THE LIFE HISTORY AND MORPHOLOGY OF A MARINE TREMATODE, COITOCAECUM BATHYGOBIUM N. SP., FROM BATHYGOBIUS FUSCUS (RÜPPELL) IN HAWAII

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF THE
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

FEBRUARY 1961

By

Donald Eugene Watson

THE LIFE HISTORY AND MORPHOLOGY OF A MARINE TREMATODE, COITOCAECUM BATHYGOBIUM N. SP., FROM BATHYGOBIUS FUSCUS (RÜPPELL) IN HAWAII

By

Donald Eugene Watson

ACKNOWLEDGEMENTS

The author wishes to gratefully acknowledge the help, the criticisms, and the encouragement of Dr. George W. Chu, Professor of Microbiology and Chairman of the Department of Microbiology, University of Hawaii, under whose direction this study was carried out, and who, graciously, did all the photography for this study. I am also grateful for the suggestions and criticisms of Dr. David E. Contois, Assistant Professor of Microbiology, University of Hawaii, Dr. Leonard D. Tuthill, Professor of Entomology, University of Hawaii, and Dr. Sidney J. Townsley, Assistant Professor of Zoology, University of Hawaii, who also kindly identified the second intermediate host. My thanks are also due to Dr. E. Alison Kay, Assistant Professor of Science, University of Hawaii, who identified the snail intermediate host, and to Dr. Maxwell S. Doty, Professor of Botany, University of Hawaii, for the identification of algae.

I should also like to thank Dr. Philip Helfrich, University of Hawaii Marine Laboratory, Mr. Donald A. Thomson, Graduate Student in Fisheries, University of Hawaii, and Mr. Al Lewis, Graduate Student in Zoology, University of Hawaii, for the identification of the various fishes examined during this study. I am further indebted to Mr. Thomson for the translation of certain Russian journals.

Further, I should like to thank the Bernice Pauahi Bishop Museum, the Hawaiian Sugar Planters Association, the Honolulu County Medical Library, and the Pineapple Research Institute whose library facilities were used for this study.

TABLE OF CONTENTS

LIST OF TABLES AND GRAPHS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

During examinations of fishes from tidal pools at Diamond Head Beach, a small digenetic trematode was constantly recovered from the intestine of a species of goby, Bathygobius fuscus (Rüppell, 1828).[1] Practically 100 percent of the gobies examined were found to be infected.[2] The average number of worms found in each fish was nine, however, one female goby measuring 31 mm. in total length contained 46 worms.[2]

The apparent high rate of infection indicated a relative ease of completion of the life cycle for this trematode. Because of the high rate of infection and relative ease in completion of life cycle, as well as the ease of collecting throughout the year, it was decided to study the morphology and the developmental history of this fluke as it occurs in Hawaii.

A review of the literature indicated that this fluke was a member of the family Opecoelidae and the genus Coitocaecum. This genus contains 22 described species and only in C. anaspidis Hickman, 1934 (this worm is from a fresh water fish found in brackish water) has the life cycle been reported.

This thesis describes this fluke as a new species, Coitocaecum bathygobium n. sp. In addition, it presents the results of a study on the developmental history of this parasite, as well as the results of experimental studies to determine the effects of certain ecological factors of the environment upon the completion of that life cycle.

---

[1] The fish host was identified by Dr. Philip Helfrich, Assistant Marine Biologist, Hawaii Marine Laboratory, University of Hawaii.

[2] See Table XII.

II. HISTORICAL REVIEW

The genus Coitocaecum was named by Nicoll (1915) to accommodate a single species, Coitocaecum gymnophallum, from the intestine of the black bream, Sparus australis, in North Queensland, Australia. He considered this genus to be closely related to the family Allocreadiidae, but the presence of the fused intestinal caeca which formed a continuous arch posteriorly and the lack of a true cirrus pouch were sufficient to separate it from that family. The genus was not assigned to any family.

A. Family and generic consideration

In 1925, Poche erected a new subfamily Coitocaecinae, to the family Allocreadiidae for this genus. Ozaki, in the same year, placed the genus in a new family, Opecoelidae, and in the following year described C. plagiorchis and C. orthorchis. The latter author (1929) redescribed C. plagiorchis and C. orthorchis and described C. unibulbosum, C. diplobulbosum, and C. latum, and created the family Coitocaecidae for these species along with C. gymnophallum. He said that Opecoelus and Coitocaecum agree in the absence of a receptaculum seminis, the presence of a small cirrus pouch enclosing but a portion of the vesicula seminalis, and in having a continuous intestine. These characters were used to separate both genera from the Allocreadiidae. The genus Coitocaecum was separated from the genus Opecoelus on the basis of the presence of an anus in the latter which he considered a "...notable and important character..." Winfield (1929) was also in agreement with the separation of Coitocaecinae from the Allocreadiidae.

Later consideration by Stunkard (1931) placed Coitocaecum within the family Opecoelidae as he did not consider the presence or absence of an anus as important a character as was previously thought. He further stated that it would perhaps be better to reduce the Opecoelidae to a subfamily within the Allocreadiidae. This was done by Manter (1934) and concurred with by Harshey (1937) who constructed a chart comparing characters of the three families Allocreadiidae, Opecoelidae, and Coitocaecidae. Harshey stated that the absence of an anus in Coitocaecidae was insufficient to separate it from the Opecoelidae. Because of overlapping of characters and of gross similarities between Opecoelidae and Allocreadiidae the former was reduced to a subfamily, Opecoelinae, within the latter. Others in agreement are MacFarlane (1939), Crowcroft (1945), and Yamaguti (1953, 1958). However, Manter (1947, 1954) again uses the family rank of Opecoelidae.

All of the work thus far mentioned considers only the adult form, which is but a part of the life history. La Rue (1926) states that "...the only safe criteria of relationships must be sought in the method of development and comparative anatomy of the various developmental stages." Crowcroft (1951) states that the final clarification of true relationships may well depend upon embryological and larval studies. Stunkard (1953) believes the really important advances in systematics have come from those studies in which correlation of both larval stages and adults has been done. Carter (1954) considers the data derived from embryological studies to be of more importance than those from the later stages in the life history. Further, there is little doubt that von Baer was correct in stating "...that in related animals the earlier stages in development are more similar than the late stage. This can only mean that evolutionary change has been less in larval stages which, then, should be of more value in determining the phylogenetic relationships of animal groups." Hyman (1951) reports that there are three types of life cycles reported for the family Allocreadiidae and that, due to this, the family is an unnatural assemblage which requires splitting into several groups.

Cable and Crandall (1956) stated, "The discovery that certain very similar adult trematodes have utterly different types of cercariae and that very dissimilar adults may have the same larval type has required drastic revision of existing concepts of relationships and phylogeny within the group." Such a revision was made by La Rue (1957) on the basis of certain characters of the cercariae such as an epithelial or non-epithelial excretory bladder, the type of cercariae, the presence or absence of structures such as a pharynx, a stylet and its position if present, caudal excretory vessels, and upon the life history where it was known. On this basis he included a family Opecoelidae in the superfamily Allocreadioidea. But he further stated that this superfamily as then set up included many varied cercarial types and this would indicate strongly that the superfamily was not a natural one. However, such a revision was not within the scope of his paper.

The cercarial type for the genus Coitocaecum was shown (MacFarlane, 1939) to be a cotylocercous cercaria. Dobrovolny (1939), who listed several early workers supporting his view, indicated that the cotylocercous cercariae are related to the family Allocreadiidae. Hyman (1951) reports the larval type for the genus Allocreadium as an ophthalmoxiphidiocercaria, that is, one containing eye spots and a stylet. The work of

Peters (1957a, 1957b) further establishes the cercarial type of the genus *Allocreadium* as ophthalmoxiphidiocercaria. As this is the type genus for the Allocreadiidae it is believed that this should be the cercarial type for all members of a restricted family Allocreadiidae.

Manter (1947) says that the family Opecoelidae is presently conceived to be that including most of the genera formerly classified as Allocreadiidae. Others in concordance with a restricted Allocreadiidae are Hopkins (1941) and Cable and Hunninen (1942). The species which are known to contain cotylocercous cercariae apparently belong in the family Opecoelidae.

In view of the data from larval and adult stages, the genus *Coitocaecum* is here considered to be a member of the subfamily Opecoelinae in the family Opecoelidae.

Up to 1932 there were ten described species in the genus *Coitocaecum*: *C. gymnophallum* Nicoll, 1915; *C. plagiorchis* Ozaki, 1926; *C. orthorchis* Ozaki, 1926; *C. skrjabini* Iwanitsky, 1928; *C. diplobulbosum* Ozaki, 1929; *C. unibulbosum* Ozaki, 1929; *C. latum* Ozaki, 1929; *C. macrostomum* Pigulewsky, 1931; *C. ovatum* Pigulewsky, 1931; and *C. testiobliquum* Wiśniewsky, 1932. In 1934 Wiśniewsky described *C. proavitum* and divided the genus into three genera: *Coitocaecum*, *Ozakia*, and *Nicolla*. The division was based upon the position of the genital pore and the condition of the cirrus sac. The genus *Coitocaecum* was considered to have a sinistral genital pore anterior to the intestinal bifurcation and a long cirrus sac, which overlapped the acetabulum, and contained a ductus ejaculatorius and a long vesicula seminalis. *Ozakia* was described as having the same genital pore location, but with a short cirrus sac which did not cross the intestinal caecum. Nicolla was described as having a median genital pore posterior to the intestinal bifurcation and a short ovoid cirrus sac.

The result of this splitting left C. gymnophallum, C. testiobliquum, and C. proavitum in the genus Coitocaecum. In the genus Ozakia, Wiśniewsky placed C. plagiorchis, as the type, C. orthorchis, C. diplobulbosum, C. unibulbosum, and C. latum. To Nicolla he assigned C. ovatum, as the type, and C. macrostomum.

It should be noted that Yamaguti (1953, 1958) considers C. diplobulbosum and C. unibulbosum to be synonyms and retains the first name by page priority. These two forms were found by Ozaki (1929) from the same host at the same time. Yamaguti considers the constricted pharynx of C. diplobulbosum to be the result of the fixation process as practically all the other characteristics of these two worms are within a very narrow range. Crowcroft (1951) states that he has never seen a contraction of this nature to occur in fixation, and as six of each form were found at the same time, he retained each as a distinct species.

In the following years Hickman (1934) described C. anaspidis. Yamaguti (1934) described C. glandulosum. Wu (1937) found the metacercaria of a Coitocaecum species; however, it was but briefly described and not identified. Then Park (1939) added C. acanthogobium and C. koreanum, both considered by Yamaguti (1953, 1958) and apparently followed by Manter (1955) to be synonyms of C. orthorchis. Manter (1940) added C. tropicum and Yamaguti in the same year included C. xesuri and C. leptoscari. Ogata (1942) found C. palaoensis and Crowcroft (1944) added C. parvum. C. tylogonium was included by Manter (1954); and

Yamaguti (1958) lists two additions, C. myzura (Pagenstrecher, 1881), and C. gallicum Dollfus, 1941, the latter from a personal communication from Dollfus to Yamaguti dated March 12, 1954.

In 1947, Manter, following the lead of Wiśniewsky, transferred C. anaspidis, C. glandulosum, C. tropicum, C. acanthogobium, C. koreanum, C. leptoscari, C. xesuri, and C. parvum to the genus Ozakia.

Crowcroft (1945, 1951) considered this splitting of the genus Coitocaecum to be unjustified in view of the uniformity of the species within the genus; however, at the time of his first paper (1945), a copy of Wiśniewsky's work was not available to him. In his later paper (1951) he reported that a comparison of Nicoll's original figure with a sketch by Wiśniewsky of Coitocaecum sensu strictu showed that Wiśniewsky mistakenly identified "...the walls of the vesicula seminalis...as a non-muscular cirrus sac containing cirrus, ejaculatory duct and vesicula seminalis interna." In addition to the examination of the figures and descriptions, Crowcroft also examined specimens of Nicoll's original material. He found that there was a small membranous sac over the terminal parts of the male duct and that the vesicula seminalis was entirely outside this sac. An examination of Nicoll's cross-sections from the original material showed that the vesicula seminalis was definitely not inclosed by another membrane. In view of these findings, it was apparent that the terminal portion of the male reproductive system of C. gymnophallum was in agreement with the generic diagnosis given by Wiśniewsky for Ozakia. Thus, the genus Ozakia was reduced to a synonym of Coitocaecum. Crowcroft went on to say that if C. ovatum, C. macrostomum, and C. skrjabini are indeed proven to have a muscular sac inclosing a vesicula seminalis, and if further species with the same characters are described, then, it might be useful to erect a genus to contain them.

B. List of known species

In accordance with the above, there is now a single genus Coitocaecum, again containing the species previously separated. The following is a list of the presently recognized species listed alphabetically by habitat and giving the host and locality.

In marine fish:

C. callyodontis Yamaguti, 1942; in Callyodon sp.; Naha, Okinawa.

C. diplobulbosum Ozaki, 1929, (synonym C. unibulbosum Ozaki, 1929); in Siganus fuscescens; Takamatsu, Japan.

C. glandulosum Yamaguti, 1934; in Epinephalus akaara and Sparus macrocephalus; Pacific Coast and Toyama Bay of Japan.

C. gymnophallum Nicoll, 1915; in Sparus australis; North Queensland, Australia.

C. latum Ozaki, 1929; in Ditrema temmineki; Shimonoseki, Inland Sea, Japan.

C. leptoscari Yamaguti, 1940; in Leptoscarus japonicus; Hamazima, Japan.

C. orthorchis Ozaki, 1926 (synonyms C. acanthogobium Park, 1939, and C. koreanum Park, 1939; from Acanthogobius hasta); in Tridentiger obscura and Acanthogobius flavimanus; Hamanaka, Japan.

C. palaoensis Ogata, 1942; in Toxotes jaculator; Palao.

C. plagiorchis Ozaki, 1926; in Mogurnada obscura, Bryttosus kawamebari, Chaenogobius annularis, Pelteobagrus nudiceps, Misgurnus anguillicaudatus, and Gobio similis; Japan.

C. tropicum Manter, 1940; in Halichoeres dispilus, Opisthognathus scops, and a blenny from the Galapagos; also in Bathygobius soporator, Mexico; and Malacoctenus zonifer; Columbia, South America.

C. tylogonium Manter, 1954; in Centriscops humerosus; Portobello, New Zealand.

C. xesuri Yamaguti, 1940; in Xesurus scalprum; Hamazima, Japan.

In fresh water fish found in brackish water:

C. anaspidis Hickman, 1934, from progenetic metacercaria in Anaspides tasmaniae and Gammarus sp.; Tasmania. Adults in Salmo faris, Gobiomorphus gobioides, Galaxias brevipennis, G. attenuatus, and Anguilla sp.; New Zealand.

C. parvum Crowcroft, 1945; in Pseudophritis urvilli and Galaxias attenuatus; Australia.

In fresh water fish:

C. gallicum Dollfus, 1941; in Cottus gobio.

C. macrostomum Pigulewski, 1931; in Siluris glanis; Dnjeprbassin.

C. myzura (Pagenstrecher, 1881); in Nerithina fluviatilis and Bithynia tentaculata.

C. ovatum Pigulewsky, 1931; in Esox lucius and Acorina cernua; Dnjeprbassin.

C. proavitum Wiśniewsky, 1933; Salmo fario and S. irideus; Yugoslavia.

C. skrjabini Iwanitzky, 1928; in Acerina cernua; Ukraine, U.S.S.R.

C. testiobliquum Wiśniewsky, 1933; in Salmo fario and S. irideus; Yugloslavia.

C. species Wu, 1937; adults unknown, undescribed metacercaria reported in fresh water shrimp, Palaemon asperulus and P. nipponensis; Shanghai area, China.

III. MATERIALS AND METHODS

The fish definitive host was collected with small hand nets. In the laboratory those fish not autopsied immediately to obtain stomach contents were retained in aerated aquaria and fed commercial frozen brine shrimp.

The digestive tract was dissected, in cold-blooded Ringer's solution, under a dissecting microscope. After all observable worms were removed, either a chloretone solution (two grams in 500 ml. Ringer's solution) or a menthol solution (as much as would dissolve in Ringer's solution) was used to relax any remaining worms and to free them from the intestine. In this manner all trematodes present in each fish intestine could be collected.

Following study in the living state, the adult flukes were fixed in Lavdowsky's solution under slight cover glass pressure and were allowed to fix overnight. The stains used for adults included acidified alum carmine, trichrome, and hematoxylin.

Algae were collected from the same tidal pools as the infected fish, brought to the laboratory and examined for the snail intermediate host. A collection of algae requiring about two to three hours to examine would generally provide 50 to 75 snails. The snails were placed in small vials, about 10 snails in each. The vials were checked for cercariae either that night or the next morning. Snails in vials which contained cercariae were placed individually in clean vials. In this manner the infected snails were separated. In the mornings the snails were placed in new dishes and the cercariae counted. These counts were made daily for four to seven days. The snail was then crushed and the total number of

III. MATERIALS AND METHODS

The fish definitive host was collected with small hand nets. In the laboratory those fish not autopsied immediately to obtain stomach contents were retained in aerated aquaria and fed commercial frozen brine shrimp.

