which more than one life-history stage may occur in a single host. Such shortened cycles are not common, and are indicators of specialization. *Proteocephalus filicollis* (Rud., 1802) should have three hosts in its life-history, but Meggitt (1914) reported the complete absence of the second intermediate host. Thus, the definitive host, in this case, was infected by a larva bearing embryonic hooks. Other examples of the loss of one intermediate host occur in the genus *Proteocephalus*. Likewise, *Hymenolepis nana* (von Siebold, 1852) should have a two host life-history, but all stages can occur in a single host. In this instance, the only intermediate host is lost, but the worm still can follow its normal pattern using an insect intermediate host. Exceptions diverge from the rule, and do not establish the rule.

The world of the cestode is monotonous, and convergence in life-history pattern as well as in morphology can be expected. The cestodes, as pointed out by Stunkard (1937) are probably

very old, possibly older than the vertebrates. Normal hosts have dropped out of life-histories, and in some cases, we can assume that new ones have been added. Speciation is still rapidly taking place among the parasites of warm-blooded vertebrates, which, as a group, have only recently appeared. On the other hand, speciation appears to be almost at a standstill among the parasites of elasmobranchs and the older bony fishes. We can not assume that any of the primitive cestode stock remains. We can, however, see that the two-host life-history is coenogenetic, and in the case of *Hymenolepis nana,* is progressing toward a one-host condition.

The two different life-history patterns establish distinct groups which are here considered as superorders.

SUPERORDER 1: TRIXENIDEA *nov.*

Vitellaria follicular, or paired lateral tubules, or a ventral vitellarium. Common vitelline duct extends posteriad to Mehlis' gland. Life-history involves three hosts of three larval stages. Infective larvae do not bear embryonic hooks.

SUPERORDER 2: DIXENIDEA *nov.* (=Order Cyclophyllidea Braun, 1900).

Dorsal vitellarium present. Common vitelline duct extends anteriad to Mehlis' gland or to union with fertilization passage. Life-history involves two hosts or two larval stages. Infective larvae bear embryonic hooks.

These two groups also seem to differ in the course followed by the fertilization passage, *i. e.,* it seems to always extend behind the Mehlis' gland in the Trixenidea, but to remain anterior in the Dixenidea. On the whole, descriptions of the Mehlis' gland complex are not numerous, and should be given more attention.

On the basis of the morphology of the plerocercoid larvae and the adults, the Trixenidea consists of three orders.

Order 1: Tetraphyllidea (=Order Tetraphyllidea Carus, 1863, *sensu* Fuhrmann, 1930, plus Diphyllidea Carus, 1863, and Tetrabothridea Baer, 1954)
Order 2: Pseudophyllidea Carus, 1863
Order 3: Trypanorhyncha Diesing, 1863, *sensu* Dollfus, 1942

The Tetraphyllidea demonstrate divergences which group them in the following systematic arrangement.

Superfamily 1: Phyllobothrioidea Southwell, 1930
Family 1: Phyllobothriidae Braun, 1900
Family 2: Onchobothriidae Braun, 1900
Family 3: Echeneibothriidae *nov*
Superfamily 2: Lecanicephaloidea Southwell, 1930
Family 1: Lecanicephalidae Braun, 1900, *sensu* Baer, 1948

Family 2: Cephalobothriidae Pintner, 1928
Family 3: Balanobothriidae Pintner, 1928
Family 4: Disculicipitidae Joyeux et Baer, 1935
Family 5: Echinobothriidae Fuhrmann, 1930
Superfamily 3: Proteocephaloidea Southwell, 1930
Superfamily 4: Tetrabothrioidea *nov.* (=Tetrabothridea Baer, 1954)

There is no great difference between this system and the familiar Carus-Braun-Luehe system. It does differ however, from the system recently proposed by Wardle and McLeod (1952) in that it places groups of equal systematic worth in equal categories, and attempts to express phylogenetic relationships. Wardle and McLeod placed the Echinobothriidae with lecanicephaloids, and my experience with this group induces me to concur.

The following host-parasite list includes the tetraphyllideans obtained in the survey of species from California elasmobranchs, and does not include helminths loaned or presented to author.

Host	Parasite
Hexanchus corinus	*Orygmatobothrium dohrnii*
Lamna ditropis	*Dinobothrium septaria*
	Phyllobothrium tumidum
Cetorhinus maximus	*Dinobothrium planum*
	Dinobothrium spinosum
Prionace glauca	*Anthobothrium laciniatum*
	Scyphophyllidum angustum n. com.
	Prosobothrium armigerum
	Cylindrophorus posteroporus n. sp.
Triakis semifasciata	*Phyllobothrium lactuca*
	Orygmatobothrium musteli
Rhinotriacis henlei	*Orygmatobothrium musteli*
Galeorhinus zyopterus	*Scyphophyllidium giganteum*
	Orygmatobothrium musteli
Raja binoculata	*Phyllobothrium radioductum*
	Echeneibothrium octorchis n. sp.
	Echeneibothrium myzorhynchum
	Pinguicollum pinguicollum n. com.
Raja inornata	*Discobothrium fallax*
	Pinguicollum pinguicollum
Raja montereyensis	*Phyllobothrium radioductum*
	Echeneibothrium octorchis n. sp.
	Echeneibothrium macrascum n. sp.
	Acanthobothrium brachyacanthum n. sp.
	Pinguicollum pinguicollum
Raja rhina	*Phyllobothrium radioductum*
	Echeneibothrium octorchis
	Echeneibothrium dolichoophorum n. sp.
	Pinguicollum pinguicollum
	Discobothrium fallax
Tetronarce californica	*Acanthobothrium hispidum* n. sp.
Aetobatus californicus	*Inermiphyllidium brachyascum n. g., n. sp.*
	Caulobothrium opisthorchis n. sp.
	Caulobothrium tetrascaphium n. sp.
	Acanthobothrium maculatum n. sp.

Much work remains to be done. The life-histories of cestodes have been barely touched. No life-histories have been completely studied in the Trypanorhyncha where the meager reports of Riser (1949b, 1951) and Ruszkowski (1932, 1934) have indicated the probable course. Riser (1949b) reported obtaining procercoid larvae of a species of *Acanthobothrium* by feeding eggs to copepods, and this is the only work on the early stages of the Phyllobothrioidea. The first intermediate hosts of the latter group are apparently crustaceans, and after working for ten years on these life-histories, the bottom copepods and isopods seem, to me, to hold the most promise.

Description of Species

Superfamily Phyllobothrioidea Southwell, 1930, emended

(Section Tetraphyllides van Ben., 1849; Section Tetraphylles van Ben., 1850; Family Tetraphyllidea Carus, 1863; Order Tetraphyllidea Braun, 1900, *pro parte,* Luehe 1910, *p.p.,* Wardle and McLeod, 1952, *p.p.*)

Scolex with pedicellate or sessile phyllidia. Strobila distinctly segmented externally. Genital pores marginal. Internal circular muscle layer absent. Innermost longitudinal muscles consist of bundles of fibers. Dorsal and ventral excretory vessels present on each side of the strobila, frequently only visible in the scolex and zone of growth. Internal seminal receptacle present. Uterine duct opens from the dorsal side into the uterus which extends anterior and posterior to this union. Uterine duct dorsal to vagina. Vagina dorsal to uterus. Ovary fundamentally quadripartite with the lobes lying against the longitudinal muscles. Vitellaria lateral, never meeting in the mid-line, follicles large. Uterus opens to the exterior by dehiscence through a specialized region of mid-ventral line of dermo-muscular sac. Vas deferens extends posteriad crossing under the vagina to enter cirrus pouch. Vaginal orifice anterior to that of cirrus. The thin-shelled eggs, at the time of liberation contain fully developed onchospheres. The second intermediate host may be an invertebrate or a teleost fish. Plerocercoid with phyllidia characteristic of the adult and with an apical organ ("fifth sucker"). Parasitic in elasmobranch and siluroid fishes.

Family Phyllobothriidae Braun, 1900

Phyllidia large and simple except for the presence of a single anterior accessory acetabulum on each in some genera. Immature proglottids broader than long. Vitelline follicles discreet. Mehlis' gland large, composed of many large claviform cells. Plerocercoids with large simple phyllidia with or without accessory acetabula; excretory vessels extend into phyllidia; body divided into three regions, vis., scolex, zone of growth, and caudal appendage into which anterior two regions can be retracted. Type genus: *Phyllobothrium* van Ben., 1850.

The most valuable character of generic worth in this family is the interrelation of the vitellaria, excretory ducts, testes, and ovarian wings. The relationship of these structures to one another is constant for each genus. Scolex characters are constant for a genus, but sometimes are shared by two or more genera.

Genus *Phyllobothrium* van Ben., 1850, emended

Craspedote apolytic cestodes with large, circular, leaflike phyllidia each bearing an anterior acetabulum. Genital atria muscular, irregularly alternating. Excretory vessels internal to or at medial ends of vitellaria and

lateral to testes; one dorsal and one ventral vessel on each side, lying one above the other. Testes in two or more layers. Ova spherical or subspherical. Type species: *Phyllobothrium lactuca* van Ben., 1850.

Phyllobothrium lactuca van Ben., 1850

nec P. lactuca Southwell, 1925, 1930

(Pl. 1, Fig. 3; Pl. 2, Fig. 4)

Specimens examined: I have obtained this species in small numbers on several occasions from *Triakis semifasciata* Girard caught in Monterey Bay, California, and from a single specimen of the same host caught in San Luis Obispo Bay, California.

Large worms reaching a length of greater than 250 mm. and breadth of 2-3 mm. Expanded scoleces 4-6 mm. in diameter, and 3 mm. in length; auxiliary acetabula 0.208 mm. in diameter. Contracted mature proglottids 0.34-0.43 mm. long by 1.05-1.85 mm., relaxed mature proglottids 0.58-1.26 mm. long by 0.93-1.20 mm., inversely proportional; contracted gravid proglottids 0.87-0.88 mm. long by 1.77-1.78 mm., relaxed gravid proglottids 1.86-1.92 mm. long by 1.21-1.24 mm. Excretory vessels at ends of ovarian wings. Genital atria 0.10-0.13 mm. deep, slightly anterior to middle of margin. Cirrus pouch 0.38-0.57 mm. long by 0.15-0.16 mm.; pouch not flexed, but with distal end anterior to genital atrium. Cirrus long, armed with short spines with large round bases. Ejaculatory duct very long and much coiled. More than 200 testes in each proglottid, 0.063 by 0.045-0.048 mm. in diameter by 0.063-0.069 mm. deep. Vagina extends anteriad from genital atrium to mid-line at about 45° angle; initial portion with thick muscular walls. Ovary in relaxed mature proglottids 0.33-0.34 mm. long by 0.46 mm.; in contracted mature proglottids 1.11-1.21 mm. wide by 0.13-0.16 mm. long. Mehlis' gland sometimes dorsal, sometimes ventral. Vitellaria densely packed, lateral to excretory vessels and testes. Ova 0.029 mm. in diameter.