The digestive tract was dissected, in cold-blooded Ringer's solution, under a dissecting microscope. After all observable worms were removed, either a chloretone solution (two grams in 500 ml. Ringer's solution) or a menthol solution (as much as would dissolve in Ringer's solution) was used to relax any remaining worms and to free them from the intestine. In this manner all trematodes present in each fish intestine could be collected.

Following study in the living state, the adult flukes were fixed in Lavdowsky's solution under slight cover glass pressure and were allowed to fix overnight. The stains used for adults included acidified alum carmine, trichrome, and hematoxylin.

Algae were collected from the same tidal pools as the infected fish, brought to the laboratory and examined for the snail intermediate host. A collection of algae requiring about two to three hours to examine would generally provide 50 to 75 snails. The snails were placed in small vials, about 10 snails in each. The vials were checked for cercariae either that night or the next morning. Snails in vials which contained cercariae were placed individually in clean vials. In this manner the infected snails were separated. In the mornings the snails were placed in new dishes and the cercariae counted. These counts were made daily for four to seven days. The snail was then crushed and the total number of sporocysts recorded.

Snails could be kept alive in the laboratory by placing them on a piece of the alga Spyridia filamentosa (Wulf.) Harvey.[1] This was kept in an aerated 1000 ml. graduated cylinder covered by Saran Wrap. The force of the bubbles rising kept the algae at the top of the water and the filaments in constant motion. A fluorescent lamp (40 watts, cool white) was kept lighted day and night about 12 inches above the algae. The algae could be kept alive for three to four weeks and easily replaced with fresh algae when necessary. By this method both infected and non-infected snails could be maintained for over four months. Amphipods, but not shrimp, could be kept alive for extended periods in this same "aquarium."

Trematode eggs for development and hatching were obtained by collecting feces from infected gobies. The feces were placed in two percent formalin for two to three minutes, followed by rinsing in filtered sea water. They were then put into vials containing filtered (triple layers of Whatman Number 2 filter paper) sea water. The vials were covered loosely. It was not found necessary to change the sea water more frequently than once a week. The eggs were examined daily under a compound microscope to follow development.

The feces from isolated gobies were collected daily and the eggs counted. These counts were made for approximately one week for each fish and the total hours of collection recorded. The fish was then autopsied and the total number of adult flukes recorded.

---

[1] The alga was identified by Dr. Maxwell S. Doty, Professor of Botany, University of Hawaii.

Miracidia obtained from hatched eggs were observed only in the living state. Attempts to use intra-vital stains (1:1000 neutral red and 1:1000 Azure A, both in Ringer's solution) resulted only in contracted specimens. The use of chloretone or menthol also yielded contracted specimens, as did the use of gentle heat or refrigeration.

Sporocysts were collected by carefully crushing the snail between glass slides. The shell fragments were then teased away from the snail body. Teasing out the sporocysts was easier after the snail body had been placed in a refrigerator at about 6^{o} C., for several hours. Recovery of the sporocysts from the effects of refrigeration was fairly rapid. They, and the developing cercariae within them were usually moving about in 10 minutes. The sporocysts were examined both in the living state and as whole mounts stained with acidified alum carmine.

Cercariae were studied in the living state, both unstained and intra-vitally stained by the use of a 1:1000 solution of neutral red. They were killed in a relaxed condition by the use of gentle heat, fixed in Lavdowsky's solution and stained with acidified alum carmine.

For experimental use, 25 ml. aliquots of diluted sea water were made. The percentages used in dilution of the sea water were: 25, 50, 75, 80, 85, 90, and 95. The specific gravities of these dilutions were determined at room temperature by use of a hydrometer. It was found that a five per-cent change in sea water dilution resulted in a single number change in specific gravity. Thus, a solution of 95 percent sea water gave a reading of 1.019 and 90 percent sea water gave a reading of 1.018.

Sea water was concentrated by evaporation by sun light and then fil-tered. Concentrations were made having the following specific gravities

1.021, 1.022, 1.023, 1.024, 1.025, 1.030, and 1.034. (1.020 was the specific gravity of normal sea water.)

Feces from infected gobies, after washing in two percent formalin for two or three minutes were placed in the various dilutions and concentrations in order to determine their effects on development and hatching of eggs.

To test the ability of the miracidia and cercariae to endure various concentrations and diluations of the sea water, ten normal appearing specimens were placed in each test solution. Each experiment was repeated at least once.

Apparently uninfected snails of the genus Rissoa were placed in Stender dishes containing miracidia hatched from eggs obtained from infected gobies. The snails remained in the dishes for about 48 hours. They were then transferred to the "snail aquarium" described above.

Shrimp were exposed by being placed in Stender dishes containing cercariae from infected snails. The shrimps, one for each dish, were exposed overnight.

All drawings were made with the aid of a camera lucida.

IV. ECOLOGY OF THE FISH DEFINITIVE HOST, BATHYGOBIUS FUSCUS

Probably the most common tide pool fish in the Hawaiian Islands is Bathygobius fuscus. This goby, locally called O'opu, is universally found in quite shallow water, such as tidal pools, pot holes, sand and mud flats (Tinker, 1944) and also in estuaries.

Gosline and Brock (1960), in discussing the shore fishes of Hawaii, state that "in shallow water the primary factor governing zonation [of fishes] is wave action... the uppermost zone is made up of pools along the shore that are located so that the water in them will be more or less frequently refreshed by wave action, but which are well above the level of maximum wave force." They also remark that perhaps the young of B. fuscus are among the fishes which move up to this zone and as they become mature tend to work again towards the deeper water. However, this fish is not found beyond the area of wave action.

The geographical distribution as given by Tinker (1944) is: the Red Sea, Mozambique, Mauritius, India, the Andaman Islands, the East Indies, along the China Coast, Queensland in Australia, through Micronesia, Melanesia, and Polynesia.

A. General appearance

The range in color of this goby is quite wide. Gosline and Brock (1960) report that it varies from a light tan over areas having a sandy bottom to black over basalt substrates. Jordan and Evermann (1903) state that some specimens are "marked with black marblings and brown edges to the scales." Others are described as "marked with pearly blue spots on a background of mottled light and dark olive." According to Tinker (1944),

B. fuscus is "reddish olive to brown and is mottled and marked with pearly blue spots."

Specimens of B. fuscus obtained during this study which were dark in color upon collection soon became a light tan with transverse dark bands after being placed in an aquarium with a sandy bottom.

It is interesting to note that Jordan and Evermann (1903) stated that they could find no differences between B. fuscus and the American example, B. soporator. This latter species was found by Manter (1940) to be a host for Coitocaecum tropicum off the Pacific Coast of Mexico.

Both Gosline and Brock (1960) and Tinker (1944) stated the maximum size of B. fuscus to be four inches. Edmondson (1946), however, gave the maximum size as six inches, but also said that most specimens were smaller.

B. Food habits

Autopsy records indicate that this fish, from the island of Oahu, seems to feed mainly on amphipods, ostracods, shrimp, isopods, insect larvae, and other small crustaceans. They are also canibalistic. Other tidal pool fish used for food are the small blenny, Istiblennius zebra, and young sargeant majors, Abudefduf abdominalis. No plant food or plant remains has ever been found among the stomach contents of B. fuscus from Diamond Head Beach during this study. However, Hiatt and Strasburg (1960) in an ecological monograph on Marshallese fish reported that seven percent of B. fuscus were found to have algal filaments mixed with sand grains within their stomachs.

C. Tolerance to habitat changes

As a tidal pool fish B. fuscus is by necessity eurythermic and euryhaline. Data from the Marshall Islands (Hiatt and Strasburg, 1960) indicated that these fish were not particularly affected by a water temperature of 106° F., at least for a few hours, while other fishes in the same tide pool were found to be dead.

This fish can be taken from sea water and placed directly into a fresh water aquarium and survive. Unpublished data from Donald A. Thomson (1958, 1959) showed that B. fuscus will survive at least two months under such conditions.[1] At the end of this time the fish was removed from the aquarium and further definite information on the longevity was not determined. Thomson, however, believes that the fish would probably survive indefinitely. On the other hand, B. fuscus has been observed by the author on Rabbit Island swimming apparently normally in tide pools where the salt concentration was such that salt had crystallized around the edges of the pool.

D. Other trematodes found in B. fuscus

In addition to Coitocaecum bathygobium, this goby also served as host for a bucephalid trematode encysted under the scales, particularly surrounding the pelvic, pectoral, and dorsal fins. This occurred in about five to ten percent of the fish. A hemiurid trematode was found in approximately ten percent of the gobies. This fluke was found in the intestines and not encysted, however, the reproductive organs have never been observed in any hemiurids thus far seen in B. fuscus.

---

[1] Graduate student, Dept. Zoology and Entomology, University of Hawaii.

V. MORPHOLOGICAL STUDIES OF *COITOCAECUM BATHYGOBIUM*

The morphology of the adult fluke indicates that it is a member of the family Opecoelidae and the genus *Coitocaecum*. There are presently 22 described species within this genus. The *Coitocaecum* species found at Diamond Head Beach differs from the majority of the described species on the basis of the position of the posterior arch which passes immediately posterior to the posterior testis. This condition is found in only a single described species, *C. parvum* Crowcroft, 1945. This latter species also has the same body size and relative size of the testes to the body size as the local species herein described. However, *C. parvum* is a trematode from fresh-water fishes and, differs from the Hawaiian *Coitocaecum* in the following: (1) the gape of the acetabulum may be papillate, (2) lobed testes, (3) the vesicula seminalis extending as far back as the posterior edge of the acetabulum, (4) a small cirrus, (5) a well-developed metraterm, (6) the vitellaria extend anteriorly to a level with the anterior edge of the pharynx, and (7) having larger eggs.

There are several described species in which the hind arch of the intestine passes fairly close to the posterior testis. These species are: *C. callyodontis* Yamaguti, 1942, *C. latum* Ozaki, 1929, *C. macrostomum* Pigulewsky, 1931, and *C. plagiorchis* Ozaki, 1926. In all remaining species this arch is located about half-way between the posterior margin of the hind testis and the posterior end of the body (see Figs. 36, 30, 31, 26).

C. callyodontis differs from the local specimen in that (1) it is two to three times as large, (2) its ovary may be indented, (3) the vitellaria extend anteriorly only as far as the posterior edge of the acetabulum, and (4) its testes may be indented or lobed. C. latum differs from C. bathygobium in that (1) the body of C. latum is broadly oval, (2) its eggs are larger, (3) the vitellaria extend anteriorly only as far as the intestinal bifurcation, (4) the vesicula seminalis extends posteriorly to about the middle of the acetabulum, and (5) it possesses a muscular cirrus sac. C. macrostomum, from a fresh-water fish, differs from the Hawaiian specimens in that (1) its acetabulum is almost as wide as the body, (2) its eggs are much larger, (3) the vitellaria extend only to the anterior edge of the acetabulum, (4) the testes are irregularly oval, (5) the vesicula seminalis overlaps the acetabulum, and (6) the genital pore is located underneath the intestinal bifurcation.

C. plagiorchis, from Japan, differs from the Hawaiian specimens in having (1) rounded testes which are relatively smaller in size compared to the body size, and which are located in the middle of the hind body, (2) possessing a well-developed, muscular, cirrus sac, (3) the possession of a spherical vesicula seminalis interna, and (4) according to Yamaguti (1934), a "Y"-shaped excretory vesicle.

In addition to the descriptions of the various species of Coitocaecum, there are four keys to the genus available. The first is that of Ozaki (1929) which includes six species. In this key the local specimen resembles C. orthorchis Ozaki, 1926. However, C. orthorchis differs from the specimen from Diamond Head Beach in (1) being one and one-half to two times as large, (2) the ovary is median, (3) the hind arch of the intestine is located at a level about one-half the distance between the posterior testis and the posterior end of the body, (4) the vesicula seminalis reaches to the center of the acetabulum, and (5) much larger eggs.

Pigulewsky (1931) presents a key including the type species for the genus and three European species. The Hawaiian Coitocaecum cannot be placed in this key at all.

In 1934, Hickman gave a key to seven species. In this key to Hawaiian species appears to be C. unibulbosum Ozaki, 1929. This Japanese form differs from the local specimens in (1) being over twice as large, (2) a decidedly pre-equatorial acetabulum, (3) the vitellaria extend anteriorly to a level slightly posterior to the intestinal bifurcation, (4) relatively smaller testes, (5) the vesicula seminalis extends to about midway on the acetabulum, and (6) much larger eggs.

The latest key is that of Crowcroft (1945) including 14 species. Here the Hawaiian Coitocaecum closely resembles C. parvum. The differences between the two forms have been discussed above.

It thus appears that the local specimens differ from all given species in the keys and from all known descriptions and figures and should be considered a new species. The name bathygobium is derived from the use of the generic name of the fish definitive host, a rather common procedure in naming trematodes.

A. Taxonomic description of a new species of Coitocaecum, C. bathygobium n. sp. (Fig. 1)

This description is based on measurements taken from 40 adult specimens, on certain measurements of 17 additional specimens, and upon observations on an additional 115 specimens. (See Tables XIV and XV)

These are small, smooth, oval distomes, which, in life, are somewhat translucent and have a yellowish tinge in the region of the vitellaria, and a golden-brown color where the eggs are found.

The vitellaria, ovary, testes, eggs, oral sucker, acetabulum, and pharynx can readily be seen. The digestive system, however, is largely hidden by the vitellaria posterior to the pharynx. The adult body averages 0.714 mm. long and 0.238 mm. wide at the acetabulum. A subterminal oral sucker averages 0.079 mm. by 0.081 mm. This is followed by a short prepharynx with an average length of 0.012 mm. The subglobular pharynx averages 0.042 x 0.053 mm. The esophagus is of medium length and averages 0.052 mm., its length is variable and depends upon the degree of contraction of the specimen. The intestinal caeca pass laterally to the posterior part of the body where they unite immediately behind the posterior testis. There is no connection between the caeca and the excretory vesicle nor are there other openings to the exterior. The large muscular acetabulum is transverse and averages 0.157 x 0.165 mm. There are no papillae or lobes on the gape. The acetabular width generally approximates one-half the body width in fixed specimens; but in life, when the fluke extends itself, the acetabulum becomes wider than the remainder of the body. The acetabulum is located very slightly pre-equatorially. The sucker ratio averages 1: 2.05. The forebody averages 0.283 mm. in length.

The dextral ovary is rounded to oval and is generally positioned immediately anterior to the anterior testis. It averages 0.066 mm. long by 0.063 mm. wide. The oviduct passes forward along the right side, just intercaecal, and very shortly gives off Laurer's canal. This structure passes transversely across half the body forming a rather loose "S" curve to open dorsally near the midline behind the acetabulum. The yolk reservoir joins the oviduct just beyond the junction of the oviduct and Laurer's canal. The uterus continues forward until it reaches approximately the middle of the acetabulum where it reverses itself and is directed posteriorly. It then forms a few loops in the intercaecal field between the anterior testis and the acetabulum. The uterus then passes forward along the left side of the acetabulum. There is no distinct metraterm. A receptaculum seminis is absent, and is replaced by a receptaculum seminis uterinum, which, at times, seems to comprise about one-third to one-half the length of the uterus. The eggs (Fig. 12, 13) are golden-brown and are uncleaved when passed. They are small for the genus and average 50 x 33μ. There is a slight thickening on one side at the end opposite the operculum. The follicular vitellaria commence at the posterior portion of the pharynx. They are frequently confluent in the area between the pharynx and the acetabulum, then pass posterior laterally on both sides of, and often overlapping, the caeca. They may also overlap the ovary and testes in places. The vitellaria are again confluent behind the posterior testis.

The transversely oval testes are tandem or oblique and are contiguous. The anterior testis averages 0.101 x 0.126 mm. The posterior testis is generally larger and averages 0.11 x 0.134 mm. They are located in the posterior one-third of the body and occupy a space equal to just under one third of the body length, or 0.207 mm. The vesicula seminalis is saccular and preacetabular. Its length averages 0.093 mm. and its width, 0.041 mm. It tapers gradually and crosses the left caecum and continues anteriorly to the genital pore located sinistrally slightly posterior to the pharynx. A weakly-developed, pear-shaped cirrus sac containing the terminal portion of the male duct can sometimes be observed. There is no distinct cirrus nor is there a distinct pars prostatica.

The excretory vesicle is saccular and extends anteriorly to the level of the posterior margin of the ovary. The excretory pore is terminal.