A brief general description of this worm was given by van Beneden from material found in the spiral valve of *Mustelus vulgaris* Mueller et Henle. A rather complete description was given by Yoshida (1917) based on specimens obtained from *Cynias manazo* Bleeker. Woodland (1927) added a few notes to the description given by Yoshida from specimens collected from the type host. He pointed out that the species described by Southwell (1921) from *Galeocerdo tigrinus* Mueller et Henle and repeated (1925) for material from *Trygon kuhle* Mueller et Henle, and *T. walga* Mueller et Henle were not *P. lactuca*. He also mentioned that the free proglottids described by van Beneden were probably those of *Calliobothrium verticillatum* (Rud., 1819). This latter contention is not logical since *C. verticillatum* has a laciniated posterior margin, and van Beneden described and figured free proglottids of this species. The specimens of *P. radioductum* Kay, reported by Young in 1954 have proven to be *P. lactuca* on examination.

The most significant diagnostic features of the species are the compact vitellaria lying lateral to the testes and excretory vessels, and the cirrus pouch lying at an angle to the horizontal axis of the proglottid.

Phyllobothrium radioductum Kay, 1942

(Pl. 1, Fig. 5)

Specimens examined: The material examined came from the spiral valves of two *Raja rhina* Jordan and Gilbert, one *R. montereyensis* Gilbert, and three specimens of the type host, *R. binoculata* Girard, all from Monterey Bay. Only one to five specimens occurred in each host.

Small worms with a maximum length of 65 mm. Expanded scoleces 2.5 mm. in diameter; auxiliary acetabula on phyllidia 0.17-0.18 mm. in diameter. Immature proglottids near scolex imbricated. Contracted mature proglottids 0.30-0.54 mm. long by 1.12-1.17 mm. wide, relaxed mature proglottids 0.66-1.48 mm. long by 1.00-1.21 mm., inversely proportional; detached gravid proglottids 1.41-2.1 mm. long by 0.90-0.91 mm. Proglottids detach shortly after uterus begins to fill with eggs. Excretory vessels at ends of or just inside ovarian wings. Genital atria slightly anterior to middle of margin. Cirrus pouch 0.37-0.43 mm. long by 0.12-0.18 mm., pouch not flexed but with distal end anterior to genital atrium. Cirrus armed with minute spines which give a serrated appearance to inner wall. About 200 testes, 30-40 of which are post-poral; mature testes 0.30-0.33 by 0.22-0.27 mm. in diameter by 0.060-0.070 mm. deep. Vagina extends anteriad from genital atrium to mid-line at about 45° angle; initial portion with thick muscular walls. Ovary in relaxed mature proglottids 0.46 mm. long by 0.48-0.51 mm.; in contracted mature proglottids 0.18-0.22 mm. long by 0.83 mm.; in contracted gravid proglottids 0.54 mm. long by 0.60 mm. wide. Mehlis' gland dorsal. Vitellaria form arcs enclosing excretory vessels and most lateral testes. Ova 0.038-0.046 by 0.029 mm.

The description by Kay was incomplete, most of the significant measurements not being given. She erred in her interpretation of the excretory vessels in the scolex, describing a ring connecting the vessels from both sides. The vessels are very difficult to trace in contracted material. It is only safe to study the excretory and nervous systems in the scolex from relaxed expanded material.

This species differs from *P. lactuca* in size, the almost euapolytic nature of the gravid proglottids, the armature of the cirrus, the peculiar imbricated appearance of the immature proglottids behind the scolex, and primarily in the distribution of the vitellaria which pass dorsal and ventral to the excretory vessels and the most lateral testes.

Heller's (1949) slides of *P. dagnalli* Southwell (1927) in so far as can be determined, are morphologically identical with *P. radioductum*.

Phyllobothrium tumidum Linton, 1915

(Pl. 1, Figs. 4, 6, 7)

Material examined: Twenty-three specimens were obtained from two *Lamna ditropis* Hubbs & Follett landed at Monterey, California. A number of specimens were also obtained from the spiral valve of a *Carcharodon carcharias* (L.) which was landed at La Jolla, California, and the spiral valve forwarded to me by Dr. C. L. Hubbs.

Large slightly craspedote tapeworms reaching a length of 160 mm. and a breadth of 1.5 mm. Maximum breadth occurs in region of immature proglottids; strobila narrows posteriorly. Expanded scolex 4-5 mm. in diameter; anterior end of scolex projects as a cone from between the phyllidia; accessory acetabula 0.25-0.27 mm. in diameter. Relaxed mature proglottids 0.54-1.05 mm. long by 0.79-1.08 mm. wide, inversely proportional. Excretory vessels lateral to ovary. Longitudinal musculature poorly developed; dorso-ventral muscles well developed. Genital atria shallow, slightly anterior to middle of margin. Cirrus pouch 0.30-0.31 mm. long by 0.12-0.13 mm.; flexed in middle, posterior half directed anteriad. Cirrus armed with slender spines 0.018-0.021 mm. long; about 0.45 mm. long, 0.045-0.075 mm. in diameter tapering to connection with ejaculatory duct. Ejaculatory duct strongly convoluted 0.024-0.027 mm. in diameter. Numerous testes in each proglottid extending from anterior end of proglottid to ovarian isthmus ventral to ovary; mature testes 0.022-0.033 mm. in diameter by 0.054-0.060 mm. deep. Vagina ascends steeply to mid-line from genital atrium, ascending portion with very muscular walls. Ovary in mature proglottids 0.30 mm.

long by 0.30-0.32 mm.; only dorsal wing of ovary present. Mehlis' gland dorsal, 0.054 by 0.045 mm. in diameter. Vitellaria extend almost to mid-line. Ova 0.024-0.039 mm. in diameter, mostly 0.027.

Linton (1915) described this species from *Carcharodon carcharias* and *Isurus dekayi* Jordan and Gilbert. The figure for maximum length given in the above diagnosis is taken from the original description by Linton; my longest specimen was 90 mm. in total length when alive.

The musculature of this worm is strikingly different from that of the other members of the genus. The longitudinal muscles are restricted to a narrow zone just inside the circular layer except at mid-line where they fill the subcuticula. The strong development of the dorso-ventral fibers, and the unbalanced arrangement of the longitudinal muscles allow a rather unusual type of contraction to occur. The margins of the strobila curl inward and the worms coil upon themselves so that a specimen 73 mm. long when relaxed, was observed to contract into a tight spiral 12 mm. long.

The ganglia from which the transverse nerve commissures in the proglottids arise are very large, 0.021-0.024 mm. in diameter (Pl. 1, Fig. 6). The dorsal and ventral commissures joining these ganglia are significant in orienting the cestode strobila as reported by Riser (1949). In attached proglottids, of course, the two ganglia lie quite a distance from one another, but in free proglottids, they are drawn close together. In *Lacistorhynchus tenuis* (van Ben.) the ganglia of the free proglottids almost touch one another.

Kohler (1894) and Tower (1900) described the primary commissures as lying in the posterior part of proglottids of the cestodes with which they worked. Unfortunately, they selected forms in which internal delimitation of the proglottids is almost non-existent. Their statements, however, resulted in an almost universal opinion that the main commissures were posterior. This led Subramaniam (1939) to describe a free phyllobothriid proglottid as a monozootic cestode, *Biporophyllaeus madrassensis*, because the ganglia and primary commissures were at the anterior end. Recently, Wardle and McLeod (1952) established an order for this proglottid.

The species differs from all other members of the genus in that the phyllidia arise posteriorly from the lateral walls of the scolex leaving an anterior cone-like projection visible, the vitellaria extend almost to mid-line, and the ventral wing of the ovary is absent.

Genus *Orygmatabothrium* Diesing, 1954

(*Phyllobothrium* Southwell, 1930, *pro parte*.)

This genus differs from the other Phyllobothriidae in that the bothridial surfaces of the phyllidia are not entirely composed of muscles. The anterior acetabulum is muscular, and there is a circular ring of muscles in the center of each phyllidium. The excretory vessels lie one above the other on each side as in *Phyllobothrium*.

Only two species of the genus can at present be identified. Several species have been described, but the descriptions have been primarily of the scolex which is extremely variable since the contraction of the muscular ring induces profound changes in the appearance of the phyllidia. Type species: *Orygmatobothrium musteli* (van Ben., 1850) Diesing, 1854.

Orygmatobothrium musteli (van Ben., 1850) Diesing, 1854

(Pl. 2, Figs. 1, 7, 9)

(*Anthobothrium musteli* van Ben. 1850, Southwell, 1925, Woodland, 1927, *Orygmatobothrium velamentatum* Yoshida, 1917)

Slender, craspedote, hyperapolytic cestodes reaching a maximum length of 45 mm. and consisting of 200 or more proglottids. Relaxed phyllidia 0.23-0.43 mm. long by 0.15-0.21 mm. Strobila begins immediately behind scolex;

mature proglottids square to longer than broad; end proglottids 1.53-3.30 mm. long by 0.43-0.70 mm. wide; free mature proglottids 4-6 mm. long by 0.9-1.2 mm. wide; free gravid proglottids 7.1-9.3 mm. long by 1.4-2.2 mm. wide. Cuticle serrate. Excretory vessels at mediad end of vitellaria; ventral vessel 0.012-0.033 mm. in diameter; dorsal vessel minute, zig-zags. Genital atria alternate irregularly in anterior ¼ of margin. Cirrus pouch in end proglottids 0.28-0.37 mm. long by 0.16-0.22 mm.; in free mature proglottids 0.33-0.36 mm. long by 0.21 mm.; in free gravid proglottids 0.34-0.45 mm. long by 0.25 mm. Cirrus long, strongly coiled, armed with fine hair-like bristles; everted cirrus with inflated bulb at base, bulb 0.24-0.27 mm. long by 0.21-0.24 mm. wide. 150-200 testes in four rows, one layer deep, on each side of vagina, rows coalescing anterior to genital atrium; mature testes almost round, 0.09-0.12 mm. in diameter. Vagina flexes anteriad to pass around heavy coils of vas deferens. Uterine duct coiled, opens into posterior ¼ of uterus. Ripe uterus with lateral sacculations. Mature uterus fills entire proglottid. Mature ovary 1.24-1.30 mm. by 0.85-0.90 mm., anterior lobes longer than posterior. Mehlis' gland 0.135 mm. by 0.180 mm. Ova round, 0.021-0.024 mm. in diameter; onchosphere 0.009-0.012 by 0.015 mm.

Van Beneden described this species from *Galeus canis* Rondelet (=*Galeorhinus galeus* Blainville), *Mustelus vulgaris,* and *Scillium canicula* (L.). Zschokke (1888) described it in detail from *Mustelus vulgaris* and *M. laevis* Risso. Woodland's specimens were from *M. vulgaris.*

Every specimen of *Rhinotriacis henlei* Gill and *Triakis semi-fasciata* which I have examined (over 50 of each) has been heavily parasitized with this tapeworm. On two occasions, I have found numerous specimens in *Galeorhinus zyopterus* Jordan and Gilbert.

The phyllidia of specimens in sea water soon develop exotic appearances. The muscular ring contracts and the velum-like margins hang in all sorts of arrangements. Van Beneden studied the living worm, and saw these modifications. Later workers diagnosed two genera from the figures given by van Beneden and helminthologists since that time have continued to perpetuate this error.

Orygmatobothrium dohrnii Oerley, 1885

(*Phyllobothrium dohrnii* Southwell, 1925, Joyeux et Baer, 1936, Rees, 1946, Wardle & McLeod, 1952, *Crossobothrium laciniatum* Linton, 1889, *Crossobothrium campanulatum* Klaptocz, 1906)

A detailed description of this species was given by Rees (1946). I have found a single specimen in a *Hexanchus corinus* Jordan and Gilbert from San Luis Obispo Bay, California. The specimen was dead and thus no details can be given of its morphology. It measured 270 mm. in length and the auxiliary acetabula were 0.173-0.176 mm. in diameter.