Table I is a comparison of 19 species of the genus Coitocaecum. This table does not include the following species. C. palaoensis, C. gallicum, and C. myzura. Ogata's paper describing C. palaoensis is apparently available only from the American Museum of Natural History; however, this institute will not lend the publication and neither a microfilm nor a photostatic copy have been received. According to Yamaguti (1958), C. gallicum was described by Dollfus (1941). This information was obtained from a personal letter from Dollfus to Yamaguti. No reference to this species has been located. The only description available concerning C. myzura is a description of Cercaria myzura by Pagenstrecher, 1881. The latter two species are fresh-water forms. C. palaoensis is from a marine fish.

A key to the 19 species is given. This key is enlarged and modified from that of Crowcroft (1945).

Species			
	length in mm.	size in mm. & position of oral sucker	
C. gymnophallum	up to 3 mm. largegland cells present elongate	0.27 x 0.31 mm. subterminal	0 p
C. glandulosum	2.8 to 3.65 mm. large gland cells present plump with broadly pointed extremities	0.29 x 0.22-0.28 mm. subterminal	0 p
C. callyodontis	2.0 to 3.35 mm. gland cells absent forebody tapers abruptly from acetablum Posterior rounded	0.2-0.33 x 0.21-0.3 mm. ventroterminal	0 p
C. proavitum	1.90 - 2.85 mm. elongate	0.2-0.27 x 0.21-0.28 mm. subterminal	0 p
C. leptoscari	1.9 mm. plump	0.15 x 0.17 mm. subterminal	0 p
C. xesuri	2.65 mm. nearly fusiform	0.188-0.2 mm. in diameter subterminal	0 p

TABLE I. COMPARISON OF SPECIES OF COITOCAECUM

Character							
size in mm. and position of acetabulum	shape and position of ovary	size of eggs in μ	vitellaria	shape & arrangement of testes	positional seminal vesicle	size in μ and condition of cirrus pouch	position of genital pore
0.43 x 0.57 mm. preequatorial	oval immediately anterior to anterior testis	81-88 x 42-43	extend anteriorly to level of posterior edge of acetabulum	anterior edges indented tandem	anterior to acetabulum	no true cirrus pouch	sinistral middle of pharynx
0.38-0.41 x 0.44-0.55 mm. preequatorial	tranversely elongate oblique to anterior testis	63-70 x 39-42	extend anteriorly to level of posterior edge of acetabulum	irregularly indented margins tandem or oblique	anterior to acetabulum sinuous	present 210 x 130	sinistral just behind pharynx
0.26-0.41 x 0.32-0.45 mm. preequatorial	oval or indented immediately anterior to anterior testis on median line or to one side	54-57 x 36	extend anteriorly to level of posterior edge of acetabulum	slightly indented or lobed tandem or oblique	overlaps acetabulum curved or twisted	present 60-80 μ diameter	sinistral anywhere between intestinal bifurcation and pharynx
0.28-0.44 x 0.32 mm. preequatorial	rounded or elliptical just anterior to anterior testis	42-68 x 33-43 filamented or not	extend anteriorly to posterior end of pharynx	more or less irregular ellipse tandem or oblique	overlaps acetabulum anteriorly	muscular	sinistral anterior to intestinal bifurcation
0.225 x 0.238 mm. preequatorial	ovoid just dextral to anterior testis	54-57 x 33-36	Extend anteriorly half-way between acetabulum and intestinal bifurcation	oval oblique	extends posteriorly to anterior margin (dextral) of acetabulum	400 μ diameter muscular	sinistral at posterior end of esophagus
0.325 mm. diameter preequatorial	subglobular just anterior to anterior testis	57 x 33	extend anteriorly to just behind the genital pore	more or less indented tandem	anterior to acetabulum	30 μ diameter directed backwards	sinistral just posterior to intestinal bifurcation

Species		
	length in mm.	size in mm. & position of oral sucker
C. testiobliquum*	0.75-140 mm. broad	
C. ovatum	1.27-1.39 mm. oval	0.182-0.217 x 0.130 -0.180 mm.
C. tylogonium	3.204 mm. elongate	0.254 mm. wide
C. macrostomum	0.79-0.87 mm. oblong-oval	0.213-0.261 mm. subterminal
C. skrjabini**		almost as large as acetabulum
C. latum	0.97-1.65 mm.	0.095-0.12 mm. wide subterminal

TABLE I. (CONTINUED) COMPARISON OF SPECIES OF COITOCAECUM

	Character						
size in mm. and position of acetabulum	shape and position of ovary	size of eggs in μ	vitellaria	shape & arrangement of testes	positional seminal vesicle	size in μ and condition of cirrus pouch	position of genital pore
	oval	52-59	vitellaria extend to neck region but are broken at acetabular level	posterior testis smaller than anterior tandem or oblique		muscles weakly developed	
0.365-0.521 x 0.087 -0.130 mm. preequatorial	oblong-oval wide, irregular notches in margins just anterior to anterior testis	67-82 x 42-52	vitellaria extend to neck region but are broken at acetabular level	irregularly notched tandem	overlaps acetabulum but does not cross intestinal caecum		under intestinal bifurcation
0.455 mm. wide equatorial	deeply four-lobed just anterior to anterior testis	53-57 x 30-32	vitellaria extend to neck region but are broken at acetabular level	slightly lobed tandem	anterior to acetabulum	present 152 x 95	median slightly posterior to intestinal bifurcation
as wide as body (0.24-0.28 mm.) preequatorial	oval immediately anterior to anterior testis	65-82 x 35-39	extend anterior to acetabulum	irregularly oval tandem	overlaps the acetabulum		underneath intestinal bifurcation
	oval		extend to anterior margin of acetabulum, may occasionally be broken at acetabulum	oval		muscular	just to right of intestinal bifurcation
0.26-0.44 mm. wide just preequatorial	transversely oval anterior to anterior testis	55-67 x 36-42	extend anteriorly to intestinal bifurcation	globular tandem or oblique	extends posteriorly to about middle of acetabulum	120 x 60 muscular	sinistral just anterior to intestinal bifurcation

Species		
	length in mm.	size in mm. & position of oral sucker
C. tropicum	0.78-1.14 mm. elongate	0.088-0.135 mm. diameter subterminal
C. orthorchis	1.15-2.45 mm. elongate	0.15-0.21 mm. diameter subterminal
C. anaspidis	0.95-2.8 mm. elongate	0.10-0.164 mm. diameter subterminal
C. diplobulbosum	1.9-2.35 mm. lancelot	0.14-0.17 mm. diameter subterminal
C. plagiorchis	0.7-1.68 mm. elongate	0.06 mm. diameter subterminal
C. parvum	0.57-1.8 mm. oval	0.09 mm. diameter subterminal

TABLE I. (CONTINUED) COMPARISON OF SPECIES OF COITOCAECUM

Character							
size in mm. and position of acetabulum	shape and position of ovary	size of eggs in μ	vitellarie	shape & arrangement of testes	positional seminal vesicle	size in μ and condition of cirrus pouch	position of genital pore
0.165-0.277 mm. wide preequatorial	ovoid just anterior to anterior testis	48-51 x 26-32	extend anteriorly to intestinal bifurcation	transverse tandem or oblique	preacetabular or rarely, extends posteriorly behind acetabulum	thin-walled	sinistral anterior one-half of esophagus
0.25-0.30 mm. diameter preequatorial	subblobular to transversely elongate just anterior to or dextral to anterior testis	58-80 x 40-50	extend anteriorly to level of pharynx	globular to transverse may be slightly lobed tandem or oblique	preacetabular	small and rudimentary	sinistral just anterior to intestinal bifurcation
0.18-0.37 x 0.26-0.28 mm. preequatorial	spherical to elongate just anterior to anterior testis	52-87 x 42-51	extend anteriorly to level of genital pore or further to posterior end of pharynx	ovoid to rounded rectangular tandem or oblique	extends posteriorly along right side to about midway on acetabulum	small	sinistral just anterior to intestinal bifurcation
0.21-0127 mm. diameter preequatorial	oval to rounded triangular anterior to anterior testis	60-70 x 38-40	extend anteriorly to level of intestinal bifurcation or slightly posterior to this	more or less oval oblique	extends posteriorly to middle of acetabulum	thin-walled rudimentary	sinistral leval of intestinal bifurcation or slightly anterior to this
0.11-0.22 x 0.14-0.29 equatorial or preequatorial	round to slightly transverse anterior to anterior testis	45-60 x 34-42	extend anteriorly to level of genital pore	rounded tandem	twisted anterior to acetabulum	33-64 μ diameter muscular conical	sinistral between pharynx and intestinal bifurcation
0.19 x 0.14 mm. preequatorial may be papillate	ovoid just anterior to, or oblique to anterior testis	60-76 x 32-40	extend anteriorly to anterior level of pharynx	anterior to intestine. lobed posterior frequently the larger tandem or oblique	may extend posteriorly to posterior edge of ecetabulum	64 x 32	sinistral just anterior to intestinal bifurcation

Species		
	length in mm.	size in mm. & position of oral sucker
C. bathygobium	0.397-1.25 mm. oval	0.056-0.102 x 0.062-0.106 mm., subterminal

TABLE I. (CONTINUED) COMPARISON OF SPECIES OF COITOCAECUM

Character							
size in mm. and position of acetabulum	shape and position of ovary	size of eggs in μ	vitellaria	shape & arrangement of testes	positional seminal vesicle	size in μ and condition of cirrus pouch	position of genital pore
0.088-0.206 x 0.132-0.265 just preequatorial	rounded to oval just anterior to, or along right side of, anterior testis	43-56 x 26-38 thickened end	extend anteriorly to posterior edge of pharynx confluent between pharynx and acetabulum	anterior to intestine oval posterior generally the larger tandem or oblique	rarely overlaps acetabulum	weakly developed may occasionally be seen	sinistral between pharynx and intestinal bifurcation

* Original paper not seen. Description from remarks by Wiśniewsky (1934) and Manter (1947), and the key by Crowcroft (1945).

** Original paper not seen. Description based on remarks by Manter (1947) and keys constructed by Pigulewsky (1932) and Crowcroft (1945).

B. Taxonomic key to species of Coitocaecum

(Enlarged from that of Crowcroft, 1945)

1. Vitellaria entirely postacetabular - - - - - - - - 2

Vitellaria extend into neck region but are broken at level of acetabulum - - - - - - - - 3

Vitellaria extend into neck region but are not broken at level of acetabulum - - - - - - 4

2. Large gland cells present in area of anterior intestinal arch; eggs 63-70 μ - - - - - - - - - *C. glandulosum*

Large gland cells present in area of prepharynx or around anterior intestinal arch; eggs 81-88μ- - - - - - - - - - - - - - *C. gymnophallum*

Gland cells absent; eggs 54-57 μ - - - - - - - - - *C. callyodontis*

3. Body broad-oval; testes transversely elongated, posterior testis smaller; ovary oval- - - - *C. testiobliquum*

Body elongate-oval; testes roundly lobed, posterior testis larger; ovary with wide irregular notches - - - - - - - - - - - - - - - *C. ovatum*

Body elongate-oval; testes slightly lobed; ovary deeply four-lobed - - - - - - - - - - - *C. tylogonium*

4. Genital pore median; cirrus sac within intestinal arch - - - - - - - - - - - - - - - *C. macrostomum*

Genital pore submedian; seminal vesicle crosses intestine - - - - - - - - - - - - - - - 5

5. Oral sucker almost as large as acetabulum- - - - C. skrjabini

Oral sucker approximately half as large as acetabulum - - - - - - - - - - - - - - - - - 6

6. Body round - C. latum

Body ovoid or elongate-oval - - - - - - - - - - - 7

7. Vesicula seminalis interna spherical - - - - - - C. plagiorchis

Vesicula seminalis interna tubular - - - - - - - 8

8. Posterior intestinal arch immediately behind the posterior testis - - - - - - - - - - - - 9

Posterior intestinal arch near posterior border of body - - - - - - - - - - - - - - - 10

9. Testes lobed; small cirrus present; eggs 60-76 μ - - - - - - - - - - - - - - - - - - - C. parvum

Testes unlobed; cirrus absent; eggs 43-56 μ - - - C. bathygobium n. sp.

10. Cirrus sac completely muscular - - - - - - - - - 11

Cirrus sac partly or entirely membranous - - - - 12

11. Vitellaria extend to posterior edge of pharynx - - - - - - - - - - - - - - - - - - - C. proavitum

Vitellaria extend to a level between acetabulum and intestinal bifurcation - - - C. leptoscari

12. Cirrus absent - - - - - - - - - - - - - - - - - - 13

Cirrus present - - - - - - - - - - - - - - - - - - 14

13. Acetabulum with papillaform protuberances - - - C. xesuri

Acetabulum simple - - - - - - - - - - - - - - - - C. diplobulbosum

14. Vitellaria entirely lateral in forebody; eggs 48-51 μ - - - - - - - - - - - - - - - - C. tropicum

Vitellaria not completely lateral in forebody;

eggs much larger - -- - - - - - - - - - - - - 15

15. Esophagus short; cirrus sac entirely

membranous - - - - - - - - - - - - - - - - - *C. orthorchis*

Esophagus long; cirrus sac muscular

anteriorly - - -- - - - - - - - - - - - - - *C. anaspidis*

C. Morphological variation

Crowcroft (1951) states that a prerequisite for the prevention of setting up of invalid species is a wider knowledge of the natural and artificial variations which are found within a species. Stunkard (1957), although speaking of similar worms from different hosts, stresses the problems of an investigator's attempting to decide whether he is dealing with one or more species. He states:

> In such variable worms, which have no skeletal system, and in which the shape is modified by the contraction of different sets of muscles, which may become sexually mature at one-fourth the maximum size and continue to grow as long as they live; in which the morphology is dependent upon the degree of maturation and in which the location and shape of organs are influenced by extension and contraction of the body, by accumulation of genital products (spermatozoa in the seminal vesicle or eggs in the uterus) or even by accumulation of fluid in the excretory vesicle; specific determination of a particular individual may pose an almost insoluble problem.

For the above reasons, and because of the ready availability of large numbers of what is considered to be a single species, it was decided to attempt to determine the extent of variation present within this species, Coitocaecum bathygobium. The following description is based on specimens taken over a three year period from a single host species and from a single host locality, with a single exception. One specimen was found in a small wrasse, Stethojulis axillaris, also from tidal pools at Diamond Head Beach.[1] The parasite was not recovered from any other locality on the island of Oahu in spite of the fact that the fish definitive host is probably the most common tidal pool fish.

---

[1] See Table XIV

1. External anatomy

The length of the body varies from 0.397 to 1.25 mm. In outline, the body is generally oval, tapering anteriorly to a blunt point. Posterior to the acetabulum the sides are somewhat parallel; then they taper to a bluntly-rounded posterior end. The shape varies in different specimens from oval to elongate-oval and from pear-shaped, rarely, to bluntly-pointed both anteriorly and posteriorly. In the last case the body tapers in both directions from the acetabulum.

At it's widest point, the body is 0.162 - 0.499 mm. In most cases the broadest point is found at the acetabulum. However, in a few specimens the widest part is at the ovarian or testicular level.

The oral sucker is rounded, primarily, but may be either wider than long, or, almost equal in occurrance, longer than wide. It was invariably subterminal in location in the specimens studied.

The acetabulum is generally transverse but may be rounded. It is occasionally found to be longer than wide. In position it is considered to be very slightly preequatorial, but in three instances it was slightly postequatorial. The acetabular position, either preequatorial, equatorial, or postequatorial was not correlated with any adult body length. It is obvious that any slight contraction of either half of the body, without a corresponding contraction in the other half, will affect the acetabular location.

The average sucker ratio is almost exactly 1: 2 (1: 2.05). However, the individual ratios varied from a low of 1: 1.7, fairly frequent, to a high of 1: 2.8, found in only a single instance.

2. Digestive system

The wide prepharynx varies in length from 0.003 to 0.015 mm. It is not observed in all specimens and its presence or absence must be correlated with a contraction of the forebody, a slight contraction being sufficient to hide this structure.

The pharynx is primarily subglobular, but a variety of shapes were found in the worms studied. The most common alternate form was a perfectly globular pharynx. Almost as common in occurrance was a markedly transverse organ. Occasionally, a pharynx was roughly rectangular in outline and elongate. One was found to be roughly square. Two were pear-shaped, one of these was rather squat, being also transverse. The other pear-shaped pharynx (Fig. 10) had a slight constriction in the anterior half. Three other pharynxes, roughly rectangular, were constricted in the center. An example of this is shown in Fig. 7. In all cases the constriction was found only following fixation of the specimen and was not observed prior to the process.

The esophagus is of moderate length and exhibits no special features. In length it varies from 0.015 to 0.039 mm. Here again, as in the prepharynx, the length is largely determined by the degree of contraction of the fluke.

The intestinal caeca are united, forming an arch immediately behind the posterior testis. However, in two examples studied this was not the case. In one specimen the posterior arch passed across the body at a level half-way between the anterior and posterior margins of the hind testis. In the other specimen (Fig. 4) the arch crossed the body between the anterior and posterior testes.