The species differs from *O. musteli* in the laciniate posterior margins of the proglottids, the greater size, the position of the genital atrium just behind the middle of the margin, and the origin of the uterus as a ball of cells instead of as a rod.

Genus *Anthobothrium* van Ben., 1850 emended

(*Phyllobothrium* Southwell, 1930 *pro parte*)

Scolex bears four sub-circular phyllidia with long pedicels inserted at a point near the lower border. Longitudinal muscles poorly developed, bundles containing more than three fibers very rare. Dorsal and ventral excretory vessels lie one above the other at the ends of the vitelline fields, and are not enveloped by the ovary. Ovary lobulate, filling all of medulla between excretory vessels. Type species: *Anthobothrium cornucopia* van Ben., 1850.

Anthobothrium laciniatum Linton, 1890

(Pl. 1, Figs. 1, 2)

(*Anthobothrium cornucopia* Southwell, 1925, *pro parte;* Iwata 1939)

Small, craspedote, hyperapolytic cestodes with a maximum length of 50 mm. and consisting of about one hundred proglottids. Posterior border of all proglottids prolonged at margins to form a characteristic dorsal and ventral projection on both sides. Proglottids begin immediately behind scolex. Anterior 80 or 90 proglottids broader than long (anteriormost proglottids frequently stretched abnormally so that they become longer than broad). Mature end proglottids 1.1-1.8 mm. by 0.61-0.93 mm.; free proglottids 6-7 mm. by 1.0-1.6 mm. Phyllidia weakly developed, 0.018-0.030 mm. thick; no morphological differentiation of surfaces. About 115 testes in each proglottid, 40-50 postporal; 0.09-0.10 mm. in diameter. Genital atria alternate irregularly in anterior ¼ of margin. Cirrus pouch in end proglottids 0.25-0.30 mm. by 0.07-0.09 mm.; in free proglottids 0.25-0.33 mm. by 0.16-0.24 mm. Cirrus armed with small spines with large round bases; bulb at base when everted 0.165 mm. in diameter and 0.21 mm. long. Ovary 0.66-0.69 mm. by 0.64-0.67 mm.; posterior lobes longest. Uterine duct opens into posterior half of uterus. Mehlis' gland 0.13-0.15 mm. by 0.09-0.10 mm. Ova 0.018-0.026 mm. in diameter.

This species has occurred in great numbers in all specimens of *Prionace glauca* which I have examined from Monterey Bay. Yamaguti gave a very satisfactory diagnosis of this species which he obtained from *Scoliodon walbeehmi* (Bleeker).

Linton (1890) described *A. laciniatum* from *Carcharias obscurus* Mueller and Henle. Later (1901, 1905, 1924), he reported it from a number of predacious sharks including *Prionace glauca* (Linnaeus). He described two varieties, viz., *brevicollis* and *longicollis* which actually were the result of the extended or contracted state in which the animal was killed.

Woodland (1927) pointed out that in *A. cornucopia,* the ovary was not typically X-shaped in transverse sections, but that it was papillate with tubules extending dorsally and ventrally.

A complete description of *A. cornucopia* was given by Zschokke (1888) in his invaluable memoir. The presence of an unsegmented "neck", as described by van Beneden, was verified and the number of testes was given as about 350.

A. laciniatum seldom reaches half of the length of *A. cornucopia.* It also differs in the absence of an unsegmented region behind the scolex, the smaller number of testes, and the armature of the cirrus.

Many workers have considered the two species synonymous (Southwell, 1925, Borcea, 1934, Joyeux et Baer, 1936), but not only do the species differ morphologically, but this is also one of the few instances in which a definite host correlation can be seen. Van Beneden, Zschokke, and Woodland have reported *A. cornucopia* from *Galeus vulgaris.* Zschokke also reported it in a species of *Raja,* while Borcea described it from *Trygon pastinaca* Linnaeus. *A. laciniatum* occurs in the large predacious carcharinids. It is difficult to visualize how a species so abundant in *P. glauca* in Monterey Bay is not found in *Galeorhinus zyopterus,* a close relative of *Galeus vulgaris,* if the worms are the same species.

As pointed out in the introduction of this paper, the *A. cornucopia* of Heller (1949) is a species of *Echeneibothrium.*

Genus *Scyphophyllidium* Woodland, 1927, emended

Phyllidia with muscular bothridial surfaces and an anterior accessory acetabulum. An unsegmented zone of growth absent. Dorsal and ventral excretory vessels present; dorsal vessel lateral to testes and internal to

vitellaria; ventral vessel internal to ovarian wings and vitellaria and ventral to testes. Oöcapt ventral. Mehlis' gland dorsal. Vitellaria extend dorsal and ventral around testes from the margin. Testes two or more layers deep. Ova spindle-shaped. Type species: *Scyphophyllidium giganteum* (van Ben., 1858) Woodland, 1927.

Scyphophyllidium giganteum (van Ben., 1858) Woodland, 1927

(Pl. 2, Figs. 5, 8; Pl. 3, Fig. 1)

(*Anthobothrium giganteum* van Ben., 1858, *Tetrabothrium maculatum* Olsson, 1866)

Specific diagnosis: Large, acraspedote, apolytic worms up to 384 mm. in length and 3.4 mm. breadth and consisting of several hundred proglottids. Phyllidia boat-shaped when relaxed, sucker-like when contracted; auxiliary acetabulum 0.21-0.22 mm. in diameter. Breadth of scolex across phyllidia 1.32-1.45 mm. Muscular bothridial surface 0.054 mm. thick, behind this a glandular layer 0.15 mm. thick. Mature proglottids broader than long, 0.72-0.78 mm. long by 1.65-1.72 mm.; gravid proglottids 0.81-3.0 mm. long by 1.68-3.40 mm. wide, strongly umbonate ventrally. Several hundred lobulate testes in each proglottid, 0.036-0.057 mm. by 0.024-0.036 mm. Genital atria alternate irregularly, 0.03 mm. deep, in anterior third of margin. Cirrus pouch 0.26 mm. by 0.19 mm. in mature proglottids; 0.37-0.41 mm. by 0.21-0.22 mm. when seminal vesicle is full. Cirrus short, lined with fine hair-like bristles. Vas deferens forms a seminal vesicle in cirrus pouch; ejaculatory duct long and coiled. Vagina passes horizontally to mid-line then turns posteriad; vaginal orifice with thick muscular walls. Ovary short and wide, enclosing both excretory vessels. Mehlis' gland 0.18 by 0.15-0.16 mm. in diameter. Ovarian isthmus 0.135-0.150 mm. by 0.135 mm. wide; ovarian lobes 0.57-0.91 mm. long tapering abruptly laterad. Uterus retort-shaped, anterior portion adheres to vagina in the latter's horizontal course since the uterine duct enters the uterus on the latters dorsal, poral side. Gravid uterus fills most of proglottid between vitellaria. Vitellaria extend almost to mid-line. Ova 0.151-0.165 mm. by 0.016 mm.; onchosphere 0.075-0.090 by 0.060 mm.

This species has been found in four of the seven *Galeorhinus zyopterus* Jordan and Gilbert from Monterey Bay, which have been examined. The infestations were always small, not over five specimens being present in a spiral valve. The specimens upon which van Beneden based his description were collected from the spiral valve of an unidentifed shark. Olsson described *Tetrabothrium maculatum* from *Lamna cornubica*. He also described *Anthobothrium cornucopia* van Ben., 1850, from this host, and I feel justifiably certain that the host was misidentified, and actually was *Galeus vulgaris*. Olsson admitted that his species was very much similar to that of van Beneden, and hesitated in describing it as a new species. Woodland obtained his material from *Galeus vulgaris* Fleming. *G. vulgaris* and *Galeorhinus zyopterus* were considered to be synonyms of *Eugaleus galeus* Gill by Garman (1913), but Jordan and Gilbert (1883) considered that the difference in dentition warranted the distinction of these two forms as two separate but closely allied species.

The accessory suckers have not been previously reported. The anatomy of the proglottids has been carefully worked out by Woodland (1927) but since he did not see living material, he failed to see the accessory suckers, and considered the contracted phyllidia to be suckers. He also failed to mention the structure of the phyllidia which, as is noted in the species diagnosis, are divided into two layers, a muscular bothridial layer beneath which lies a thick layer containing numerous large unicellular glands. The glands are not present in the region where the pedicel joins the phyllidium.

Woodland's specimens were immature; thus he was unable to make observations concerning the uterus. The unique method by which the uterine duct and uterus unite at the level of the genital atrium is the result of the uterine duct lying on the dorsal, poral side of the vagina and thus it does not free itself of the vagina until after the latter begins its horizontal course. The uterus dehisces anteriorly to form a single large opening primarily anterior to the level of the genital atrium. The longitudinal muscle bundles fill the entire space between the sub-cuticula and the vitellaria. The longitudinal muscles in the sub-cuticula are scattered individual fibers. This is another species in which the ganglia in the proglottids are very large.

Scyphophyllidium angustum (Linton, 1889) n. com.
(Pl. 2, Figs. 2, 3, 6)

(*Orygmatobothrium angustum* Linton, 1889; Yoshida, 1917; *Crossobothrium angustum* Linton, 1901; *Phyllobothrium prionacis* Yamaguti, 1936, Wardle & McLeod 1952)

Specific diagnosis: Small, slender, craspedote, hyperapolytic worms reaching a length of 35 mm. and consisting of 100-200 proglottids. Scolex small; phyllidia 0.42-0.52 mm. by 0.16-0.30 mm.; auxiliary acetabula 0.105-0.130 mm. in diameter. Muscular bothridial surface 0.024-0.030 mm. thick. Mature proglottids longer than broad; mature end proglottids 2.55-3.37 mm. by 0.33-0.48 mm., inversely proportional. Free gravid proglottids 7 mm. by 0.9-1.1 mm. Cuticle serrated. Internal longitudinal muscle bundles not intermingled with outer longitudinal muscle fibers. Genital atria in anterior ¼ of margin. Cirrus pouch in mature proglottids 0.18-0.30 mm. by 0.075-0.150 mm.; in free proglottids 0.42 mm. by 0.15-0.18 mm. Everted cirrus inflated at base, bulb 0.225-0.30 mm. by 0.165-0.185 mm.; armed with stiff bristles 0.009 mm. long. Vagina rises slightly anteriad as it passes vas deferens. Ovarian lobes long, enclosed by vitellaria; posterior lobes longer than anterior; ovary in free ripe proglottids 1.17-1.20 mm. long by 0.42-0.45 mm. maximum breadth. Uterine duct opens into uterus about 1/3 the distance between ovarian isthmus and genital atrium. Ova 0.165 mm. by 0.015 mm.; onchospheres 0.075-0.081 by 0.060 mm.

Linton has reported this tapeworm from four species of sharks of the genus *Carcharinus*, and also from *Carcharius taurus* Rafinesque, *Galeocerdo arcticus* Faber, *Prionace glauca* (=*Galeus glaucus* Rondelet), and *Vulpecula marina* Valmont all from the Atlantic seaboard of the United States. Yamaguti (1936) described *Phyllobothrium prionacis* from *Prionace glauca;* this host has a circumglobal distribution, and thus it was not surprising to find specimens from the California coast also parasitized by *S. angustum*. The worm dies very soon after the death of the host, and must be examined and killed within a maximum of two hours after the shark is landed. Although the species has been abundant in all of the *Prionace glauca* from Monterey Bay which have been examined, only two lots of satisfactory material have been obtained.

Inermiphyllidium, new genus

(*Anthobothrium* Linton, 1890-1924, *pro parte*, Southwell, 1925, *pro parte*, Joyeux et Baer, 1936, *pro parte*, Wardle & McLeod, 1952, *pro parte*)

Scolex bears four, large, sub-circular, unarmed phyllidia. Bothridial surface of phyllidium internally delimited. Strobila begins immediately behind scolex. Inner longitudinal muscle bundles form a distinct layer separate from the outer layer. Ventral excretory vessel large, either ventral or midway between dorsal and ventral surfaces; dorsal vessel small, midway between dorsal and ventral surfaces, lateral to ventral vessel; both vessels lie between ovarian lobes. Cirrus pouch and vagina follow an "S"-shaped course

between excretory vessels. Nerve cord dorsal to cirrus pouch and vagina. Vitellaria compact, arch mediad around lateral testes, nerve cord, and excretory vessels. Ovary distinctly quadripartite. *Anthobothrium*, the other phyllobothriid genus in which the phyllidia are unarmed, has dispersed vitelline follicles, the dorsal and ventral excretory vessels lie one above the other and do not lie between the lobes of the ovary, and the ovary is papillate and not typically quadripartite. Type species: *Inermiphyllidium pulvinatum* (Linton, 1890) n. com.

Anthobothrium auriculatum (Rud.) of Rees, 1943, is difficult to place generically. The arrangement of the excretory vessels, one above the other; the nerve cord outside the vitellaria, and the presence of a myzorhynchus definitely exclude this species from the genus *Inermiphyllidium*.

Inermiphyllidium pulvinatum (Linton, 1890) n. com.

(Pl. 3, Fig. 7, Pl. 4, Fig. 6)

(*Anthobothrium pulvinatum* Linton, 1890, 1897, 1900, 1901, 1905, 1910, 1911, 1924; Southwell, 1925, *pro parte;* Joyeux et Baer, 1936; Wardle and McLeod, 1952)

Two mature strobilae from *Dasyatis centrura* Jordan and Gilbert collected by Linton at Woods Hole, Mass., were presented to me for this study by Dr. D. H. Wenrich. Additional specimens were collected by the author during the summer of 1952.

(All italicized data are from Linton, 1890).

Large, craspedote, apolytic cestodes reaching a length of 55 *cm* and consisting of several hundred proglottids. Relaxed phyllidia large, 3 mm. in diameter in alcohol; contracted phyllidia purse to form sac-like structures with aperture directed anteriorly. Contracted mature proglottids 0.78-0.90 mm. long by 2.40-2.55 mm. wide; *end proglottids 2 mm. long by 2 mm. wide; free proglottids 4.5 mm. long by 3 mm.* Normal end proglottids shaped like a shepherd's purse. Ventral excretory vessel 0.18-0.19 mm. in diameter; dorsal vessel 0.012-0.030 mm. in diameter. Excretory vessels extend into phyllidia. Muscle bundles of inner longitudinal layer large; layer one or two bundles deep. Genital atrium muscular, slightly anterior to middle of margin. Cirrus pouch 0.73-0.75 mm. long by 0.31-0.33 mm. Cirrus sparsely armed with small rose-thorn-shaped spines 0.003-0.006 mm. long. More than 150 spherical testes in each proglottid, 50-60 postporal; mature testes 0.060-0.063 mm. in diameter. Vagina ascends from genital atrium to anterior end of uterus before turning posteriad. Ovary in contracted mature proglottids 0.45-0.52 mm. long by 1.92-2.02 mm. wide. *Ova* 0.028 *by* 0.036 *mm.* The type host of this species is *Dasyatis centrura*, in which it is a very common parasite. In 1924, Linton reported it also from *Squalus acanthias* Linnaeus. Most of the specimens collected in 1952 were 18 cm. in length with many free proglottids present. The specimens described by Southwell in 1925 from *Chiloscyllium indicum* lacked postporal testes, and disagreed in many respects from Linton's species. Its actual systematic position can not be ascertained until additional material is observed.

Inermiphyllidium brachyascum n. sp.

(Pl. 3, Fig. 7)

Large, craspedote, apolytic cestodes reaching a length of more than 15 cm. and a breadth of greater than 1.5 mm. Expanded phyllidia 4.9-5.1 mm. in diameter in living worms, 2.8-3.4 mm. in toto mounts. Contracted mature proglottids 0.60-0.81 mm. long by 1.17-1.27 mm., inversely proportional. Ventral excretory vessels 0.06-0.10 mm. in diameter; dorsal vessel 0.03-0.05 mm. in diameter. Inner longitudinal muscle layer two or more bundles deep; bundles almost all equal in size. Genital atrium muscular, 0.07-0.10 mm. deep, about in middle of margin. Cirrus pouch 0.25-0.28 mm. long by

0.12-0.13 mm. Cirrus armed with small rose-thorn-shaped spines 0.006-0.009 mm. long. 110-130 testes in each proglottid, 26-28 postporal; mature testes 0.075-0.09 mm. in diameter by 0.1-0.14 mm. deep. Vagina ascends from genital atrium to anterior tip of uterus before dropping posteriad. Ovary in contracted mature proglottids 0.27-0.45 mm. long by 0.75-1.02 mm., inversely proportional.

Type host: *Actobatus californicus Gill.*

Type locality: Monterey Bay, Calif.

Type Specimen: U. S. N. M. Helm. Coll. No. 37409.

Three mature worms were found in a mature female sting ray. None of the strobilae bore gravid proglottids. The living worms moved about quite freely with the aid of the giant phyllidia which were frequently attached to the surface film of the saline as well as to the bottom of the dish. The excretory vessels form a hairpin loop just inside the base of the phyllidium. It seems strange that the excretory vessels do not extend to the margins of these giant phyllidia since they invariably do in other forms with large phyllidia such as *I. pulvinatum, Phyllobothrium lactuca,* etc. The species differs from *I. pulvinatum* in the shortness of the cirrus pouch, in the smaller number of testes, smaller size of the ovary in mature proglottids, and the arrangement of the muscle bundles in the inner longitudinal layer. The spines on the cirrus of *I. brachyascum* are densely packed, while in *I. pulvinatum,* they appear to be definitely spaced. There is neither an inner nor an outer muscular ring in the phyllidia of *I. brachyascum,* though both are present in those of *I. pulvinatum.*

Genus *Dinobothrium* van Ben., 1889, emended

(*Phyllobothrium* Southwell, 1925, *pro parte, Gastrolecithus* Yamaguti, 1952)

Scolex with four large muscular phyllidia joined together in pairs. Each phyllidium surmounted by a muscular auricle; the outermost ends of which terminate in bifurcated flanges. An accessory sucker present on internal mediad surface of auricle. Uterus with lateral sacculations. Genital atria alternate irregularly. Type species: *Dinobothrium septaria* van Ben., 1889.

This genus has been the subject of recent studies by Sproston (1948), Baylis (1950), and Yamaguti (1952). *Dinobothrium* is strikingly different from all of the members of the superfamily in the characters of the scolex. The scolex is morphologically quite similar to that found in some of the Tetrabothriidae.

Three of the known species of the genus *Dinobothrium* are represented in California sharks. A minute species, *Dinobothrium spinosum* Baylis, 1950, the gravid strobilae of which were less than 20 mm. long was found in a single specimen of *Cetorhinus maximus.* The specimens of this worm showed no features not already described by Baylis in his type description.

Dinobothrium septaria van Ben., 1889

(Pl. 3, Figs. 2, 6)

For synonymy, see Baylis, 1950.

Large acraspedote worms reaching a length of over 21 cm. and consisting of several hundred proglottids all over 1 mm. wide. Phyllidia 3.4-3.8 mm. wide by 4.2-6.1 mm. long. Auricles 2.4-2.6 mm. in horizontal length. Mature proglottids (slightly contracted) 2.8-3.3 mm. long by 1.5-1.6 mm. wide. Ripe proglottids 4 mm. long by 1.6-1.8 mm. Over 400 oval testes 0.30-0.40 by 0.21-0.25 mm. in diameter and 0.051 mm. deep; 55-80 post poral. Genital atria 0.18-0.21 mm. deep, slightly posterior to middle of proglottid. Cirrus pouch 1.27-1.45 mm. long by 0.30-0.31 mm. wide tapering to 0.19-0.22 mm. at tip, long axis of pouch almost in longitudinal axis of proglottid. Cirrus 1.05-1.33 mm. long, armed with rose-thorn-shaped hooks 0.018-0.029 mm.

long with bases 0.009-0.015 mm. wide. Ejaculatory duct long with many coils inside cirrus pouch. Vagina with numerous thick coils extends anteriad to mid-line at anterior end of proglottid, then turns posteriad. A single vaginal sphincter 0.195-0.225 mm. internal to orifice. Ovary 0.60-0.75 mm. long by 0.84-0.90 mm. Mehlis' gland 0.15-0.16 mm. long by 0.075-0.081 mm. Maturing uterus with thirty or more long finger-like branches, most posterior of which are directed back over the ovary.

This species occurred with *Diplobothrium simile* van Ben., 1889, on one occasion in the spiral valve of a *Lamna ditropis* caught in Monterey Bay. It was recovered with *Phyllobothrium tumidum* and *Nybelinia* sp. in two other *L. ditropis* taken from the same vicinity. The species was described by van Beneden from some immature specimens from *Lamna cornubica*.

The two specimens of *Diplobothrium simile* yielded the following information (Pl. 3, Figs. 3, 5).

Large acraspedote worms reaching a length of over 190 mm. and consisting of several hundred proglottids. Scolex 3.2-3.6 mm. wide. Phyllidia cupped. Auricles 1.1-1.3 mm. in horizontal length. Mature proglottids 1.74-1.80 mm. long by 2.17-2.26 mm.; gravid proglottids 2.4-3.0 mm. long by 1.6-1.9 mm. About 400 spherical testes 0.051-0.057 by 0.051-0.069 mm. in diameter and 0.051-0.072 mm. deep. Genital atria 0.135-0.165 mm. deep, slightly posterior to middle of proglottid margin. Cirrus pouch 0.81-0.85 mm. long by 0.3 mm.; directed anteriad. Cirrus 0.91 mm. long, armed with rose-thorn-shaped spines 0.024 mm. long with bases 0.012-0.015 mm. wide. Ejaculatory duct short with 3 or 4 large coils in cirrus pouch. Vagina coils anteriad to mid-line then turns posteriad; two sphincters, one at orifice and one 0.27-0.31 mm. internal to orifice. Ovary 0.033-0.036 mm. by 1.20-1.27 mm. Mehlis' gland 0.090 by 0.096 mm. Maturing uterus with about twenty rounded lateral sacculations. Ova 0.025-0.030 mm. in diameter.

The above diagnosis is from two specimens found in one of three *Lamna ditropis* caught in Monterey Bay, Calif.

This species was described by van Beneden from some immature specimens from a *Lamna cornubica* landed at Ostend, Belgium. Loennberg (1892) added a little information concerning the anatomy of specimens also from the type host.

The phyllidia of these worms tend to form cups when contracted and contain clusters of unicellular glands as well as multicellular neurones among the bothridial muscles. The auricles are very short and do not bear prongs. The size and shape of the proglottids, testes, ovary, uterus, and cirrus pouch, and ejaculatory duct in many ways seem to indicate a distinct species and yet, many of these features could be the result of excessive contraction of specimens of *D. septaria*, and thus the species must remain questionable.