3. Female reproductive system

The ovary was invariably dextral and measured 0.04 - 0.112 mm. long by 0.046 - 0.089 mm. wide. In the majority of specimens it was transversely oval, but it might also be rounded or longitudinally oval. In one specimen, where it was longitudinal, it was roughly rectangular, while in another, it resembled a tear-drop with the rounded point directed posteriorly. Occasionally the ovary was not contiguous with the anterior testis (Figs. 3, 9, 11). It may be located either anterior to or dextrally lateral to the anterior testis. In a single specimen studied it was contiguous with both the anterior and posterior testes. It is intercaecal but may, on rare occasions, overlap but not overreach the right caecum.

The condition of the vitellaria is considered to be of taxonomic importance in the genus Coitocaecum. Species are divided by the anterior extent of the vitellaria and by whether or not they are broken laterally in continuity. This character is, of course, taken in consideration with others, but is still thought to be of importance in itself.

In the Hawaiian species the vitellaria extend anteriorly, for the most part, to a level even with the posterior end of the pharynx. However, in various specimens they may stop at the level of the intestinal bifurcation or any position between these levels. They are generally confluent anteriorly in the area of the intestinal bifurcation and posteriorly behind the hind testis. Laterally, they extend along both sides of the caeca, surrounding and often obscuring these structures. This distribution was markedly changed in a few specimens studied. In two worms the vitellaria were not confluent posteriorly and were, in fact, completely missing from that portion of the body (Figs. 6, 7). A single fluke showed the vitellaria to be missing on the right side from the posterior end of the body to a level midway up the anterior testis (Fig. 5). Another specimen had these structures interrupted on both sides of the body (Fig. 3). On the left side they were missing for the length of the anterior testis and again for a short distance along the anterior portion of the acetabulum. On the left side they were interrupted slightly along the posterior testis. It thus appears that the vitellaria are not constant in distribution and perhaps some of the above specimens could, if found alone, present taxonomic problems.

4. Male reproductive system

The tandem or oblique testes are located intercaecally in the posterior one-third of the body. The anterior testis, 0.05 - 0.178 mm. long by 0.083 - 0.191 mm. wide, is oval in outline but may show an indentation where the ovary is contiguous. Both testes are often flattened along a line where they meet, or occasionally the posterior testis may be indented at this level. The posterior testis, 0.056 - 0.175 mm. long by 0.083 - 0.165 mm. wide, may occasionally resemble a rough triangle with the blunt point directed posteriorly. In one case the posterior testis was completely missing and the anterior testis appeared to be degenerating (Fig. 6). This specimen was one of the two which were missing the vitellaria posteriorly. In another fluke in which the testes were oblique, the anterior testis overlapped and overreached the left caecum and the posterior testis overlapped but did not overreach the right caecum. The margins are smooth, only rarely is there any irregularity in this respect, and they do not appear to be lobed.

The vesicula seminalis is a sac-like structure lying free in the parenchyma. It is not enclosed within another membranous or muscular sac. This organ is located between the acetabulum and the intestinal bifurcation. Starting on the right side of the body, it passes diagonally to the left side, gradually tapering, and crosses the left caecum to open sinistrally just below the pharynx. A weakly developed, pear-shaped cirrus sac consisting of a single membranous layer can occasionally be observed. There is no distinct cirrus or pars prostatica. The few prostate cells which may be present are hidden by the vitellaria. The vesicula seminalis only rarely overlaps the acetabulum for a short distance (Figs. 7, 10). In isolated specimens studied it was found to be almost transverse instead of diagonal. In another specimen it was located on the midline, turning sinistrally just below the intestinal bifurcation. Two specimens showed the vesicula seminalis to be entirely sinistral, running longitudinally with the body (Fig. 4). The terminal portion of the male duct and the position of the genital pore is more variable than is the vesicula seminalis. The genital pore is usually sinistral. The only exception found was one specimen in which the ductus ejaculatorius passed directly to the side of the body to open laterally at a level even with the intestinal bifurcation. Generally, this duct turns anteriorly to open some distance in front of the vesicula seminalis. The duct may pass directly forward (Figs. 3, 4) or may circumscribe an arc inward (Figs. 9, 11), before opening to the exterior. A single specimen was found where the ductus ejaculatorius, in making this arc, continued around until it passed directly posteriorly and opened to the outside at the level of the intestinal bifurcation. The genital pore was not found on the midline nor posterior to the intestinal bifurcation. Further, the vesicula seminalis always crossed the left caecum, and thus, the genital pore was not found within the intestinal arch.

5. Excretory system

There is little variation in the excretory vesicle or in the location of the excretory pore.

6. The eggs

Yamaguti (1934), in describing C. glandulosum, remarked on the close similarity of this species to C. gymnophallum and suggested that Nicoll might have overlooked certain gland cells which were found to be prominent in the neck region of C. glandulosum. Crowcroft (1951), when examining Nicoll's type specimens, found such glands present. Crowcroft retained these two species as being separate due to the difference in egg size. He did, however, state that nothing had been decided as to the "...divergence of egg size to be tolerated within a species nor [are we] aware of the effect of growth and development within different hosts. There is also the possibility that egg size changes with the age of the fluke and number of eggs produced." At the same time he gave a comparison of egg sizes of a small and a large specimen of C. gymnophallum and the type specimen of C. glandulosum. The small specimen of C. gymnophallum, 2.5 mm. long, contained eggs 0.088 mm. long, while those of the larger specimen, the type, 3 mm. long, measured 0.081-0.084 mm. The specimen of C. glandulosum, 3.6 mm. long, had eggs measuring 0.063 - 0.070 mm. Crowcroft stated that if these two species are indeed identical, there exists an inverse proportion between body size and egg size. He further stated, however, that it was not known if the egg sizes would be constant for a large number of specimens.

Again, because of the ready availability of large numbers of specimens, a study was undertaken to determine the relationship, if any, existing between the body length and egg size, and between the number of eggs present and egg size. Two-hundred and seven eggs were measured from a total of 57 specimens of C. bathygobium.

The results of the comparison of egg size and body size are given in Table II. In this table all the worms within each 0.1 mm. range in length, with their eggs, are averaged together. A glance at Table II decidedly indicates no inverse proportion of body length to egg size. The average length of the eggs of a single worm at 0.3 mm. is, for all practical purposes, identical to that of two worms at 1.2 mm. in length. In actual measurements the lengths of the larger worms are just over three times that of the small worm.

As these animals continue to grow during their entire adult life, the size of the fluke would be indicative of its age, the largest flukes generally being the oldest. The same conclusion found above would apparently apply equally to a consideration of egg size to age of worm.

Table III shows the result of a comparison of the number of eggs present to the average size of the eggs. Again, there is practically no variation in the size of the eggs in a single specimen containing 20 eggs and that of 15 specimens having a single egg each. This would indicate that the number of eggs present is not a factor in the size of the eggs. The average size, in micra, of all 207 eggs measured may be stated to be 50 ± 7 x 33 ± 7 μ, or to have a 15 percent maximum variation in range in either direction.

Crowcroft indicated that a possibility of C. glandulosum's being a synonym of C. gymnophallum exists except for the difference in egg size. If the above variation percentage of 15, found for C. bathygobium is applied, the variation range is a maximum of 12 μ in either direction. Both the examples given for C. gymnophallum, 88 μ and 81 - 84 μ are found to lie within this range. However, for C. glandulosum, 63 - 70 μ, only the upper limits fall within the range and the lower limit is quite removed. In view of this, these two are, here, still considered to be valid species.

Two problems still exist in this connection. First, it is not known if the percentage figure found for C. bathygobium can be applied to the other members of the genus for the "...divergence of egg size to be tolerated...". Second, C. gymnophallum and C. glandulosum are from different fish hosts. In the single example of C. bathygobium found in a fish other than B. fuscus, there were two eggs present. The eggs measured 46 x 30 μ and 50 x 30 μ. These measurements are well within the limits found for the species. However, with only two egg measurements from a different host, a definite idea as to the effect on the egg size due to different fish hosts remains unknown at present.

TABLE II. COMPARISON OF BODY LENGTH WITH EGG SIZE[2]

Number of worms measured	Size of worms in mm.	Number of eggs measured	Average egg size in μ
1	0.3 - 0.39	2	$50 \pm 0 \times 31 \pm 2$
3	0.4 - 0.49	6	$51 \pm 2 \times 31 \pm 2$
14	0.5 - 0.59	34	$49 \pm 7 \times 33 \pm 4$
15	0.6 - 0.69	39	$52 \pm 6 \times 32 \pm 6$
9	0.7 - 0.79	40	$51 \pm 5 \times 33 \pm 5$
4	0.8 - 0.89	26	$52 \pm 6 \times 35 \pm 5$
4	0.9 - 0.99	28	$50 \pm 7 \times 32 \pm 6$
2	1.0 - 1.09	7	$51 \pm 7 \times 34 \pm 3$
1	1.1 - 1.10	6	$53 \pm 2 \times 33 \pm 1$
2	1.2 - 1.29	17	$50 \pm 6 \times 33 \pm 2$

[2] Summary of data presented in Table XV.

TABLE III. COMPARISON OF NUMBER OF EGGS PRESENT TO EGG SIZE[3]

Number of worms examined	Number of eggs present in each worm	Number of eggs measured	Average egg size in μ
1	20	20	$50 \pm 4 \times 32 \pm 3$
3	12	36	$51 \pm 5 \times 34 \pm 4$
1	10	10	$51 \pm 2 \times 36 \pm 3$
2	7	14	$52 \pm 4 \times 34 \pm 4$
4	6	24	$52 \pm 6 \times 34 \pm 3$
4	5	20	$47 \pm 7 \times 32 \pm 4$
2	4	8	$49 \pm 4 \times 31 \pm 2$
12	3	36	$51 \pm 7 \times 33 \pm 5$
11	2	22	$51 \pm 5 \times 33 \pm 4$
15	1	15	$51 \pm 8 \times 32 \pm 5$

[3] Summary of data presented in Table XV.

VI. LIFE HISTORY STUDIES

A. The egg

A study was conducted from October 3, 1958, to May 18, 1959, covering the egg production of the flukes. The results are summarized in Table IV and indicate approximately 2800 eggs a year are produced by each fluke. This is less than the reported daily output by *Schistosoma japonicum* (3500, Chandler, 1955), and about one-tenth the reported mean daily output for *Fasciolopsis buski* (25,000 - 30,000, Belding, 1942).

Experiments with the egg

As *C. bathygobium* lives in a tidal pool fish, the free-living forms are exposed to both dilution of the environment by rain and concentration by evaporation by the tropical sun. For this reason, as well as to further knowledge on possible methods for distribution and speciation, a series of experiments were performed to determine the effects of both diluted and concentrated sea water on the development and hatching of ova. All experiments were at room temperatures. Twenty to 30 eggs were used for each dilution or concentration. Each experiment was repeated twice with similar results. The results are given in Tables V and VI. With the exception of the eggs in tap water, embryos in eggs in all dilutions and concentrations developed viable miracidia. However, the contained miracidia in the eggs in concentrated sea water did not hatch. These miracidia will hatch when sufficient tap water, or distilled water, is added to reduce the salinity to or below that of normal sea water. This is offered as further evidence that a reduction in salt concentration favors hatching.

TABLE IV. NUMBER OF EGGS PRODUCED BY <u>C</u>. <u>BATHYGOBIUM</u>

Dates	Number of hours eggs collected	Number of eggs collected	Number of mature flukes found	Eggs per day per fluke
10-3 to 10-11	192	597	8	9.4
11-26 to 12-8	254	289	10	2.7
	254	529	19	2.6
1-13 to 1-19	168	485	11	6.3
	143	215	4	8.9
3-18 to 3-23	168	319	9	5.7
	168	363	7	7.4
5-12 to 5-18	166	610	7	12.7
	166	655	8	11.8

TABLE V. EFFECT OF DILUTED SEA WATER ON DEVELOPMENT AND HATCHING OF OVA

	Dilution in terms of specific gravity and salinity							
	1.000*	1.005 8.8‰	1.010 17.6‰	1.015 26.3‰	1.016 28.1‰	1.017 29.1‰	1.018 31.6‰	1.019 33.4‰
Days required for first movement of miracidium	-	4	4	3	7	6	6	8
Days required for hatching	-	6	6	5	9	8	8	10

* tap water

TABLE VI. EFFECT OF CONCENTRATED SEA WATER ON DEVELOPMENT AND HATCHING OF OVA

	Concentration in terms of specific gravity and salinity						
	1.020* 35.1‰	1.021 36.8‰	1.022 38.6‰	1.023 40.5‰	1.024 42.1‰	1.025 43.9‰	1.030 52.6‰
Days required for first movement of miracidium	7	4	5	6	4	4	5
Days required for hatching	9	-	-	-	-	-	-

* normal sea water

B. The miracidium and the snail host

1. Snail host

An undescribed rissoid snail (Fig. 18) possibly belonging to the genus Rissoa serves as the first intermediate host.[1] In a total of 1322 snails examined (Table XIX), 22 or 1.66 percent were found to contain cotylocercous cercariae. This percentage figure is biased as the more minute snails were omitted. In addition trichocercous and cystophorus cercariae were each found a single time (0.08 per cent). Cystophorus cercariae are known to occur in the families Hemiuridae (Dawes, 1946, Hyman, 1951, Yamaguti, 1958), and Acanthocolpidae (Yamaguti, 1953). Trichocercous cercariae are found in Lepocreadiidae (Dawes, 1946, Hyman, 1951) and Heterophydae (Yamaguti, 1958). An ophthalmocercariae was the most common cercaria found other than that of C. bathygobium. It was present in 1.2 percent of the snails examined. This cercariae perhaps belongs to the family Monorchidae (Yamaguti, 1958). No single snail contained more than one type of cercaria. This is in all probability due to the small size of the snail host.

The rissoid snail lives on various algae in the tide pools, but especially on Spyriria filamentosa (Wulf.) Harvey. As is usual in gastropod intermediate hosts, the larger snails are found to be infected (Dawes, 1946, Hyman, 1951, Martin, 1958). The size range (Table XX) for the positive snails is from 1.81 to 2.19 mm. in length and from 1.0 to

---

[1] The snail intermediate host was identified by Dr. E. Alison Kay, Assistant Professor of Science, University of Hawaii. Specimens were also submitted to Bishop Museum, but no reply was received.

1.16 mm. in width at the aperture. The average size is 1.92 x 1.06 mm. The negative snails measure 1.45 - 2.26 x 0.81 - 1.19 mm. and average 1.84 x 1.01 mm. These figures are taken from measurements on 338 snails.

2. Eggs from *Coitocaecum bathygobium* hatch at room temperature in normal sea water in seven to ten days. The length of life of the miracidium in sea water is from 12 to 14 hours at room temperature.

The miracidium (Fig. 14) is smaller and more slender than that found by MacFarlane (1939) for *C. anaspidis*. The miracidium of *C. bathygobium* measures 60 long by 20 wide at rest. While swimming it elongates and contracts alternately.

In contrast to the findings of MacFarlane for *C. anaspidis*, the opening of the operculum and emergence of the miracidium from the egg of *C. bathygobium* is by muscular action alone. The use of cilia to aid in the opening of the operculum, an alternate method for *C. anaspidis*, has not been observed.

Anteriorly there is a blunt trebratorium on which the two apical glands open. There are two large cells located at the posterior end and four or five cells, apparently germ cells, spread along the middle two-thirds of the body. Two flame cells are located just behind the middle of the body.

The miracidium is a rapid swimmer, and as with other miracidia, revolves on its long axis while swimming. Location of the snail host is apparently by accident and not by chemical means as no reaction can be noted when the snail host is introduced into water containing miracidia. The touching of the snail body by the miracidium results in an immediate withdrawal of the snail body and the closing of the shell. This often results in the capture of the miracidium within the closed shell. More often, however, the miracidium is carried out with the water expelled by the closure.