Dinobothrium planum Linton, 1922

(Pl. 4, Fig. 7)

For synonymy see Baylis, 1950.

Large craspedote worms reaching a length of 114 cm. Phyllidia to 11 mm. in length and 6 mm. in breadth. Auricles to 4 mm. in horizontal length. All proglottids broader than long; mature and ripe proglottids 0.67-0.75 mm. long by 3.6-5.1 mm. wide. Ventral excretory vessel 0.73-1.05 mm. in diameter; dorsal vessel 0.030-0.063 mm.; numerous small lateral branchlets given off at random from ventral vessel. Numerous densely packed testes 0.072-0.078 by 0.060-0.078 mm. in diameter by 0.060-0.093 mm. deep. Genital atria in about middle of margin. Cirrus pouch 0.45-0.78 mm. long by 0.165-0.210 mm.; long axis in transverse axis of proglottid. Cirrus armed with very thin spines 0.012-0.018 mm. long. Vagina convoluted, extends

directly to mid-line; proximal 0.45 mm. of vagina with thick muscular walls. Mature ovary 0.40-0.43 mm. long by 0.82-0.90 mm. Mehlis' gland ventral. Vitellaria ventral, in two lateral bands between excretory vessels and mid-line. Gravid uterus with two lateral branches on each side. Ova 0.052-0.065 mm. in diameter.

Linton (1922) described this species from the spiral valve of a *Cetorhinus maximus* taken off the New England coast. The form had previously been described by Mola (1906), Masi (1912), and Nybelin (1914) as *D. septaria*, from European waters, and has been the subject of several investigations in recent years. I found twelve to forty-two specimens in each of the nine specimens of *C. maximus* which I examined from Monterey Bay.

The species is apparently restricted to the basking shark, a circumglobal plankton feeder, and is remarkable for its large size. The length measurements were made from specimens directly removed from the fresh spiral valve, and suspended scolex down.

The significant characters which differentiate this species from the other members of the genus are; the horizontal position of the cirrus pouch, the quadripartite configuration of the uterus, the ventral distribution of the vitellaria, the very short wings of the ovary, and the craspedote strobila. Yamaguti (1952) considered these characters adequate for establishing a separate genus, *Gastrolecithus*, for the species. Characters of family or generic worth in one group of animals may only be of specific value in another group, and I can see no valid reason for splitting the genus *Dinobothrium*.

Family Echeneibothriidae *nov.*

Phyllidia pedicellate, elongate, oval, with bothridial surface muscular and divided by temporary ridges into loculi. Type genus: *Echeneibothrium* van Ben., 1850.

The genera *Echeneibothrium, Rhinebothrium, Caulobothrium* and *Spongiobothrium* are mutually similar in the structure of their phyllidia. A group of plerocercoids are known with scoleces as in the family diagnosis, and with the bodies consisting of the scolex and a zone of growth but without a flaccid caudal appendage.

Genus *Echeneibothrium* van Ben., 1850 emended

Bothridial surface not strongly muscular, ridges between loculi obscured on contraction. Myzorhynchus present. Proglottids begin immediately behind scolex, first proglottids broader than long; no postporal testes. A single dorsal and ventral row of vitelline follicles on each side. Vitellaria lateral to excretory vessels and testes. Ovary compact, enclosing excretory vessels between lateral lobes. Oöcapt ventral. Mehlis' gland dorsal. Type species: *Echeneibothrium variabile* van Ben., 1850.

Echeneibothrium octorchis n. sp.

(Pl. 5, Figs. 1, 4)

Small, craspedote, hyperapolytic tapeworms 5 mm. in maximum length and consisting of about 25 proglottids. Phyllidia to 0.5 mm. in length with typically 10 loculi formed by a single longitudinal and four transverse ridges which divide each phyllidium into four pairs of loculi with a single loculus at either end. Abothridial surface of phyllidia and pedicels armed with small curved hooks. Contracted myzorhynchus 0.045-0.075 mm. in diameter; myzorhynchal organ 0.021 mm. long by 0.03 when myzorhynchus is everted. Last 5 or 6 proglottids longer than broad; end proglottids 0.51-0.63 mm. long by 0.155-0.195 mm. wide. Genital atria alternate irregularly; slightly posterior to middle of margin. Cirrus pouch 0.087-0.111 mm. long by 0.051-0.066 mm. Cirrus armed with fine hairs. 7-9 testes, usually 8, in each proglottid; mature testes 0.051-0.06 by 0.06-0.075 mm. in diameter. Last 9-13 proglottids

contain testes. Ovary in end proglottid compact; ratio of length of ovary to end proglottid length 1/3—1/4. Ova 0.021-0.024 by 0.021 mm.

Type host: *Raja montereyensis* Gilbert.
Type locality: Monterey Bay, Calif.
Type specimen: U.S.N.M. Helm. Coll. No. 37410

This species was abundant in all four specimens of the type host which were examined. It was recorded also from *Raja binoculata* and *R. rhina*.

A free proglottid stained and mounted in clarite was 0.735 mm. long by 0.190 mm. wide. The ovary was 0.24 mm. long and the genital atrium was in the middle of the margin. The genital atrium was 0.012 mm. deep.

This species differs from all species previously described in the small size of the strobila, and number of testes.

Echeneibothrium dolichoophorum n. sp.
(Pl. 5, Figs. 2, 5)

Small, craspedote, hyperapolytic cestodes up to 7 mm. in length and consisting of about 35 proglottids. Phyllidia to 0.3 mm. in length with ten loculi formed by a single longitudinal and four transverse ridges which divide each phyllidium into four pairs of loculi with a single loculus at either end. Contracted myzorhynchus large and bulbular, 0.09-0.105 mm. in diameter. End proglottids 0.46-0.72 mm. long by 0.165-0.210 mm. wide. Genital atria alternate irregularly in middle third of proglottid margin. 11-13 testes in each proglottid; mature testes 0.051-0.57 by 0.039-0.042 mm. in diameter. Last 17-19 proglottids contain testes. Cirrus pouch 0.081-1.02 mm. long by 0.27-0.63 mm. Ovarian wings in end proglottids long and narrow, 0.18-0.33 mm. long; ratio of length of ovary to end proglottid length *ca* 1/2.

Type host: *Raja rhina* Jordan et Gilbert.
Type locality: Monterey Bay, Calif.
Type specimen: U.S.N.M. Helm. Coll. 37411

This species was found in two specimens of the type host. A free gravid proglottid which was stained and mounted in clarite was 1.08 mm. long by 0.3 mm. wide, tapering at both ends. The ovary was 0.43 mm. long, the poral wing being slightly longer than the aporal. The genital atrium was in the middle of the margin. *E. dolichoophorum* differs from *E. octorchis* in the number of testes, number of proglottids containing genitalia, and the long narrow ovary. The diameter of the contracted myzorhynchus may also possibly have some systematic worth.

Echeneibothrium macrascum n. sp.
(Pl. 5, Figs. 6, 8, 10)

Small, craspedote, hyperapolytic worms reaching a length of 30 mm. and consisting of as many as 200 proglottids. Phyllidia muscular, 0.6 mm. long by 0.32 mm. wide, typically with ten loculi formed by a single longitudinal and four transverse ridges which divide each phyllidium into four pairs of loculi with a single loculus at either end; minute spines on abothridial surface of phyllidia and pedicels. Pedicels attach to posterior ends of phyllidia. Contracted myzorhynchus visible only in sections, everted myzorhynchus 0.24 mm. long by 0.09 mm. in diameter; myzorhynchal organ 0.03 mm. deep by 0.03 mm. in diameter. Proglottids circular in transverse sections, broader than long except last proglottids which are square or slightly longer than broad. End proglottids 0.46-0.64 mm. long by 0.25-0.43 mm. Dorsal excretory vessel not visible in sections of proglottids; ventral vessel 0.030-0.042 mm. in diameter. Genital atria deep, alternate irregularly, in middle or slightly anterior to middle of proglottid margin. Cirrus pouch pyriform 0.22-0.25 mm. long by 0.13-0.16 mm. wide; lying with swollen base between lobes of ovary. Cirrus armed with small spines. Ejaculatory duct

long and much coiled. 20-23 testes in each proglottid; mature testes 0.042-0.051 by 0.036-0.039 mm. Vitellaria densely packed, each lateral field 0.105 mm. wide. Ovary papillate in surface view, wings close together. Uterine duct opens into uterus at level of anterior margin of cirrus pouch. Ova laid in packets.

Type host: *Raja montereyensis*.
Type locality: Monterey Bay, Calif.
Type specimen: U.S.N.M. Helm. Coll. No. 37412.

This species was present in each of the four specimens of the type host which were examined. It occurred only in this ray, and was not very abundant, the maximum number from a single host being twelve.

Free gravid proglottids which were stained and then mounted in clarite were 2.25-2.55 mm. long by 0.52 mm. wide. The ovarian wings in these proglottids were 0.52-0.55 mm. long. The genital atria were in the middle of the margin. Vitelline follicles were 0.042-0.063 mm. in diameter.

This species differs from all previously described species in the rudimentary nature of the myzorhynchus and the attachment of the pedicels to the posterior borders of the phyllidia. It is most closely allied to *E. gracile* Zschokke, 1888, from which it differs in the number of loculi in the phyllidia, the massive development of the cirrus pouch, and the shorter and broader posterior proglottids. Zschokke's description leads one to believe that the strobila is apolytic in *E. gracile*.

Echeneibothrium myzorhynchum Hart, 1936
(Pl. 5, Figs. 3, 7)

Large, craspedote, apolytic worms reaching a length of 40 mm. and consisting of as many as 200 proglottids. Phyllidia up to 0.6 mm. long, musculature weak, typically (only clearly visible in living material) with 18 loculi formed by a single longitudinal and 8 transverse ridges which divide each phyllidium into 8 pairs of loculi with a single loculus at either end. Pedicels and abothrial surfaces of phyllidia densely covered with small hooks. Pedicels attached to posterior two-thirds of phyllidia. Myzorhynchus well developed 0.52-0.61 mm. in diameter when contracted; everted myzorhynchus *ca* 0.7 mm. long; myzorhynchal organ 0.042 mm. deep by 0.060 mm. in diameter. Proglottids broader than long, only the gravid proglottids longer than broad; end proglottids 0.55-0.67 mm. long by 0.37-0.42 mm. Dorsal and ventral excretory vessels visible in proglottids; dorsal vessel about 1/3 the diameter of ventral, ventral vessel 0.012-0.018 mm. in diameter. Genital atria alternate irregularly, posterior to middle of margin except slightly anterior to middle in posterior gravid proglottids. Cirrus pouch 0.15 mm. long by 0.060-0.117 mm., average width 0.099 mm.; lying on poral lobe of ovary. Cirrus armed with short bristles. 23-24 testes, 10-11 poral and 12-13 aporal; mature testes 0.063-0.072 by 0.090-0.120 mm., long axis in horizontal plane. Vitellaria densely packed; each lateral field 0.045 mm. wide. Ovary short and wide; wings not encroaching upon interovarian space. Uterus bipartite, constricted in middle. Uterine duct opens into uterus at the level of the genital atrium. As many as 18 gravid proglottids attached to strobila. Ova 0.029 by 0.023-0.026 mm.

Hart described *E. myzorhynchum* from the spiral valve of *Raja binoculata* from Puget Sound, Washington. His description is of a complex of species. Since his figures were primarily of an apolytic species, I have selected the apolytic form to bear the specific name given by Hart. This species was encountered in almost every one of the 73 *Raja binoculata* from Monterey Bay which were examined. It was found in greatest numbers in rays less than 50 cm. long. *Echeneibothrium myzorhynchum* differs from other large members of the genus in the strongly apolytic nature of the strobila, the eggs being laid individually, and the distinctive shape of the gravid uterus.

Genus *Caulobothrium* Baer, 1948
(*Rhinebothrium* Linton, 1890, *pro parte*)

Baer diagnosed the genus as follows:—"Strobila craspedote, segments apolytic. Scolex born on long peduncle, formed out of four bothridia with surfaces divided into loculi; myzorhynchus absent. Sexual pores irregularly alternate, open into a genital atrium. Longitudinal musculature of the parenchyma well developed. Vagina crosses the pouch of the cirrus and opens in front of the latter. Testes occupy all the region between the vitelline glands and the ovary. Uterus tubular. Vitelline glands encroach laterally on the dorsal and ventral surfaces of the medullary parenchyma. Ova with filaments." Type species: *Caulobothrium longicolle* (Linton, 1890).

He placed three species in this genus, viz. *C. longicolle* (Linton, 1890), *C. insignia* (Southwell, 1911), and *C. tobijei* (Yamaguti, 1934). All of these species had originally been described in the genus *Rhinebothrium* or in *Echeneibothrium*. Only *C. longicolle* was described by Baer in the cited paper.

Caulobothrium tetrascaphium n. sp.
(Pl. 4, Figs. 2, 3, 4; Pl. 5, Fig. 9)

Large apolytic cestodes reaching a length of over 20 cm. and breadth of 3 mm., and consisting of several hundred proglottids. Phyllidia very large, as much as 4 mm. in length by 1.8 mm. in width. Bothridial surface muscular, divided into 22 loculi by 10 transverse and one longitudinal ridge, loculi at either end unpaired. Pedicels strongly developed, 0.22-0.52 mm. in diameter, diameter inversely proportional to length, maximum length observed 0.75 mm. Cephalic peduncle 13-35 mm. long by 0.36-0.94 mm. broad at junction with strobila; a red pigmented area at junction with strobila usually present in living material. Relaxed mature and gravid proglottids about 1.3 times as long as broad, 0.97-3.1 mm. long by 0.75-2.4; contracted mature proglottids 0.42-0.67 mm. long by 1.83-1.87 mm. wide. Free gravid proglottids 2.7-3.1 mm. long by 1.8-2.4 mm., width inversely proportional to length. Longitudinal muscle layer divided into three parts; innermost longitudinal muscle bundles separated from one another by parenchyma; a layer of isolated longitudinal fibers separates innermost layer from subcuticula; outermost longitudinal layer against outer circular muscles. Ventral excretory vessel 0.030-0.045 mm. in diameter; dorsal vessel 0.009-0.015 mm. Genital atria in anterior third of margins. Cirrus pouch 0.24-0.30 mm. long by 0.060-0.120 mm. Ratio of cirrus pouch length to proglottid width 1/5. Over 200 testes present in each proglottid; mature testes 0.06-0.084 by 0.060-0.075 mm. in diameter; testicular field extends to posterior margin of ovary. Vagina rises slightly anteriad after passing excretory vessels in course toward midline; ventral to cirrus pouch. Vaginal sphincter present. Ovary in relaxed mature proglottids *ca* 0.45 mm. long by 0.52 mm. wide; in contracted proglottids *ca* 0.79 mm. wide by 0.30 mm. Vitellaria enclose almost all testes, do not isolate nerve trunks. Ova monoflagellate, rarely biflagellate, 0.026-0.042 by 0.023-0.033 mm. exclusive of flagella. Flagella 0.042-0.057 mm. long. Onchospheres 0.015-0.018 by 0.015-0.023 mm.

Type Host: *Aetobatus californicus.*

Type locality: Monterey Bay, Calif.

Type specimen: U.S.N.M. Helm. Coll. No. 37414.

This species is distinctly different from all other members of the genus except *C. tobijei* from which it differs in the size of the scolex, strobila, and proglottids; number of loculi in the phyllidia; greater number of testes; and distribution of the vitellaria.

Caulobothrium opisthorchis n. sp.
(Pl. 4, Figs. 1, 5)

Small, faintly craspedote, hyperapolytic members of the genus, less than 15 mm. in length and consisting of about 25 proglottids. Phyllidia to 1.06 mm. in length, very narrow, musculature of bothridial surface weak, divided into 38 loculi by a single longitudinal and 18 transverse ridges. Cephalic peduncle to 1.12 mm. in length by 0.195-0.225 mm. First 15-17 proglottids broader than long; posterior proglottids longer than broad; end proglottids 1.03-1.75 mm. long by 0.27-0.34 mm.; free mature proglottids 1.72-1.77 mm. long by 0.33-0.37 mm. Cuticle striated producing serrate appearance on margins. Excretory vessels lateral to vitellaria; dorsal vessel 0.006 mm. in diameter, ventral vessel 0.009 mm. in diameter. Genital atria in anterior fourth of proglottid margin. Cirrus pouch 0.09-0.13 mm. long by 0.042-0.075 mm. 78-90 testes in each proglottid, testes in all but anterior 9-12 proglottids; mature testes 0.189-0.204 by 0.294-0.306 mm., in two lateral fields extending from anterior margin of proglottid to posterior margin. Vitellaria do not meet laterally and thus do not isolate nerve trunks. Ovary 0.96-0.97 mm. long; anterior wings almost twice as long as posterior wings. Uterus extends anterior to genital atrium. Ova monoflagellate, 0.027-0.030 mm. in diameter exclusive of flagella; flagella 0.042-0.057 mm. long.

Type host: *Aetobatus californicus.*
Type locality: Elkhorn Slough, Monterey Co., Calif.
Type specimen: U.S.N.M. Helm. Coll. No. 37415.

This species is very abundant in the type host. If the worms are not fixed immediately after the death of the host, the phyllidia develop very abnormal configurations and tend to lose all the appearances of echeneibothriid holdfasts. A gravid proglottid stained and then mounted in clarite was 2.28 mm. long by 0.54 mm. wide. The cirrus pouch and ovary were the only structures not obliterated by the uterus. This species differs radically from the other members of the genus in that the testes extend posterior to the ovary, the excretory ducts are marginad of the vitellaria, and the species is hyperapolytic. These characters are adequate for placing this species in a separate genus, but our present knowledge of the Echeneibothriidae makes it unwise to establish genera at random.

Family Onchobothriidae Braun, 1900, emended

Phyllidia sessile, divided into three loculi by two permanent septa; anterior loculus surmounted by a pair of hooks above which lies one or more small suckers. Excretory vessels do not extend into phyllidia. Mehlis' gland small, composed of relatively few cells. Plerocercoids with phyllidia divided into three loculi. *Type genus*: *Onchobothrium* (Rud., 1819) Southwell, 1925.

The vaginal extension and oviduct unite lateral to the Mehlis' gland and a short fertilization passage is formed outside the Mehlis' gland in the species which are to be described. If this character is relatively constant in the other genera of the family, it is an excellent family character, since in the Phyllobothriidae and Echeneibothriidae, the vaginal extension and oviduct fuse as they enter the posterior aspect of the gland.

Genus *Acanthobothrium* van Ben., 1850, emended

Each phyllidium surmounted by a pair of bifurcated hooks. Posterior end of phyllidia free. Accessory suckers born on a small triangular flap which also bears the hooks. Cephalic peduncle present. Testicular field does not extend lateral, dorsal, or ventral to ovary. A single dorsal and ventral row of vitelline follicles on each side of proglottid. Vagina crosses vas deferens at distal end of cirrus pouch. Uterus arises as an elongated rod of cells. Type species: *Acanthobothrium coronatum* (Rud., 1819).

Acanthobothrium hispidum n. sp.
(Pl. 6, Figs. 1, 5, 8, 9; Pl. 7, Fig. 1)

Hyperapolytic, slightly craspedote, fragile worms reaching a maximum length of 85 mm. and consisting of up to 200 proglottids. Phyllidia of living worms 1.33-1.50 mm. long by 0.36-0.39 mm.; of toto mounts 0.55-0.82 mm. long by 0.23-0.38 mm., anterior loculus 0.43-0.45 mm. long, middle loculus 0.16-0.18 mm., posterior loculus 0.15-0.20 mm. Total length of hooks 0.138 mm., handle to bifurcation 0.048-0.051 mm., inner prong 0.096-0.099 mm., outer prong 0.093-0.096 mm. Cephalic peduncle 2.1-3.0 mm. long by 0.23-0.30 mm. Peduncle and strobila of living worms densely covered with minute hairs. Zone of growth short, 0.30-0.38 mm. long. Mature proglottids longer than broad. End proglottids 1.6-2.1 mm. long by 0.56-0.60 mm.; free proglottids 4.0-5.2 mm. long by 0.75-0.88 mm. Genital atria alternate irregularly; slightly posterior to middle of margin. Cirrus pouch 0.25-0.30 mm. long by 0.13-0.24 mm. Cirrus over 1.4 mm. long, armed with minute spines. 47-52 spherical testes in each proglottid, 8-9 postporal, 10-16 anteroporal, 21-27 aporal; mature testes 0.05-0.11 mm. in diameter. Vaginal sphincter present. Ovary in end proglottid 0.61-0.72 mm. long by 0.36-0.37 mm.; aporal lobe longer than poral; poral lobe touches or almost touches cirrus pouch. Ova 0.059-0.063 mm. by 0.049-0.059 mm. in diameter, granular layer 0.025-0.028 mm. in diameter, onchospheres 0.018 mm. in diameter.

Type host: *Tetronarce californica* (Ayres).

Type locality: Monterey Bay, Calif.

Type specimen: U.S.N.M. Helm. Coll. No. 37416.

This species has occurred in great numbers in all of the *T. californica* examined from Monterey Bay and San Luis Obispo Bay. It is a very fragile worm after fixation and the proglottids separate very readily. The conjugation of independent proglottids in the spiral valve of the California electric ray can seemingly be witnessed at almost any time of the year. It is worthy of note however, that when the host is allowed to die or become moribund before it is opened, the act of copulation is never witnessed, the pairs probably separating as the conditions change. On the other hand, if the host is promptly opened and the contents of the spiral valve are washed out with a killing fluid, numerous fine examples of copulating individuals will be found. United individuals tend to separate quite rapidly if one attempts to study them alive. The species is most closely allied to *A. benedeni* Loennberg, 1889, from which it differs in the much larger strobila, the arrangement and numbers of testes, the relative proportions of the hooks, and the size of the cirrus pouch.