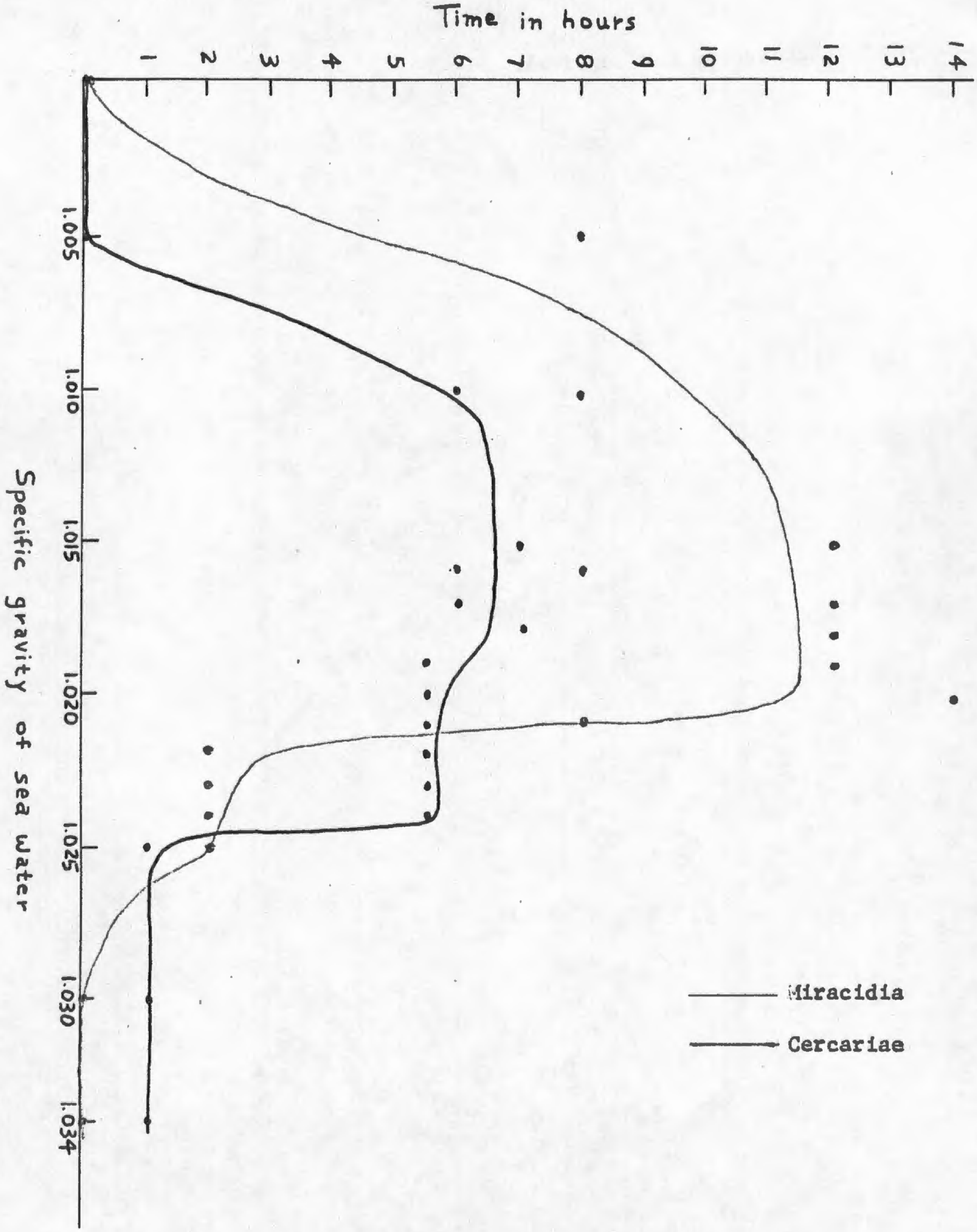
3. Experimental studies on the miracidia

Stunkard and Shaw (1931) working on the effects of dilution of sea water on cercariae stated that the same should be done with miracidia but that they were unable to do so as sufficient miracidia were not available.

Tables VII and VIII illustrate the effects of dilution and concentration of the sea water, respectively, on miracidia. In the dilutions, with the exception of tap water and perhaps 25 percent sea water (specific gravity 1.005), the miracidia are normal in swimming habits and appearance six hours or longer. The concentrations show marked effects except during the first hour during which time they appear normal.

Graph I illustrates the effects of both dilution and concentration upon the survival of 50 percent of the larval forms in a normal condition. Fifty percent is used to compensate for individual differences in the larvae.

For the miracidia there is a rise to a plateau followed by a small drop to another plateau then a sharp drop. These plateaus illustrate the areas of tolerance in a normal condition. Miracidia tolerate a relatively wide range of both dilutions and concentrations. Dilution of the sea water by rain can occur at low tide any time and concentration by evaporation is especially prevalent at low tide during daylight hours. As miracidia hatch from eggs typically during periods of warmth and light, the ability to tolerate either a dilution or concentration of the sea water is necessary for survival.



Graph I. Effect of dilution and concentration upon survival, in normal condition, of 50 percent of the larvae

ABBREVIATIONS USED IN TABLES VII, VIII, X, AND XI

Nor ------- normal

SM ------- swims at a moderate rate

SS ------- swims slowly

SW ------- swollen in appearance

Rec ------- recovered

Ext ------- extended or normal in appearance, but on the bottom of the dish

C ------- contracted on the bottom of the dish; in the case of cercariae they are no longer able to grasp the substrate with any of their suckers

MF ------- moves feebly on the bottom of the dish

D ------- dead

TABLE VII. EFFECT OF DILUTED SEA WATER ON MIRACIDIA

Time	Dilution in terms of specific gravity and salinity								
	Tap water	1.005 8.8‰	1.010 17.6‰	1.015 26.3‰	1.016 28.1‰	1.017 29.8‰	1.018 31.6‰	1.019 33.4‰	1.020* 35.1‰
1 min.	SW	-	Nor	Nor	Nor	Nor	Nor	Nor	Nor
2 min.	"	SW	"	"	"	"	"	"	"
12 min.	C	SS	"	"	"	"	"	"	"
30 min.	D	"	"	"	"	"	"	"	"
1 hr.		Rec	"	"	"	"	"	"	"
6 hr.		Nor	"	"	"	"	"	"	SS
7 hr.		"	SS	"	SS	SS	"	C	"
8 hr.		"	"	SS	"	SM	SS	"	SM
9 hr.		C	"	Ext	C	Ext	Ext	"	SS
21 hr.		D	D	D	D	D	D	D	D

* normal sea water

TABLE VIII. EFFECT OF CONCENTRATED SEA WATER ON MIRACIDIA

Time	Concentration in terms of specific gravity and salinity						
	1.021 36.8‰	1.022 38.6‰	1.023 40.5‰	1.024 42.1‰	1.025 43.9‰	1.030 52.6‰	1.034 59.6‰
1 hr.	Nor	Nor	Nor	Nor	Nor	Nor	Nor
6 hr.	SS	SS	SS	SS	C	C	D
7 hr.	MF	C	"	MF	MF	MF	
8 hr.	C	"	C	"	D	D	
9 hr.	D	D	"	"			
10 hr.			D	C			
11 hr.				"			
21 hr.				D			

C. The sporocyst

The rissoid snail hosts, as previously noted, are quite small, the largest positive specimen bound being 2.19 mm. long. As would be expected from the size of the host, the sporocysts found in nature (Fig. 15) are few in number. The largest number of sporocysts found in any one snail was five. Generally, there were but three present.

The daughter sporocysts are simple, elongate, sac-like structures. The fully developed specimens (Table XVI) measure 1.06 - 1.67 mm. in length and 0.067 - 0.096 mm. in width. Both ends of the sporocyst are roundly pointed. The germ cells are located at one end of the body and this portion is slightly narrower than the remainder of the body. An accumulation of yellowish granular material in this region of the body was found by MacFarlane (1939) for Coitocaecum anaspidis, but is not present in C. bathygobium. There is what appears to be a permanent terminal birth pore at the end opposite the germ cells.

No mother sporocysts have been found in naturally infected snails. However, they are found in experimentally infected snails during the first three weeks of infection, but not after this time. There are two possible explanations for this occurrence. The first is that the mother sporocyst disintegrates, although no evidence of this has been observed. The second, and perhaps more plausible, is that the mother sporocyst does not disintegrate but produces cercariae instead of further formation of daughter sporocysts. Such an occurrence, in part, has been reported by Hussey, Cort, and Ameel (1958) for a strigeid mother sporocyst which produced daughter sporocysts and cercariae. They believed that the crowding of the digestive gland prevented further development of daughter sporocysts and stimulated the mother sporocyst to produce cercariae.

Fairly-well developed cercaria are few in number, varying from five to ten. These cercariae are found spread through most of the sporocyst and are not concentrated at the end containing the birth pore. There are, however, many rounded aggregates of cells, which are cercariae in earlier phases of development. Some of these masses have a small segment on one end of the main group of cells as if the tail portion were separated from the body proper relatively early in development.

Cercaria are not released from the snail daily, but are released for three or four days, followed by a period of two or three days during which no cercariae are released. This can be correllated with the condition of the sporocyst where cercariae are developed in groups. The low number of sporocysts present could account for the periods when no cercariae are released.

In laboratory infected snails, daughter sporocysts can be found 15 days following exposure of the snails. At this time the mother sporocyst measures 0.51 - 0.73 x 0.03 mm. and is an elongate sac completely filled with cell masses and developing daughter sporocysts. There is an apparently permanent birth pore at one end. The germ cells are not located in one end of the sporocyst as occurs in the daughter sporocyst.

The second generation sporocysts are also saccular in form and at this time contain only developing masses of cells. The germinal cells are found at one end of the sporocyst as is the case in naturally developed sporocysts. These daughter sporocysts measure 0.15 - 0.27 x 0.03 mm.

Nineteen days following exposure, cotylocercous cercariae can be found upon cracking the snail. These cercariae are released into the sea water 20 to 25 days after exposure. At this time the sporocysts are roundly and abruptly pointed on one end and taper to a rounded point on the end containing the birth pore. The sporocysts at this time measure 0.53 - 1.12 x 0.013 - 0.02 mm.

D. The cercaria

The cercaria of Coitocaecum bathygobium is a cotylocercous, also called cotylomicrocercous, cercaria (Fig. 16). This type was separated by Dollfus in 1914 from the microcercous cercaria of Lühe. It is characterized by (1) development in simple sporocysts in marine snails, (2) the oral sucker contains a stylet and stylet glands fill a large part of the forebody, (3) a large nonbifurcate excretory bladder occupies most of the body posterior to the acetabulum; the bladder wall is composed of large cells which have a glandular appearance, (4) the tail is in the form of a cup, with thick walls containing large cells, and functions as a sucker.

A restriction of this group of cercaria to marine snails is not tenable. In fact Cort, in 1915, only one year after the characterization of the group, suggested that fresh water forms should be included because the habitat of the host did not appear to be a valid reason for exclusion. At that time only a single freshwater form, Cercaria micrura Filippi, 1857, was known. In addition to developing in a fresh water snail host, C. micrura differed by having a completely developed digestive tract. Sewell (1922) included C. micrura as a cotylocercous cercaria, but in a separate group from the majority of the marine forms on the basis of the complete digestive tract.

The cercariae of Coitocaecum bathygobium are released one at a time.

The release generally occurs between 10:00 p.m. and midnight; during day light hours no cercariae are released. The snail host abruptly closes its operculum, as if suddenly disturbed. After a short period of time the shell aperture is reopened. Then the operculum is again snapped shut; this time the water expelled by the closure of the shell carries out a single cercaria. The cercaria wiggles about in the water while dropping to the substrate. As would be expected from the condition of the tail, cotylocercous cercaria do not swim in search of their host. When it reaches the substrate the cercaria immediately attaches the caudal sucker and starts waving about in search of the next host. The free-life of the cercaria is under 20 hours.

According to MacFarlane (1939), the cercaria of Coitocaecum anaspidis is able to move rapidly over the substrate by the use of the oral and caudal suckers. McCoy (1929) reports that the cotylocercous cercaria of Hamacreadium mutabile, conversely, does not use the caudal sucker for locomotion, but instead uses the acetabulum and oral sucker. The cercaria of C. bathygobium have been observed to move about by using the oral and caudal suckers, or the oral sucker and acetabulum, tending, however, to prefer the latter method.

Measurements have been recorded for 14 cercariae (Table XVII). The smooth body has a length of 0.106 - 0.139 mm., its width at the acetabulum is 0.03 - 0.043 mm. The forebody measures 0.069 - 0.096 mm., or approximately seven-tenths of the body length. The oral sucker measures 0.02 - 0.03 mm. in length and is 0.015 - 0.023 mm. wide. The acetabulum is 0.02 - 0.033 mm. long by 0.02 - 0.033 mm. wide. Generally, the acetabulum is about the same size as the oral sucker; and, occasionally, it is slightly smaller. In contrast, in C. anaspidis the acetabulum is larger than the oral sucker, but not in the same ratio as in the adult. (With the exception of C. skrjabini, the adult ratio for the genus is 1: 2.) The stylet is double pointed. It is vertically placed in the anterior portion of the oral sucker. Its length is 7.5 μ and the width, at the base of the points, is 3.5 μ . There are three pairs of stylet glands located between the pharynx and the acetabulum. Their ducts pass anteriorly and open to the outside at the base of the stylet. There is a prepharynx and a pharynx present; however, the remaining portion of the digestive tract could not be discerned. The oval excretory bladder may overlap the posterior border of the acetabulum. The wall is composed of large gland-like cells. It measures 0.023 - 0.03 mm. in length and 0.015 - 0.023 mm. in width. A common collecting tubule passes anteriorly, one on each side of the body. At the level of the acetabulum the tubules divide into anterior and posterior collecting tubules. The flame-cell formula is $2[(2+2) + (2+2)]$. The stubby tail is 0.015 - 0.026 mm. long by 0.015 - 0.025 mm. wide. There is a protrusible papilla present.

Experimental studies on cercariae

Studies on the number of cercariae released daily were conducted during the months of May and June, 1959. The results, Table IX, show a daily fluctuation, as was found by Cort (1922) for cercariae from Planorbis trivoluis. The average number of cercariae released daily by each sporocyst was 8.2, or approximately 3,000 each year. This would be in the range of 10 to 12 thousand cercariae yearly for each snail. A snail emitting cercariae of Schistosoma mansoni (3500 cercariae per day, Chandler, 1955) will, in three days, release a number of cercariae equal to that released in a full year for Coitocaecum bathygobium.

In 1931, Stunkard and Shaw worked on the effects of dilution of sea water on six species of cercariae (cercaria of Cryptocotyle lingua, Cercarium lintoni, Cercaria quissetensis, C. variglandis, C. sensifera, and C. parnicaudata). Their purpose was to "...secure data bearing on the question of the origin, distribution, and evolution of present groups of digenetic trematodes." The findings indicated that, with these six species at least, the cercariae survived for considerable periods, and would be able to complete their life cycle in brackish water if suitable hosts were present.

Tables X and XI give the respective effects of diluted and concentrated sea water on the cercariae of C. bathygobium. The effect of tap water (specific gravity 1.000) is almost immediately fatal. Cercariae in 25 and 50 percent (1.005 and 1.010) sea water had an immediate reaction, but after an hour have recovered and appear normal. In the remaining dilutions and the first concentration of the sea water (Specific gravity 1.021) the cercariae are normal for eight to 12 hours. The concentrations with a 50 and 70 percent increase in salinity (1.030 and 1.034) are almost immediately harmful. In the remaining concentrations (1.022, 1.023, 1.024, 1.025) normal activity is maintained for about two hours.

Graph I illustrates the effects of both diluted and concentrated sea water upon the survival, in a normal condition, of 50 percent of the free-living larvae. The cercariae are able to tolerate a wider range of dilutions and a narrower range of concentrations than can miracidia.

The cercariae also remained normal for longer periods of time than did the miracidia; this might be expected as the cercariae had a longer free-life than the miracidia.

The sharp drop in tolerance shown by the cercariae after just a five percent increase in salinity is not surprising when considered with the typical night time release of cercariae. The cercariae are not normally subjected to any great increase in salinity except during those few times when a low tide occurs during the early part of the morning on clear hot days. Rain can occur anytime, causing a dilution of the sea water and is quite common on Oahu at night. An ability to tolerate diluted sea water is, therefore, of more importance to the survival of the cercariae than is the ability to tolerate an increased salinity.