Acanthobothrium maculatum n. sp.
(Pl. 6, Figs. 6, 7, 11)

Craspedote, hyperapolytic worms reaching a maximum length of 35 mm. Phyllidia of toto mounts 0.35-0.39 mm. long by 0.16-0.18 mm., anterior loculus 0.30-0.35 mm. long, middle loculus 0.073-0.075 mm. long, posterior loculus 0.060-0.075 mm. long. Total length of hooks 0.135-0.141 mm., handle to bifurcation 0.072-0.078 mm., inner prong 0.072-0.078 mm., outer prong 0.075-0.078 mm. Cephalic peduncle 5.4-6.1 mm. long by 0.18-0.22 mm. Zone of growth 0.18-0.22 mm. long. Mature proglottids broader than long except for last one or two. End proglottids 0.93-1.83 mm. long by 0.51-0.52 mm. wide. Genital atria alternate irregularly; slightly anterior to middle of margin. Vagina adheres closely to cirrus pouch and drops posteriad immediately after passing mediad end of pouch. Vagina with sphincter at level of the vitellarian field. Cirrus pouch 0.15-0.18 mm. long by 0.075 mm. Cirrus

armed with rose-thorn-shaped spines 0.007 mm. long. Spines of narrow distal portion 0.010-0.012 mm. long. 75-85 spherical testes in each proglottid, 11-15 postporal, 28-32 anteroporal, 30-41 aporal; mature testes 0.060-0.069 mm. in diameter. Poral wing of ovary 0.37-1.03 mm. long, aporal wing 0.46-1.14 mm. long, aporal wing always longer than poral, poral wing touches cirrus pouch.

Type host: *Aetobatus californicus.*
Type locality: Monterey Bay, Calif.
Type specimen: U.S.N.M. Helm. Coll. No. 37417.

This worm has been frequently found in the type host, but always in small numbers. It is the most muscular species of the genus encountered in this study, and in this respect contrasts strikingly with *A. hispidum*. *A. maculatum* is most similar to *A. dasybati* Yamaguti, 1934, from which it differs in the smaller number of testes, the inner and outer prongs of the hooks being of equal or almost equal length, and the longer handle of the hooks.

Acanthobothrium brachyacanthum n. sp.
(Pl. 6, Figs. 2, 3, 10)

Small, acraspedote, hyperapolytic worms from 3-5 mm. long and consisting of 10-12 proglottids. Phyllidia 0.30-0.42 mm. long by 0.15-0.19 mm. maximum breadth. Cephalic peduncle 0.54-0.60 mm. long. Peduncle and strobila of living worms covered with minute hair-like spines. Total length of hooks 0.090 mm.; handle to bifurcation 0.033 mm., inner prong 0.066 mm., outer prong 0.057-0.060 mm. End proglottids 0.90-0.97 mm. long by 0.24 mm. wide. Genital atria alternate irregularly; slightly posterior to middle of margin. 33-34 spherical testes, 6-8 of which are post poral; mature testes 0.030-0.036 mm. in diameter. Cirrus pouch 0.123-0.135 mm. long by 0.090-0.120 mm. Vaginal sphincter present. Ovary in end proglottid with unequal lobes, poral lobe 0.042 mm. long, aporal lobe 0.049 mm. long.

Type hosts: *Raja montereyensis.*
Type locality: Monterey Bay, Calif.
Type specimen: U.S.N.M. Helm. Coll. No. 37418.

This species has been found in every *Raja montereyensis* examined, but in only two *R. binoculata*. It differs from all other species of the genus in that the hooks are less than 0.120 mm. long.

Genus *Calliobothrium* van Ben., 1950

Each phyllidium bears a pair of simple hooks above which lie one to three large suckers. Type species: *Calliobothrium verticillatum* van Ben., 1850.

Calliobothrium pellucidum n. sp.
(Pl. 6, Fig. 4; Pl. 7, Fig. 7)

Small slightly craspedote hyperapolytic tapeworms 5-8 mm. in length and consisting of 10-14 proglottids, six of which contain genitalia. Phyllidia 0.48-0.51 mm. long by 0.21-0.27 mm. wide. Large outer hooks 0.135 mm. long; inner hooks 0.090 mm. long. Accessory sucker 0.15-0.16 mm. in diameter; anterior loculus 0.15-0.18 mm. long; middle loculus 0.090-0.093 mm. long; posterior loculus 0.102 mm. long. End proglottids 1.2-1.5 mm. long by 0.33-0.38 mm.; free ripe proglottids 1.1-1.7 mm. long by 0.33-0.49 mm. Genital atria in posterior third of proglottid margin. Cirrus pouch 0.135-0.165 mm. long by 0.090 mm. Cirrus short, armed with stiff bristles. 34-39 testes, 2-3 of which are postporal; mature testes 0.072-0.081 mm. in diameter and 0.11-0.12 mm. deep. Vagina crosses middle of cirrus pouch as it drops

posteriad. Ovary 0.25-0.36 mm. by 0.25-0.30 mm. Uterine ova round, 0.027-0.033 mm. in diameter.

Type host: *Mustellus californicus* Gill.

Type locality: Southern California.

Type specimen: U.S.N.M. Helm. Coll. No. 37419.

Three specimens and a number of free proglottids were given to me by Dr. R. T. Young of the San Diego Zoological Society. The internal anatomy was perfectly clear in the fixed specimens. The finest details could be observed in stained whole mounts. The available material had unilateral genital atria, but with such small worms, I feel it unwise to use this as a specific character until more material is examined. The species is similar to *C. eschrichti* (van Ben., 1849) differing from the latter species in the smaller size of the hooks and the smaller number of testes.

Pinguicollum, new genus

Large, apolytic, craspedote cestodes. Organs of attachment, highly modified phyllidia and hooks at the four angles of the scolex; each phyllidium consisting of three, muscular, individual, sucker-like loculi in tandem. A pair of bifurcated hooks are embedded in a muscular flap which overlies the anterior loculus. Hooks chitinous, ancylosed in a common matrix. Longitudinal muscles of strobila inserted in posterior third of anterior loculus, one muscle bundle arising from either side of loculus. Pseudoscolex present as a thickened cephalic peduncle. Distinct dorsal and ventral excretory vessels present in proglottids. Nerve trunk dorsal to cirrus pouch and vagina. Mehlis' gland dorsal to ovary. Vagina ventral to vas deferens and testes, but dorsal to ovary. Vagina without convolutions. Testes extend from anterior to posterior edge of proglottid dorsal to ovary, vas deferens, and vagina. Ovary not typically X-shaped in cross-section. No preformed uterine pore. In spiral valve of Rajidae. Scolex embedded in mucosa. Type species: *Pinguicollum pinguicollum* (Sleggs, 1927) n. com.

There are only two genera in the family to which this genus bears much similarity, viz. *Acanthobothrium,* and *Uncibilocularis* Southwell. *Pinguicollum* differs from *Acanthobothrium* in having the hooks fused in a common matrix, immobile phyllidia, and a pseudoscolex. Also, the ovary is not typically X-shaped, and the vitellaria form two broad lateral fields on either side of the proglottids. The genus *Uncibilocularis* is not well established. Southwell (1925) defined it as follows: "each bothridium has its surface divided into two loculi by a single septum, and is armed anteriorly with either simple or compound hooks." The genus contains two species, viz., *U. trygonis* (Shipley and Hornell, 1906) and *U. mandleyi* Southwell, 1927, which, from the descriptions, are not generically similar. The phyllidia of the type species, *U. trygonis*, consist of two clearly defined suckers. I would not be surprised if a small third sucker had been overlooked. No pseudoscolex is present. The longitudinal musculature is highly developed as in *Pinguicollum*. Southwell (1925) stated that the vagina ran ventral to the cirrus pouch, but this was apparently a misinterpretation. Shipley and Hornell (1906) made no mention of the internal anatomy in their original description. *Pinguicollum* differs from *Uncibilocularis* in having a pseudoscolex and hooks ancylosed in a common matrix, and the vagina opens dorsal to the opening of the cirrus pouch. *Taenia dysbiotos* MacCallum, 1921, the type of which was generously loaned to me by the U. S. National Museum appears from MacCallum's figures to have great similarity to *Uncibilocularis* and to *Pinguicollum,* but is a species of *Acanthobothrium,* morphologically similar to *A. crassicolle.*

Pinguicollum pinguicollum (Sleggs, 1927) n. com.

(Pl. 7, Figs. 2, 3, 4, 5, 6)

(*Onchobothrium pinguicollum* Sleggs, 1927; *Pedibothrium pinguicollum* (Sleggs, 1927) Hart, 1936)

Large thick cestodes up to 820 mm. in length and 10.5 mm. in breadth. Scolex variable. Anterior loculus 0.34-0.40 mm. long by 0.24-0.26 mm.; middle loculus 0.10-0.13 mm. long by 0.15-0.16 mm.; posterior loculus 0.07-0.10 mm. long by 0.13 mm. Total length of hook in matrix 0.15-0.18 mm., outer prong 0.060-0.075 mm., inner prong 0.07 mm., handle to bifurcation 0.10-0.12 mm., total length matrix cleared away, 0.15-0.16 mm., outer prong 0.060-0.075 mm., inner prong 0.060-0.070 mm., handle to bifurcation 0.095-0.105 mm.

Genital atria alternate irregularly in middle of margin, 0.06-0.09 mm. deep. Cirrus pouch pyriform, 0.18-0.20 mm. long by 0.053 mm.; crossed by one or both excretory vessels. Ratio of length of cirrus pouch to width of proglottid 1:10 to 1:11. Turgid vas deferens large, 0.053 mm. in diameter, much coiled. 110-120 testes in each proglottid; mature testes 0.070-0.097 mm. in diameter. Excretory vessels with a spiral course; ventral vessel 3 times diameter of dorsal. Proglottid margin to vitellaria 0.10-0.16 mm. Eggs when first discharged are oval in sea water, outer membrane 0.042-0.047 by 0.024-0.031 mm.; second membrane 0.031-0.035 mm.; onchosphere 0.017-0.021 by 0.014-0.017 mm.; outer membrane later becomes more uniformly round, 0.043-0.045 by 0.037-0.040 mm.

Sleggs figured and named the species from an unidentified skate caught in Monterey Bay, but he gave no significant data. Hart found similar cestodes in *Raja binoculata* at Puget Sound. He only gave host data and placed the worms in the genus *Pedibothrium*. Over seventy rays from Monterey and San Luis Obispo Bays were examined for parasites during the course of this study. The most common cestode occurring in them belonged to this species. There was no case of a single specimen of the worm occurring alone; two to nine specimens were recorded in all infections. There was a suggestion of an immunity being established by the host, since in almost all cases, all *P. pinguicollum* in an individual ray were approximately of the same stage of development indicating a single infection. One specimen of *R. montereyensis*, however, contained two mature specimens of this cestode which measured 264 and 280 mm. in length, three immature specimens less than 100 mm. in length, and one specimen 5.2 mm. in length. It is to be expected that a host response would be set up against a parasite which destroys tissues to the extent that this species does. This species was found in *Raja inornata*, *R. binoculata*, *R. rhina* and *R. montereyensis*.

Most members of the family Onchobothriidae are delicate and small, less than 10 cm. long. *P. pinguicollum* thus is quite unique for the great size which it attains. It is also remarkable for the strongly developed musculature. Its ability to contract is greatly enhanced by these muscles, and thus great variation in the appearance of the strobila can be observed. This makes the description of a typical specimen very difficult.

The size and shape of the scolex varies considerably from worm to worm depending upon the degree of contraction. Contracted scoleces (Pl. 7, Fig. 4) are wrinkled to such an extent that one could be led to believe that segmentation actually commenced at the anterior tip of the scolex. A few relaxed scoleces were obtained by leaving the worms in tap water until they were almost dead. The three loculi of a phyllidium form a letter "J" with the back being formed by the anterior loculus, the bottom of the curve by the middle loculus, and the upturned tip by the posterior one. This appearance is strongly accentuated in contracted scoleces, but in relaxed ones, the posterior loculus directs itself slightly more outward than anteriad.