TABLE IX. PRODUCTION OF CERCARIAE BY SPOROCYSTS OF C. BATHYGOBIUM

Dates of count	Number of cercaria each day	Number of sporocysts present	Cercariae per day per sporocyst
5-13 to 5-20	5-13---37 5-16---32 5-17---23 5-18--- 0 5-19--- 0 5-20---34	4	5.3
5-26 to 5-20	5-26--- 0 5-27---45 5-28---45 5-29---17 5-20---21	3	8.1
6-13 to 6-15	6-13---60 6-14---56 6-15---75	5	12.3
6-25 to 6-30	6-25---47 6-27---41 6-28--- 0 6-29--- 0 6-30---54	3	9.4
	6-25---23 6-27---29 6-28---13 6-29--- 0	3	6.1

TABLE X. EFFECT OF DILUTED SEA WATER ON CERCARIAE

Time	Dilution in terms of specific gravity and salinity								
	1.000	1.005	1.010	1.015	1.016	1.017	1.018	1.019	1.020
		8.8%.	17.6%.	26.3%.	28.1%.	29.8%.	31.6%.	33.4%.	35.1%.
10 min.	D	C	C	Nor	Nor	Nor	Nor	Nor	Nor
30 min.		Rec	"	"	"	"	"	"	"
45 min.		C	"	"	"	"	"	"	"
1 hr.		Rec	Rec	"	"	"	"	"	"
2 hr.		Nor	Nor	"	"	"	"	"	"
4 hr.		"	"	"	"	"	"	"	"
8 hr.		"	"	"	"	"	"	"	"
12 hr.		C	C	"	C	"	"	"	"
13 hr.		"	D	C	"	C	C	C	"
14 hr.		D		D	D	"	D	D	"
15 hr.						D			C
16 hr.									"
17 hr.									D

TABLE XI. EFFECT OF CONCENTRATED SEA WATER ON CERCARIAE

Time	Concentration in terms of specific gravity and salinity						
	1.021 36.8‰	1.022 38.6‰	1.023 40.5‰	1.024 42.1‰	1.025 43.9‰	1.030 52.6‰	1.034 59.6‰
30 min.	Nor	Nor	Nor	Nor	Nor	C	C
45 min.	"	"	"	"	"	"	"
1 hr.	"	"	"	"	"	"	Rec
2 hr.	"	"	"	"	"	Rec	Nor
4 hr.	"	C	C	C	C	Nor	C
8 hr.	"	"	"	"	"	C	"
12 hr.	C	D	"	D	D	D	D
13 hr.	D		D				

E. The shrimp host and the metacercaria

The metacercaria (Fig. 17) of C. bathygobium is found encysted in the abdominal muscles of a small, common, tide pool shrimp, Palaemonetes paludosus (Gibbes) (Fig. 19)[2]. These shrimp are also found in brackish water and will invade freshwater. Approximately nine percent of these shrimp from the tidal pools at Diamond Head Beach are infected. There is generally one or, occasionally, two cysts present in the infected shrimp. The cysts are not visible in the living host and an autopsy is required to locate them. Amphipods, another crustacean serving as the second intermediate host for this genus, are not found to be naturally infected; over 1200 were examined, and none could be experimentally infected out of a total 43 attempted.

The identity of the cyst was only partially proven experimentally. Five shrimp were exposed to the cercariae overnight and then dissected. The metacercariae recovered, 12 in number, were fed to a non-infected B. fuscus. This goby was found dead the next morning and seven cysts were recovered upon autopsy. The metacercariae were still within the cyst. It would appear that over 36 hours are required for the cyst to become infective. The shrimp were difficult to keep alive under laboratory conditions, none surviving over one week. This was not sufficient time to permit final proof of the host.

It is believed that the shrimp P. paludosus is the correct host for the following reasons: (1) the young cysts recovered from experimental infection resemble quite closely the smallest naturally occurring cysts

---

[2] The shrimp was identified by Dr. Sidney J. Townsley, Assistant Professor of Zoology, University of Hawaii.

found, (2) the shrimp have been observed, under a dissection microscope, to pick up and consume the cercariae, and (3) in six autopsies, the snail host was found within the digestive tract of the shrimp. Dawes (1946) reports that cystophorus cercariae are eaten by Cyclops. Some of these are digested but others penetrate the gut to encyst in the body. There is no apparent reason to assume that the same could not occur for cotylocercous cercariae. In fact, the presence of a stylet should make it easier for the cercariae of C. bathygobium to penetrate the gut wall than is possible for cystophorous cercariae.

The metacercarial cyst (Table XVIII) measures 0.147 - 0.249 mm. in length and 0.095 - 0.198 mm. in width. The oral sucker, acetabulum and the excretory vesicle are the most prominent structures. In the youngest, 18 hours, experimental cysts found, the stylet and penetration glands could not be seen. The cyst wall is thin and surrounded by a loose fibrous material which in turn is surrounded by the host tissue. Nevertheless, the cyst is quite fragile and easily broken. Progenetic metacercaria have not been found, although this phenomenon is quite common in this genus.

The genital anlagen are visible in specimens from naturally infected shrimp, but the digestive system can not be completely traced. The excretory vesicle, now thin-walled, is still large, occupying most of the hindbody. The excretory ducts are readily visible with reflected light, and assume a bluish color. The vitellaria are relatively undeveloped at this point.

The life cycle is completed when infective metacercariae are ingested by B. fuscus and develop to maturity in the intestine. The time required for this development is not presently known.

VII SUMMARY

1. A new species of trematode, *Coitocaecum bathygobium*, from the intestine of *Bathygobius fuscus* is described.

2. This fluke shows a high degree of host specificity. Only a single specimen was found in 142 other fishes examined belonging to 29 genera and 33 species.

3. On the island of Oahu this parasite is found only at Diamond Head Beach where almost 100 percent of the *B. fuscus* are infected.

4. An unidentified rissoid snail serves as the first intermediate host. Of 1322 snails examined, 22 or 1.66 percent were found to contain cotylocercous cercariae. These cercariae are released 20 to 25 days following exposure to miracidia, at room temperature.

5. A common shrimp, *Palaemonetes paludosus* is the second intermediate host. Nine percent of these shrimp from Diamond Head Beach tidal pools are infected.

6. The range of variation in morphology of the adults is given from measurements of 57 specimens and observations on an additional 115 mature specimens. In four instances a constricted pharynx was found. This condition was found only after fixation. This offers possible supporting evidence for Yamaguti's contention that *C. unibulbosum* is a synonym of *C. diplobulbosum*.

7. Two-hundred and seven eggs were measured from 57 adults. The average egg size is $50 \pm 7 \times 33 \pm 7\mu$, or a 15 percent maximum variation in either direction. An inverse ratio of body size to egg size was not found nor was there any difference in egg size due to the number of eggs present in the fluke.

8. The yearly production of about 2,800 eggs for each fluke and 10 to 12 thousand cercariae for each snail is quite small.

9. In general, studies on the effects of dilutions of sea water show that tap water is fatal to eggs, miracidia, and cercariae. A solution of 25 percent is harmful to miracidia and cercariae, but not to the development of eggs, and could probably prevent completion of the life cycle. In all other dilutions employed, completion of the life cycle is a possibility if suitable hosts are available.

Concentrated sea water allows development and miracidia within the eggs but prevents hatching. It is harmful to cercariae in practically all concentrations. However, these forms are not generally exposed to conditions of increased salinity. Miracidia show a greater tolerance to concentrated sea water than do cercariae. As they hatch during daylight hours, they are often subjected to periods of increased salinity.

10. It would thus appear that the high degree of host specificity of C. bathygobium can be correllated with the relative ease of completion of the life cycle in the goby. And, further, that a tidal pool, in spite of the hazard of a wide range of salinity, is a favorable habitat for the completion of a complicated life cycle.

VIII. APPENDIX

TABLE XII. EXAMINATION OF BATHYGOBIUS FUSCUS

Date	Fish number	Total length in mm.	Sex	Number of Coitocaecum	Other trematodes
11-24-57	1	35	M	9	-
	2	45	M	11	-
	3	31	F	46	-
	4	31	F	2	-
	5	34	M	4	-
	6	31	M	8	-
	7	21	M	6	-
	8	27	F	15	-
	9	32	F	7	-
	10	35	F	13	-
1-12-58	11	40	M	1	-
	12	20	M	3 (all immature)	-
	13	21	M	12 (all immature)	-
	14	24	F	16 (all immature)	-
	15	22	M	7	-
	16	29	M	3	-
	17	30	M	6	-
	18	28	M	5	-
	19	37	F	25	-

TABLE XII (Continued) EXAMINATION OF BATHYGOBIUS FUSCUS

Date	Fish number	Total length in mm.	Sex	Number of Coitocaecum	Other trematodes
	20	41	M	21	1 hemiurid
	21	40	M	16	-
	22	43	F	7	-
1-19-58	23	28	M	10	-
	24	27	M	13	-
	25	26	F	25	-
	26	36	F	20	-
	27	44	M	8	-
	28	25	M	15	-
3-16-58	29	38	M	3	-
	30	33	F	9	-
	31	31	M	8	-
	32	32	M	14	-
	33	29	M	5	-
	34	27	M	1	-
	35	30	M	6	-
	36	27	M	2	-
	37	26	M	4	-
	38	29	M	6	-
	39	29	M	4	-
	40	27	M	5	-

TABLE XII. (Continued) EXAMINATION OF BATHYGOBIUS FUSCUS

Date	Fish number	Total length in mm.	Sex	Number of Coitocaecum	Other trematodes
	41	28	M	4	-
	42	30	F	9	-
	43	26	M	1	-
	44	38	M	9	-
	45	41	M	7	-
4-12-58	46	42	F	8	-
	47	34	F	19	-
	48	39	F	17	-
	49	25	M	9	-
4-27-58	50	38	M	35	12 bucephalid metacer-cariae
	51	41	M	2	-
	52	37	F	3	-
	53	32	F	1	-
	54	25	M	0	-
	55	38	F	5	-
	56	39	F	1	-
	57	37	M	5	-
5-3-60	58	25	M	7	-
	59	25	M	14	3 bucephalid metacer-cariae

TABLE XII. (Continued) EXAMINATION OF BATHYGOBIUS FUSCUS

Date	Fish number	Total length in mm.	Sex	Number of Coitocaecum	Other trematodes
	60	26	M	7	1 bucephalid metacercariae
	61	24	M	1	-
	62	29	M	5	1 hemiurid
	63	32	M	3	-
5-11-58	64	32	F	2	2 hemiurids
	65	38	M	9	4 hemiurids 1 bucephalid metacercariae
	66	35	M	5	-
	67	45	M	5	-
5-18-58	68	32	F	5	-
	69	38	M	7	-
	70	51	M	12	-
12-13-58	71	49	F	3	-
	72	38	F	10	-
	73	27	M	4 (all immature)	-
	74	28	M	4	-

TABLE XIII OTHER FISHES EXAMINED[1]

Abudefduf abdominalis	19
A. imparipennis	2
A. melas	7
Acanthurus olivaceus	5
A. sandvicensis	26
Amanses sandwichiensis	1
Apogon erythrinus	5
Asterropteryx semipunctatus	1
Coris rosea	1
Ctenochaetus strigosus	1
Dascyllus albisella	3
unidentified eleotrid	1
Forcipiger longirostris	1
unidentified goby	2
Holocentrus diadema	1
Istiblennius zebra	8
Kelloggella oligolepis	4
Kuhlia sandvicensis	26
unidentified labrid	1
Mugil cephalus	2

[1] The various fishes were identified by Dr. Philip Helfrich, Hawaii Marine Laboratory, University of Hawaii, and Mr. Al Lewis and Mr. Donald A. Thomson, Graduate Students, Dept. Zoology and Entomology, University of Hawaii.

TABLE XIII. (Continued) OTHER FISHES EXAMINED

Mulloidichthys auriflamma	3
M. samoensis	7
Myripristis berndti	1
Naso hexacanthus	1
Naso sp.	1
Ostracion lentiginosus	2
unidentified parrot fish	1
Parupeneus porphyreus	2
Pervagor spilosoma	1
Pristipomoides microlepis	2
Seriola dumerilii	1
Stethojulis axillaris	2
Zanclus canescens	2

Fluke No.	Length	Width	Oral Sucker Length	Oral Sucker Width	Acetabulum Length	Acetabulum Width
1	0.456	0.184	0.056	0.062	0.106	0.132
2	0.485	0.162	-	-	0.109	0.109
3	0.499	0.265	0.066	0.066	0.118	0.14
4	0.499	0.228	0.083	0.079	0.124	0.162
5	0.529	0.211	-	-	0.147	0.162
6	0.529	0.162	0.073	0.066	0.118	0.132
7	0.573	0.279	0.079	0.076	0.088	0.132
8	0.588	0.279	0.069	0.076	0.132	0.132
9	0.603	0.184	0.074	0.074	0.147	0.132
10	0.603	0.191	0.069	0.066	0.191	0.160
11	0.603	0.206	0.066	0.073	0.147	0.147
12	0.603	0.265	0.079	0.079	0.132	0.162
13	0.603	0.279	0.073	0.079	0.147	0.173
14	0.647	0.235	0.062	0.073	0.129	0.135
15	0.647	0.279	0.086	0.083	0.14	0.152
16	0.647	0.309	0.069	0.086	0.147	0.176
17	0.662	0.279	0.076	0.069	0.14	0.176
18	0.676	0.279	0.069	0.08	0.139	0.139
19	0.690	0.309	0.096	0.089	0.132	0.176
20	0.713	0.265	0.083	0.092	0.162	0.162
21	0.720	0.211	0.594	0.561	0.132	0.119
22	0.735	0.499	0.086	0.066	0.147	0.176

TABLE XIV. MEASUREMENTS OF C. BATHYGOBIUM

Prepharynx	Pharynx Length	Pharynx Width	Esophagus	Ovary Length	Ovary Width	Anterior Testis Length	Anterior Testis Width	Posterior Testis Length	Posterior Testis Width	Vesicula Seminalis Length	Vesicula Seminalis Width	Forebody	Testicular Space
-	0.033	0.04	0.033	0.04	0.053	0.069	0.106	0.066	0.109	-	0.043	-	0.132
-	-	-	-	0.036	0.033	0.073	0.069	0.089	0.069	-	-	-	0.135
0.003	0.04	0.043	0.026	0.046	0.066	0.098	0.1	0.083	0.106	0.063	0.033	-	-
-	-	-	-	0.04	0.059	0.083	0.092	0.066	0.096	0.086	0.046	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	0.036	0.04	0.033	0.04	0.046	0.06	0.096	0.056	0.086	0.05	0.03	-	-
0.007	0.04	0.043	0.036	0.063	0.066	0.085	0.148	0.076	0.135	0.056	0.036	-	-
-	0.036	0.05	0.05	0.053	0.069	0.066	0.132	0.112	0.139	-	-	0.026	-
-	0.036	0.043	-	-	-	-	-	-	-	-	-	-	-
0.015	0.036	0.04	0.043	0.05	0.04	0.066	0.086	0.069	0.083	0.083	0.04	-	0.139
-	0.033	0.05	-	-	-	-	-	-	-	-	-	-	0.132
0.007	0.063	0.046	0.033	0.055	0.063	0.086	0.129	0.102	0.102	0.04	0.026	-	-
-	0.046	0.062	-	0.056	0.066	0.109	0.129	0.135	0.149	0.116	0.056	0.211	-
-	0.04	0.046	0.05	0.059	0.062	0.096	0.132	0.099	0.122	0.096	0.046	0.211	0.161
0.007	0.033	0.04	0.076	0.059	0.066	0.083	0.109	0.073	0.083	-	-	-	-
0.011	0.046	0.05	0.036	0.066	0.063	0.076	0.083	(missing)		0.063	0.03	0.265	-
0.033	0.043	0.043	0.043	0.053	0.073	0.069	0.132	0.119	0.116	0.04	0.03	0.309	-
0.013	0.036	0.053	0.056	0.056	0.066	0.086	0.135	0.099	0.165	0.099	0.05	0.258	0.173
0.013	0.046	0.046	0.083	0.066	0.059	0.102	0.129	0.096	0.106	0.096	0.033	-	-
0.01	0.036	0.079	-	0.066	0.05	0.089	0.149	0.096	0.139	0.066	0.04	0.279	0.206
0.007	0.033	0.046	0.086	0.053	0.053	0.062	0.116	0.106	0.106	0.086	0.053	0.279	0.191
-	0.043	0.059	0.059	0.046	0.073	0.109	0.139	-	-	0.149	0.05	-	-

Fluke No.	Length	Width	Oral Sucker Length	Oral Sucker Width	Acetabulum Length	Acetabulum Width	P
23	0.75	0.255	0.082	0.088	0.146	0.211	
24	0.75	0.279	0.069	0.073	0.161	0.161	
25	0.75	0.279	0.083	0.086	0.162	0.173	
26	0.75	0.295	0.099	0.096	0.173	0.162	
27	0.772	0.323	0.083	0.092	0.147	0.162	
28	0.794	0.294	0.096	0.086	0.132	0.152	
29	0.882	0.309	0.092	0.092	0.154	0.265	
30	0.882	0.353	0.089	0.092	0.206	0.172	
31	0.926	0.323	0.109	0.096	0.191	0.176	
32	0.946	0.412	0.102	0.106	0.206	0.228	
33	0.956	0.279	0.069	0.073	0.206	0.162	
34	0.956	0.353	0.096	0.096	0.191	0.191	
35	0.960	0.368	0.083	0.062	0.191	0.206	
36	0.985	0.368	0.074	0.103	0.191	0.176	
37	1.053	0.396	0.102	0.088	0.287	0.199	
38	1.088	0.323	0.096	0.086	0.173	0.206	
39	1.132	0.416	0.089	0.089	0.206	0.173	
40	1.147	0.338	0.086	0.089	0.196	0.177	

TABLE XIV. (Continued) MEASUREMENTS OF C. BATHYGOBIUM

Prepharynx	Pharynx Length	Pharynx Width	Esophagus	Ovary Length	Ovary Width	Anterior Testis Length	Anterior Testis Width	Posterior Testis Length	Posterior Testis Width	Vesicula Seminalis Length	Vesicula Seminalis Width	Forebody	Testiclar Spac
-	0.046	0.05	-	0.043	0.033	0.073	0.083	0.073	0.066	-	-	-	-
0.01	0.036	0.04	0.046	0.069	0.053	0.132	0.118	0.162	0.132	0.099	0.036	-	0.17
0.007	0.036	0.036	0.043	0.04	0.046	-	-	-	-	0.102	0.04	-	-
0.015	0.043	0.066	0.015	0.04	0.043	0.099	0.076	0.126	0.116	0.116	0.03	0.279	0.20[illegible]
-	0.05	0.036	0.05	0.055	0.079	0.083	0.191	0.102	0.142	0.083	0.033	0.279	-
0.003	0.046	0.053	0.083	0.066	0.063	0.109	0.165	0.116	0.149	0.099	0.036	-	-
0.017	0.05	0.063	0.033	0.086	0.089	0.142	0.083	0.132	0.115	-	-	-	-
0.007	0.053	0.069	0.033	0.066	0.086	0.128	0.185	0.066	0.158	0.086	0.053	-	-
0.015	-	-	-	-	-	-	-	-	-	-	-	-	-
0.013	0.066	0.068	0.05	0.059	0.066	0.092	0.099	0.092	0.099	0.043	0.033	-	-
-	0.033	0.05	0.066	0.106	0.073	0.122	0.116	0.149	-.149	-	-	0.338	0.23[illegible]
-	0.036	0.073	0.062	0.089	0.069	0.178	0.149	0.165	0.132	0.106	0.036	-	0.35[illegible]
0.003	0.046	0.059	0.089	0.083	0.059	-	-	-	-	0.132	0.05	0.338	0.33[illegible]
-	0.044	0.103	0.147	0.088	0.088	0.162	0.191	0.162	0.147	-	-	-	-
0.02	-	-	-	0.088	0.074	0.147	0.176	0.176	0.132	-	-	-	-
0.015	0.04	0.066	0.089	0.083	0.066	0.165	0.135	(disintegrating)		0.139	0.062	0.409	-
0.01	0.043	0.043	0.083	0.191	0.083	0.147	0.162	0.173	0.173	0.165	0.05	0.426	0.30[illegible]
0.013	0.043	0.05	0.053	0.112	0.079	0.145	0.154	0.175	0.165	0.165	0.05	0.426	-

TABLE XV. MEASUREMENTS OF EGGS

Fluke Number	Body length of worm in mm.	Size of eggs in μ	Fluke Number	Body length of worm in mm.	Size of eggs in μ
41	0.397	50 x 30	48	0.544	46 x 33
		50 x 33	49	0.544	46 x 30
42	0.412	50 x 30			46 x 31
1	0.456	50 x 31			46 x 33
		50 x 33			50 x 33
		53 x 30	50	0.559	46 x 30
3	0.499	50 x 33			50 x 30
		53 x 33	51	0.559	56 x 30
43	0.5	50 x 28	52	0.559	55 x 30
		50 x 30	53	0.559	46 x 30
44	0.5	56 x 31			50 x 31
45	0.507	46 x 33			56 x 33
46	0.515	53 x 33	7	0.573	50 x 30
6	0.529	43 x 33			50 x 30
		46 x 30			50 x 30
		46 x 30			53 x 30
		46 x 30	54	0.573	50 x 30
		46 x 30			50 x 31
5	0.529	50 x 31			50 x 31
		50 x 31	8	0.588	50 x 36
		50 x 33			53 x 36
47	0.544	50 x 33	12	0.603	51 x 33
		50 x 33			56 x 36

TABLE XV. (Continued) MEASUREMENTS OF EGGS

Fluke Number	Body length of worms in mm.	Size of eggs in μ	Fluke Number	Body length of worms in mm.	Size of eggs in μ
55	0.603	56 x 30			53 x 33
		56 x 33			53 x 33
10	0.603	53 x 30			56 x 33
13	0.603	53 x 33			56 x 36
		50 x 36	17	0.662	46 x 30
		53 x 33			53 x 36
		53 x 33			53 x 38
		53 x 33	18	0.676	53 x 30
		55 x 36			53 x 30
16	0.647	50 x 33	59	0.676	43 x 26
		50 x 33	60	0.676	53 x 30
		53 x 33	19	0.69	46 x 30
		53 x 36			50 x 30
		53 x 36			50 x 30
		53 x 36	61	0.706	50 x 36
		53 x 36			53 x 36
15	0.647	50 x 30	21	0.72	53 x 30
		55 x 33	22	0.735	48 x 30
		56 x 38			50 x 30
14	0.647	53 x 30			50 x 30
57	0.647	53 x 30	62	0.735	51 x 36
58	0.662	50 x 33			53 x 38
		53 x 33			56 x 36

TABLE XV. (Continued) MEASUREMENTS OF EGGS

Fluke Number	Body length of worms in mm.	Size of eggs in μ	Fluke Number	Body length of worms in mm.	Size of eggs in μ
23	0.075	53 x 30			50 x 35
24	0.75	49 x 33			53 x 30
63	0.764	43 x 30			53 x 31
		46 x 28			53 x 31
		46 x 28			53 x 33
		46 x 30			53 x 33
		55 x 33			53 x 35
64	0.765	50 x 30			53 x 35
		50 x 31			56 x 33
		50 x 33	65	0.823	48 x 33
		51 x 31			50 x 36
		51 x 33			50 x 36
		53 x 30			51 x 33
		53 x 33			53 x 36
		53 x 33			53 x 36
		53 x 33	66	0.83	50 x 35
		53 x 33			50 x 36
		53 x 35			50 x 36
		53 x 36			51 x 35
27	0.772	50 x 30			51 x 36
		50 x 31			51 x 36
		50 x 33			53 x 33

TABLE XV. (Continued) MEASUREMENTS OF EGGS

Fluke Number	Body length of worms in mm.	Size of eggs in μ	Fluke Number	Body length of worms in mm.	Size of eggs in μ
		53 x 35			50 x 33
		53 x 36			50 x 33
		53 x 36			50 x 33
67	0.867	53 x 35			50 x 33
		53 x 36			50 x 33
		58 x 36			50 x 33
29	0.882	50 x 30			50 x 33
		50 x 31			50 x 35
		51 x 31			51 x 33
		53 x 33			53 x 31
		53 x 35			53 x 33
		55 x 35			53 x 33
		56 x 35			55 x 33
68	0.911	50 x 31	34	0.956	43 x 26
		50 x 31			46 x 30
		50 x 31	35	0.96	50 x 30
32	0.946	48 x 31			50 x 30
		50 x 30			56 x 33
		50 x 30	37	1.053	50 x 36
		50 x 30	69	1.06	46 x 33
		50 x 39			50 x 31
		50 x 30			50 x 33

TABLE XV. (Continued) MEASUREMENTS OF EGGS

Fluke Number	Body length of worms in mm.	Size of eggs in μ	Fluke Number	Body length of worms in mm.	Size of eggs in μ
		53 x 33			53 x 31
		53 x 35			53 x 33
		58 x 36			53 x 33
40	1.147	51 x 33			56 x 33
		53 x 31			
		53 x 33			
		53 x 33			
		55 x 31			
		55 x 33			
70	1.205	46 x 33			
		46 x 35			
		50 x 33			
		50 x 36			
		50 x 36			
71	1.25	50 x 31			
		50 x 33			
		50 x 33			
		50 x 33			
		50 x 33			
		50 x 33			
		50 x 34			
		51 x 31			

TABLE XVI. MEASUREMENTS OF MATURE SPOROCYSTS

Sporocyst Number	Length in mm.	Width in mm.	Number of mature Cercariae
1	1.06	0.067	5
2	1.18	0.07	6
3	1.32	0.074	9
4	1.6	0.089	10
5	1.67	0.096	6

Cercaria Number	Length	Width	Tail Length	Tail Width
1	0.122	0.033	0.02	0.015
2	0.122	0.036	0.02	0.015
3	0.129	0.03	0.015	0.015
4	0.139	0.043	0.025	0.025

Cercaria Number	Length	Depth	Tail Length	Tail Depth
5	0.106	0.033	0.02	0.015
6	0.116	0.036	0.015	0.015
7	0.119	0.026	0.015	0.015
8	0.119	0.036	0.015	0.015
9	0.122	0.023	0.026	0.015
10	0.125	0.023	0.023	0.015
11	0.125	0.036	0.015	0.015
12	0.129	0.03	0.015	0.015
13	0.135	0.025	0.023	-
14	0.135	0.043	0.023	0.015

TABLE XVII. MEASUREMENTS OF CERCARIAE IN MM.

Ventral Specimens

Oral Sucker Length	Oral Sucker Width	Acetabulum Length	Acetabulum Width	Forebody	Excretory Vesicle Length	Excretory Vesicle Width
0.02	0.02	0.023	0.023	0.096	0.026	0.015
0.02	0.02	0.02	0.023	0.076	0.02	0.02
0.023	0.02	0.02	0.023	0.083	0.026	0.023
0.03	0.023	0.03	0.033	0.088	0.023	0.023

Lateral Specimens

Oral Sucker Length	Oral Sucker Depth	Acetabulum Length	Acetabulum Depth	Forebody	Excretory Vesicle Length	Excretory Vesicle Depth
0.023	0.017	0.02	0.015	0.069	0.023	0.02
0.02	0.02	0.02	0.02	0.076	0.029	0.02
0.02	0.023	0.023	0.073	0.026	0.02	
0.02	0.015	0.023	0.015	0.073	0.03	0.02
0.023	0.015	0.026	0.02	0.076	0.023	0.02
0.026	0.015	0.033	0.023	0.081	0.026	0.02
0.023	0.02	0.023	0.015	0.096	0.026	0.015
0.023	0.02	0.02	0.023	0.093	0.026	0.023
0.022	0.022	0.029	-	0.086	0.029	0.02
0.023	0.023	0.026	0.02	0.086	0.026	0.02

TABLE XVIII. MEASUREMENTS OF METACERCARIAE

Metacercariae Number	Length in mm.	Width in mm.
1	0.147	0.095
2	0.147	0.118
3	0.206	0.162
4	0.249	0.198
5	0.25	0.173
6	0.265	0.191
7	0.294	0.21
8	0.309	0.21

TABLE XIX. EXAMINATION OF SNAILS

Date of Collection	Number of snails examined	Number of snails infected	Nature of Infection
6-23-58	361	8	7 cotylocercous 1 cystophorous
6-29-58	18	0	-
7-14-58	6	0	-
7-28-58	160	2	1 cotylocercous 1 trichocercous
11-24-58	36	2	2 cotylocercous
12-15-58	29	0	-
2-29-59	42	2	2 cotylocercous
3-11-59	191	0	-
5-13-59	40	1	1 cotylocercous
5-26-59	123	4	3 cotylocercous 1 ophthalmocercous
6-12-59	167	8	4 cotylocercous 2 ophthalmocercous
10-21-59	149	3	2 cotylocercous 1 ophthalmocercous

TABLE XX. MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative	Sporocysts	Length Width	Positive or Negative	Sporocysts
1.84 x 0.97	-		1.74 x 1.0	-	
1.87 x 0.97	-		2.0 x 1.03	-	
1.84 x 0.94	-		2.0 x 1.06	-	
1.71 x 1.0	-		1.58 x 1.06	-	
1.65 x 0.83	-		1.94 x 1.0	-	
1.84 x 1.03	-		1.55 x 0.84	-	
1.9 x 1.0	-		1.84 x 0.81	-	
1.77 x 0.9	-		1.68 x 0.94	-	
1.68 x 0.84	-		1.71 x 0.94	-	
1.71 x 0.9	-		1.61 x 0.97	-	
1.55 x 0.9	-		1.77 x 1.0	-	
1.58 x 0.9	-		1.87 x 0.97	-	
1.97 x 1.06	-		1.74 x 0.97	-	
1.84 x 1.0	-		1.71 x 1.1	-	
1.71 x 0.97	-		1.77 x 0.94	-	
1.87 x 1.06	-		1.46 x 0.84	-	
2.03 x 1.06	-		1.87 x 0.97	-	
1.84 x 0.97	-		1.77 x 0.94	-	
1.87 x 1.06	+	2	1.94 x 1.06	+	3
2.19 x 1.06	-		1.87 x 0.97	-	
1.87 x 1.0	-		1.84 x 1.0	-	
2.0 x 1.0	-		1.52 x 0.87	-	

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative	Sporocysts	Length Width	Positive or Negative	Sporocysts
1.55 x 0.94	-		1.87 x 1.06	-	
1.65 x 0.97	-		1.84 x 1.03	-	
1.71 x 1.0	-		1.77 x 1.06	Ophthalmocercariae	
1.94 x 1.03	-		2.1 x 1.06	-	
1.87 x 1.06	-		2.16 x 1.19	-	
1.77 x 1.1	-		2.16 x 1.13	-	
1.68 x 1.0	-		1.45 x 0.94	-	
1.84 x 0.97	-		1.97 x 1.13	-	
1.55 x 0.97	-		1.90 x 1.03	+	4
1.71 x 1.0	-		1.87 x 1.03	-	
1.71 x 0.97	-		1.81 x 1.0	-	
1.77 x 1.0	-		1.77 x 0.94	-	
1.81 x 1.0	-		1.71 x 0.97	-	
2.0 x 1.06	-		1.94 x 0.97	-	
1.87 x 1.06	-		1.61 x 0.97	-	
1.97 x 1.1	-		1.84 x 1.06	-	
1.74 x 1.03	-		2.03 x 1.03	-	
1.55 x 0.87	-		1.94 x 1.03	-	
1.94 x 0.97	-		2.0 x 1.0	-	
2.19 x 1.1	+	3	2.19 x 1.06	-	
2.0 x 1.06	-		2.0 x 1.0	-	
1.68 x 0.94	-		1.97 x 1.06	-	

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative	Sporocysts	Length Width	Positive or Negative	Sporocysts
1.71 x 0.94	-		1.81 x 0.97	-	
2.0 x 1.1	-		2.03 x 1.13	-	
2.16 x 1.06	-		1.87 x 0.97	-	
1.77 x 1.0	-		1.90 x 1.06	-	
1.81 x 1.06	-		2.1 x 1,06	-	
1.7 x 0.9	-		1.97 x 0.97	-	
1.94 x 0.97	-		1.84 x 1.03	-	
2.16 x 1.06	-		1.81 x 1.03	-	
1.74 x 1.03	-		2.06 x 1.0	-	
1.87 x 1.03	-		2.10 x 1.1	-	
1.97 x 1.03	-		1.9 x 1.06	-	
1.74 x 1.0	-		2.16 x 1.0	-	
1.67 x 0.97	-		2.26 x 1.13	-	
1.87 x 1.06	-		1.71 x 1.03	-	
1.71 x 1.03	-		1.81 x 1.03	+	4
2.0 x 1.0	-		2.0 x 1.13	-	
1.81 x 1.03	-		1.94 x 1.06	-	
1.90 x 1.06	-		2.06 x 1.1	-	
1.90 x 1.03	-		1.94 x 1.03	-	
1.87 x 1.03	-		1.97 x 1.0	-	
2.0 x 1.0	-		2.0 x 0.97	-	
2.0 x 0.97	-		1.94 x 1.0	-	

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative	Sporocysts	Length Width	Positive or Negative	Sporocysts
1.84 x 1.03	-		1.74 x 0.97	-	
1.77 x 1.03	-		1.81 x 0.97	-	
2.16 x 1.1	-		1.9 x 1.06	-	
1.97 x 1.03	-		1.65 x 0.97	-	
2.03 x 1.06	-		2.1 x 1.1	-	
1.97 x 1.06	-		1.45 x 0.9	-	
1.74 x 1.0	-		1.9 x 1.0	-	
1.90 x 1.03	-		2.0 x 1.06	-	
2.0 x 1.0	-		1.94 x 1.03	-	
1.74 x 1.03	-		1.97 x 1.06	-	
1.97 x 1.1	-		2.06 x 1.10	-	
2.19 x 1.06	-		1.9 x 1.0	-	
2.19 x 0.97	-		1.68 x 0.97	-	
1.81 x 0.97	-		1.81 x 1.0	-	
2.13 x 1.03	-		2.16 x 1.03	-	
1.97 x 1.06	-		2.0 x 1.0	-	
1.97 x 1.06	-		1.84 x 0.97	-	
2.0 x 1.13	-		2.06 x 1.06	-	
2.16 x 1.13	-		1.97 x 1.1	-	
1.9 x 1.0	-		2.1 x 1.03	-	
1.81 x 1.03	-		1.94 x 1.06	-	
1.97 x 1.06	-		1.94 x 1.03	-	