The bothridia lie embedded in the scolex and are overgrown by the scolex tissues so that only the anterior loculus communicates with the outside. It communicates by a narrow slit through the general scolex tissues. The only indication of the phyllidial nature of the organ is a small fleshy nipple which extends freely from the tip of the posterior loculus. Thus the phyllidia differ from all those previously described.

The hooks are embedded in a muscular flap which arises anteriorly on the scolex and contains many muscle fibers originating from subcuticular longitudinal muscles and from the muscle ball (a structure to be described later). The flap extends over the anterior loculus, and thus the hooks appear to be located on the loculus. The hooks, except for the prongs, are brownish color in life. This color is contributed by the matrix which joins each pair of hooks together. The bifurcation is uneven in all of the hooks (Pl. 7, Fig. 2) so that the inner prong is directed more toward the scolex.

There is a short narrow part of the cephalic peduncle posterior to the scolex. This is from 1.2-1.9 mm. long and 0.9-1.2 mm. in maximum breadth. Following this narrow region, the peduncle swells to form the pseudoscolex which is 3.7-3.8 mm. long by 1.3-1.8 mm. wide. Sections of this region show an exaggerated development of the muscles and of the excretory vessels. The latter form extensive large coils spiraling so that they almost fill all of the space internal to the muscle bundles. When the scolex is embedded in the mucosa of the spiral valve of the host, the pseudoscolex is pressed firmly against the sides of the hole made by the scolex. This probably assists in maintaining the worm's position in the gut. According to my observations, it also prevents the worm from breaking through into the coelom; I have found several cases in which the tip of the scolex projected into the body cavity, and was surrounded by caseous material, but I have not found any case in which more than the tip protruded on the coelomic side.

The longitudinal muscle layer consists of two groups of fibers. The primary muscles are the large bundles of striated fibers which are inserted into the walls of the anterior loculi. They are eight in number and divide in the pseudoscolex to form smaller bundles. These small bundles are the most noticeable structures of the parenchyma and the strobila. A few isolated longitudinal fibers lie amidst the large bundles and between the latter and the outer circular muscles. The musculature is very similar to that of *Acrobothrium musculosum* Baer, 1948, the type of which was generously loaned to me by Dr. Baer. Diagonal muscle fibers are abundant throughout the strobila.

The scolex musculature (Pl. 7, Fig. 5) is very complex, and yet very distinctive. The most anterior muscles connect the anterior loculi of either side to one another. This connection is very common among the cestodes and occurs as an open cross or as a closed or solid cross. Deeper in the scolex, a thick layer of large muscle fibers forms an open ring around the anterior half of each anterior loculus. Further strengthening of the connection between the attachment organs is brought about by a heavy mass of striated fibers which form the muscle ball, the fibers connecting all four of the anterior loculi. Cross-sections through this muscle ball have the appearance of vertebrate cardiac muscle. This ball of muscles is one of the most noticeable features of whole mounts of the scolex. In toto mounts it measures 0.46-0.67 mm. in width and 0.39-0.48 mm. in length.

Onchobothrium tortum Linton, 1916, from *Aetobatis narinari* constitutes a second species in the genus *Pinguicollum*. In Linton's material, the excretory vessels were greatly inflated and the proglottids had begun to degenerate prior to fixation. The total length of isolated hooks (Pl. 8, Fig. 7) is 0.25 mm., outer prong 0.083-0.095 mm., inner prong 0.09-0.095 mm., and handle to bifurcation 0.167 mm.; handle to bifurcation matrix cleared away, 0.11-0.12 mm.

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TWO UNUSUAL ANATOMICAL ANOMALIES OCCURRING IN THE BILIARY TRACT OF THE CAT AND CHICKEN

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Considerable data are available in the literature concerning congenital anomalies of the biliary tract in the various classes of vertebrates.

Accessory gall bladders have been reported in sheathfish (Gehrke, 1933); seasnakes (Bergman, 1935); rabbit (Stahl and Ruizeveld, 1930); loris (Rau, 1928); rhesus monkey (Tittler, 1945; Kirkman, 1946); hyrax (Thomson, 1938); sheep, swine, and cattle (Boyden, 1926); cat (Boyden, 1926; Bartlett, 1951; Mann and Fratta, 1952) and chicken (Mann, 1955). These conditions may occur quite frequently in cats and calves but are rare in the other animals.

Absence of a gall bladder has also been observed in a cat (Gribble, 1950). We have, however, been unable to find another reference in which this particular anomaly has been reported either in domestic fowl or in other animals.

It therefore seemed desirable to describe the following two unusual anatomical abnormalities of the biliary tract.

OBSERVATIONS

Case 1 (Fig. 1). This specimen was obtained from a pullet. Examination of the visceral surface of the right lobe of the liver failed to reveal the presence of a gall bladder. Instead there was found upon dissection, a hepatic duct, approximately 3 cm. in length, which extended from the right lobe of the liver to a termination point in the duodenum close to the openings of the pancreatic ducts. The distal third of this hepatic duct was of a wider, more irregular shaped diameter which continued with gradual decrease to one of 2 mm. at its point of origin in the duodenum.

Case 2 (Fig 2, 3). This specimen was obtained from a young female cat. Two functional gall bladers, each of normal contour and possessing a separate cystic duct were observed. The gall bladder on the right was smaller. Its overall length including the cystic duct was 30 mm. The bladder proper measured 15 mm. in length and 10 mm. in maximum diameter. Its cystic duct, with a diameter of 2 mm. measured 15 mm. in length and

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joined the cystic duct of the larger gall bladder (left) to form a single stem which was continued as the common bile duct.

The larger bladder measured 20 mm. in length and 15 mm. in maximum diameter, and possessed a somewhat irregular shaped neck. This bladder arose from a cystic duct whose extended length was 15 mm. with a diameter of approximately 1½ times that of the right cystic duct. There was a small, white, appendage projecting from the medial surface of the fundus, which upon gross inspection was interpreted as either a rudimentary diverticulum or an atrophied portion of the distal part of the fundus. Furthermore, as we sometimes find, in both man dog, an accessory pancreas growing out of the fundus (Thorsness, 1940), this piece of tissue was sectioned and stained. Microscopic examination revealed the appendage to be a fibrotic rudimentary diverticulum containing some calcium deposits.

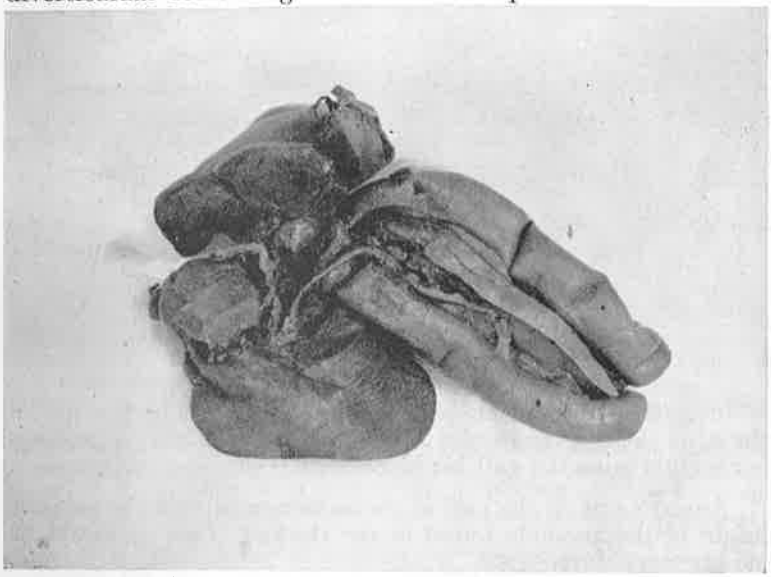

Fig. 1. Visceral surface of the liver of pullet.

Discussion

So far as the writer is aware, this is the first report concerned with the lack of a gall bladder in *Gallus domesticus* although one cat (*Felis domesticus*) was observed in the 900 examined by Gribble (1950) in which no trace of this organ or its cystic duct could be found.

The gall bladder occurs in most vertebrates but is normally absent in the parrot, pigeon, dove, pocket gopher, elk, deer, albino rat, horse, zebra, ass, tapir, peccary of South America, rhinocerous, guinea-fowl, prairie-chicken, cuckoo, African ostrich, camel, sea cows, elephant, parakeet, whales, dolphins, and porpoises. It may or may not be found in the giraffe.

(McMaster, 1922; Higgins, 1926; Mann, 1920; Milne-Edwards, 1860; Hyman, 1942).

According to Nelsen (1953), the gall bladder in the chick arises toward the end of the third day of incubation from the caudal hepatic diverticulum, although there are two separate hepatic outgrowths, i.e., cephalic and caudal hepatic diverticula

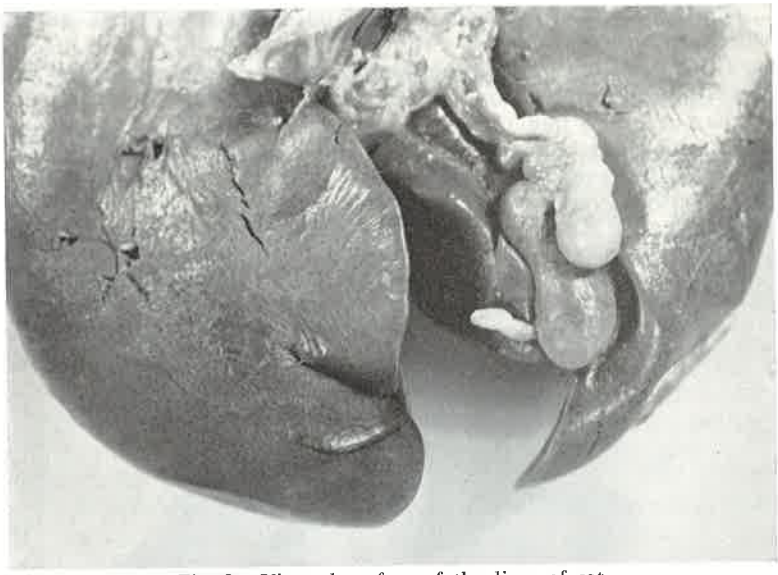

Fig. 2. Visceral surface of the liver of cat.

of the gut that are characteristic of this fowl. The portion of the liver arising from the cepahalic diverticulum is without connection with the gall bladder.

Any attempt on the part of the author to explain the possible origin of the anomaly found in the chicken (Case 1) would be merely conjecture.

With reference to Boyden (1926), the specimen obtained from the cat (Case 2) may be classified as a ductular gall bladder. This Y-shaped type of double biliary vesicle is apparently quite rare, having been found in only three of 2600 cat specimens

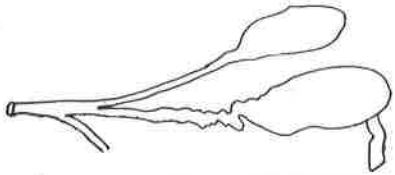

Fig. 3. Diagramatic representation of gall bladders and associated ducts of specimen shown in Fig. 2.

examined by Boyden. Ductular gall bladders are supernumerary vesicles derived from either cystic, hepatic or common bile ducts and occur chiefly in both man and cat. Since the cystic duct in the cat and human embryo is solid and therefore unlikely to be subdivided, the accessory bladder described in Case 2 was was probably formed by enlargement of the diverticulum of the primary cystic duct of the embryo.

Summary

The following two unusual anatomical abnormalities of the biliary tract of two domestic animals have been observed and described: absence of the gall bladder in a chicken, a Y-shaped double biliary vesicle in a cat.

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