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive Sporocysts or Negative	Length Width	Positive Sporocysts or Negative
1.84 x 1.03	-	1.74 x 0.97	-
1.77 x 1.03	-	1.81 x 0.97	-
2.16 x 1.1	-	1.9 x 1.06	-
1.97 x 1.03	-	1.65 x 0.97	-
2.03 x 1.06	-	2.1 x 1.1	-
1.97 x 1.06	-	1.45 x 0.9	-
1.74 x 1.0	-	1.9 x 1.0	-
1.90 x 1.03	-	2.0 x 1.06	-
2.0 x 1.0	-	1.94 x 1.03	-
1.74 x 1.03	-	1.97 x 1.06	-
1.97 x 1.1	-	2.06 x 1.10	-
2.19 x 1.06	-	1.9 x 1.0	-
2.19 x 0.97	-	1.68 x 0.97	-
1.81 x 0.97	-	1.81 x 1.0	-
2.13 x 1.03	-	2.16 x 1.03	-
1.97 x 1.06	-	2.0 x 1.0	-
1.97 x 1.06	-	1.84 x 0.97	-
2.0 x 1.13	-	2.06 x 1.06	-
2.16 x 1.13	-	1.97 x 1.1	-
1.9 x 1.0	-	2.1 x 1.03	-
1.81 x 1.03	-	1.94 x 1.06	-
1.97 x 1.06	-	1.94 x 1.03	-

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative	Sporocysts	Length Width	Positive or Negative	Sporocysts
2.1 x 1.1	-		1.94 x 1.06	-	
1.84 x 1.1	-		1.74 x 1.0	-	
1.74 x 1.0	-		1.94 x 1.06	-	
1.87 x 1.03	-		1.97 x 1.0	-	
1.77 x 1.03	-		1.87 x 1.13	-	
1.81 x 0.94	-		1.74 x 1.06	-	
1.93 x 1.03	-		1.9 x 1.03	-	
1.84 x 0.94	-		1.68 x 0.94	-	
2.13 x 1.1	-		1.61 x 0.94	-	
1.68 x 0.87	-		1.94 x 0.97	-	
1.81 x 1.03	-		2.06 x 1.1	-	
1.97 x 1.03	-		2.0 x 1.06	-	
1.94 x 1.1	-		1.45 x 0.9	-	
1.97 x 1.06	-		1.94 x 1.13	-	
2.13 x 1.1	-		1.74 x 0.97	-	
1.81 x 1.0	-		1.77 x 1.13	-	
1.74 x 0.97	-		2.03 x 1.13	-	
2.06 x 1.03	-		1.68 x 1.0	-	
1.84 x 0.97	-		2.06 x 1.06	-	
1.90 x 1.06	-		1.71 x 1.0	-	
1.97 x 0.97	-		1.87 x 1.0	-	
1.48 x 0.94	-		1.87 x 1.03	-	
1.58 x 0.97	-		1.97 x 1.1	-	

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative Sporocysts	Length Width	Positive or Negative Sporocysts
1.74 x 1.0	-	2.03 x 1.1	-
1.9 x 0.94	-	1.94 x 1.03	-
1.94 x 1.03	-	1.97 x 1.1	-
1.71 x 1.0	-	1.94 x 1.1	-
1.87 x 1.03	-	1.97 x 1.03	-
1.94 x 1.03	-	1.94 x 1.0	-
1.71 x 1.0	-	1.71 x 0.97	-
1.9 x 1.06	-	1.58 x 0.94	-
1.81 x 0.97	-	1.77 x 1.1	-
2.0 x 1.1	-	1.87 x 1.0	-
1.9 x 1.0	-	1.68 x 0.97	-
1.84 x 0.97	-	1.65 x 1.0	-
1.87 x 1.03	-	1.77 x 1.0	-
1.97 x 1.03	-	1.84 x 1.06	-
1.9 x 1.06	-	1.9 x 1.03	-
1.58 x 0.9	-	1.48 x 0.94	-
2.22 x 1.1	-	1.97 x 1.03	-
2.06 x 1.06	-	2.26 x 1.19	-
1.74 x 1.0	-	1.81 x 0.97	-
2.03 x 1.1	-	2.19 x 1.06	-
1.9 x 1.03	-	2.22 x 1.13	Ophthalmocercariae
2.06 x 1.06	-	2.13 x 1.06	-

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative	Sporocysts	Length Width	Positive or Negative	Sporocysts
2.13 x 1.13	-		1.91 x 1.0	-	
1.65 x 0.94	-		1.87 x 1.03	-	
2.03 x 1.06	-		1.74 x 0.97	-	
1.94 x 1.03	+	3	1.74 x 0.97	-	
2.06 x 1.06	-		2.03 x 1.1	-	
1.84 x 0.97	-		1.71 x 0.94	-	
1.9 x 1.03	-		1.48 x 0.94	-	
1.84 x 0.97	-		1.68 x 0.97	-	
2.1 x 1.1	-		1.94 x 1.06	-	
2.13 x 1.1	-		2.03 x 1.06	-	
1.55 x 0.87	-		1.81 x 1.0	-	
1.81 x 1.0	-		1.77 x 1.06	-	
1.84 x 0.97	-		1.52 x 0.94	-	
1.68 x 0.97	-		1.94 x 1.06	-	
1.87 x 1.0	-		1.45 x 0.9	-	
1.74 x 0.94	-		1.48 x 0.9	-	
1.94 x 1.06	Ophthalmocercariae		1.77 x 1.06	-	
1.84 x 1.06	-		1.84 x 1.03	-	
2.13 x 1.06	Ophthalmocercariae		1.74 x 1.03	-	
1.77 x 1.0	-		1.84 x 1.03	-	
1.87 x 1.0	-		1.81 x 1.0	-	
1.71 x 1.0	-		1.94 x 1.06	-	

TABLE XX. (Continued) MEASUREMENTS OF SNAILS IN MM.

Length Width	Positive or Negative	Sporocysts	Length Width	Positive or Negative	Sporocysts
1.65 x 0.94	-		1.9 x 1.03	-	
1.61 x 0.94	-		1.6 x 0.94	-	
1.87 x 1.0	+	3	1.77 x 1.0	-	
1.97 x 1.1	-		1.97 x 1.1	-	
1.87 x 1.03	-		1.81 x 1.01	+	3
1.68 x 0.97	-		2.05 x 1.16	+	5
1.81 x 0.97	-				
1.91 x 1.1	-				
2.06 x 1.06	-				
1.77 x 0.97	-				
1.97 x 1.06	-				
1.74 x 1.03	-				
1.97 x 1.03	-				
2.0 x 1.06	-				
1.84 x 1.0	-				
1.94 x 1.06	-				
1.87 x 1.0	-				
1.84 x 1.06	-				
1.81 x 1.06	-				
2.1 x 1.06	-				
1.84 x 1.0	-				
1.84 x 1.13	-				

IX. BIBLIOGRAPHY

Abdel-Malek, Emile T. 1951. Menthol relaxation of helminths before fixation. J. Parasitol. 37 (3): 321.

Baer, Jean G. 1951. Ecology of Animal Parasites. 224 pp. University of Illinois Press. Urbana, Ill.

Belding, David L. 1942. Textbook of Clinical Parasitology. xxi + 888. D. Appleton-Century Co., Inc. New York.

Cable, Raymond M. and Richard B. Crandall. 1956. Larval stages and phylogeny as exemplified by the lung fluke of turtles. Sci. 124 (3227): 890.

__________ and Arne V. Hunninen. 1942. Studies on Deropristis inflata (Molin), its life history and affinities to the family Acanthocolpidae. Biol. Bull. 88 (2): 292-312.

Carter, George S. 1954. On Hadzis' interpretation of animal phylogeny. Syst. Zool. 3 (4): 163-167, 173.

Chandler, Asa C. 1955. Introduction to Parasitology with Special Reference to the Parasites of Man. 9th Ed. xiv + 779. John Wiley and Sons Inc. New York.

Cort, William W. 1915. Some North American larval trematodes. Ill. Biol. Monogr. 1 (4): 441-532.

__________. 1922. A study of the escape of cercariae from their snail host. J. Parasitol. 8: 177-184.

Crowcroft, Peter W. 1945. New trematodes from Tasmanian fishes. Pap. and Proc. Roy. Soc. Tasmania. 1944 [1945]: 61-69.

__________. 1951. Notes on the taxonomy of the genus Coitocaecum Nicoll, 1915 (Digenea: Opecoelidae). J. Parasitol. 37 (3): 251-257.

Dawes, Ben. 1946. The Trematoda. xvi + 644. Cambridge University Press. Cambridge, England.

Dobrovolny, Charles G. 1939. Life history of Plagioporus sinitsini Mueller and embryology of new cotylocercous cercariae (Trematoda). Trans. Amer. Micro. Soc. 58 (2): 121-155.

Edmondson, Charles H. 1946. Reef and Shore Fauna of Hawaii. iii + 381. Bernice P. Bishop Museum Spec. Publ. 22. Honolulu.

Gosline, William A. and Vernon E. Brock. 1960. Handbook of Hawaiian Fishes. ix + 372. University of Hawaii Press. Honolulu.

Gower, William C. 1939. A modified stain and procedure for trematodes. Stain Tech. 14 (1): 31-32.

Hargis, William J. 1953. Chloretone as a trematode relaxer, and its use in mass-collecting techniques. J. Parasitol. 39 (2): 224-225.

Harshey, K. R. 1937. On two new trematodes of the genus Opegaster Ozaki with a systematic discussion on the families Opecoelidae Ozaki, 1925 and Coitocaecidae Ozaki, 1928. Proc. Ind. Acad. Sci. Sec. B. 5 (2): 64-75.

Hiatt, Robert W. and Donald W. Strasburg. 1960. Ecological relationships of the fish fauna of the Marshall Islands. Ecol. Monogr. 30 (1): 65-127.

Hickman, V. V. 1934. On Coitocaecum anaspidis sp. n., a trematode exhibiting progenesis in the freshwater crustacean Asaspides tasmaniae. Parasitol. 26 (1): 121-128.

Hopkins, Sewell H. 1941. The excretory systems of Helicometra and Cymbephallus (Trematoda), with remarks on their relationships. Trans. Amer. Micro. Soc. 60 (1): 41-44.

Horen, William P. 1957. Trichrome stain: a useful technique for staining helminths. J. Parasitol. 43 (6): 669.

Hussey, Kathleen L., William W. Cort, and Donald J. Ameel, 1958. The production of cercariae by a strigeid mother sporocyst. J. Parasitol. 44(3): 289-291.

Hyman, Libbie H. 1951. The Invertebrates: Platyhelminthes and Rhynchocoela the acoelomate Bilateria. Vol. II. vii + 550. McGraw-Hill. New York.

Jordan, David S. and Barton W. Evermann. 1903. The Aquatic Resources of the Hawaiian Islands. Part 1. The Shore Fishes. xxviii + 574. Bull. U. S. Fish. Comm. Vol. 23. U. S. Gov. Print. Off. Washington.

La Rue, George. 1957. The classification of digenetic Trematoda: A review and a new system. Exp. Parasitol. 6 (3): 306-349.

McCoy, Oliver R. 1929. The life-history of a marine trematode Hamacreadium mutabile Linton, 1910. Parasitol. 21 (1/2): 220-225.

MacFarlane, W. V. 1939. Life cycle of Coitocaecum anaspidis Hickman, a New Zealand digenetic trematode. Parasitol. 31 (2): 172-184.

Manter, Harold W. 1940. Digenetic trematodes of fishes from the Galapagos Islands and neighboring Pacific. Allan Hancock Pac. Expedition. 2 (14): 329-497.

__________. 1947. The digenetic trematodes of marine fishes of Tortugas, Florida. Amer. Midl. Nat. 38 (2): 257-416.

__________. 1954. Some digenetic trematodes from fishes of New Zealand. Trans. Roy. Soc. New Zealand. 82 (2): 475-568.

__________. 1955. The zoogeography of trematodes of marine fishes. Exp. Parasitol. 4 (1): 62-86.

Martin, William E. 1958. Hawaiian Helminths 1. Trigonocryptus conus n. gen., n. sp. (Trematoda: Fellodistomidae). Pac. Sci. 12 (3): 251-254.

Nicoll, William. 1915. The trematode of North Queensland. iii. Parasites of Fishes. Parasitol. 8: 22-44.

Ogata, Toji. 1942. Sur une nouvelle espèce de Trématode du genre Coitocaecum. Zool. Mag. Tokyo. 54 (2): 85-88.[1]

Ozaki, Yoshimasa. 1926. On some new fresh water fish trematodes. (In Japanese). Dobuts. Zasshi Tokyo. 38: 124-130.

_________. 1929. Note on Coitocaecidae, a new trematode family. Annot. Zool. Jap. Tokyo. 12 (1): 75-90.

Peters, L. E. 1957a. An analysis of the trematode genus Allocreadium Looss with the description of Allocreadium neotenicum sp. nov. from water beetles. J. Parasitol. 43 (2): 136-142.

_________. 1957b. The cercarial type in the genus Allocreadium. J. Parasitol. 43 (5) Sec. 2: 35.

Pigulewsky, S. W. 1931. Neue Arten von Trematoden aus Fischen des Dnjeprbassins. Zool. Anz. 96 (1/2): 9-18.

_________. 1932. [Parasitic worms in the fishes of the Dnieper Basin.] (In Russian). Ann. Mus. Zool. Acad. Sci. URSS. 32 (4): 425-452.

Sewell, Robert B. S. 1922. Cercariae Indicae. Ind. J. Med. Res. 10: 1-372.

Stunkard, Horace W. 1930. An analysis of the methods used in the study of larval trematodes. Parasitol. 22 (2): 268-273.

---

[1] From Biological Abstracts, original not available.

__________. 1931. Further observations on the occurrence of anal openings in digenetic trematodes. Zeitschr. Wiss. Biol. Abt. F. Zeitschr. Parasitenk. 3 (4): 713-725.

__________. 1953. Life histories and systematics of parasitic worms. Syst. Zool. 2 (1): 7-18.

__________. 1957. Intraspecific variation in parasitic flatworms. Syst. Zool. 6 (1): 7-18.

__________ and C. Ruth Shaw. 1931. The effect of dilution of sea water on the activity and longevity of certain marine cercariae, with descriptions of two new species. Biol. Bull. 61 (2): 242-271.

Tinker, Spencer W. 1944. Hawaiian Fishes. 404 pp. Tong Publ. Co. Honolulu.

Winfield, Gerald F. 1929. Plesiocreadium typicum, a new trematode from Amia calva. J. Parasitol. 16 (2): 81-87.

Wiśniewsky, Lesław W. 1934. Beitrag zur Systematik der Coitocaecidae (Trematoda) Nicolla g.n., Ozakia g.n., Coitocaecum proavitum sp. n. Mem. Acad. Polon. Crawcow Cl. Sci. Math. Nat. B. 6: 27-41.

Wu, Kuang. 1937. Two encysted trematodes of freshwater shrimps around Shanghai region. Peking Nat. Hist. Bull. 11: 199-204.

Yamaguti, Satyu. 1934. Studies on the helminth fauna of Japan. Part 2. Trematodes of fishes i. Jap. J. Zool. 5: 249-541.

__________. 1938. Studies on the helminth fauna of Japan. Part 21. Trematodes of fishes. iv. 139 pp. Published by the Author. Kyoto.

__________. 1939. Studies on the helminth fauna of Japan. Part 26. Trematodes of fishes. vi. Jap. J. Zool. 8: 211-230.

__________. 1940. Studies on the helminth fauna of Japan. Part 31. Trematodes of fishes. vii. Jap. J. Zool. 9 (1): 35-108.

__________. 1942. Studies on the helminth fauna of Japan. Part 39. Trematodes of fishes mainly from Naha. Trans. Biogr. Soc. Japan. 3 (4): 329-398.

__________. 1953. Systema Helminthum. Part 1. Digenetic Trematodes of Fishes. 405 pp. Maruzen Co., Ltd. Nihonbashi, Tokyo, Japan.

__________. 1958. Systema Helminthum. Vol. I. The Digenetic Trematodes of Vertebrates. Part 1. xi + 979. Interscience Publishers, Inc. New York.

Yeh, James and Kuang Wu. 1951. Progenesis of Microphallus minus Ouchi (Trematoda: Microphallidae) in freshwater shrimps. Peking Nat. Hist. Bull. 19 (2/3): 194-208.

Yamaguti, Satyu. 1934. Studies on the helminth fauna of Japan. Part 2. Trematodes of fishes i. Jap. J. Zool. 5: 249-541.

_________. 1938. Studies on the helminth fauna of Japan. Part 21. Trematodes of fishes. iv. 139 pp. Published by the Author. Kyoto.

_________. 1939. Studies on the helminth fauna of Japan. Part 26. Trematodes of fishes. vi. Jap. J. Zool. 8: 211-230.

_________. 1940. Studies on the helminth fauna of Japan. Part 31. Trematodes of fishes. vii. Jap. J. Zool. 9 (1): 35-108.

_________. 1942. Studies on the helminth fauna of Japan. Part 39. Trematodes of fishes mainly from Naha. Trans. Biogr. Soc. Japan. 3 (4): 329-398.

_________. 1953. Systema Helminthum. Part 1. Digenetic Trematodes of Fishes. 405 pp. Maruzen Co., Ltd. Nihonbashi, Tokyo, Japan.

_________. 1958. Systema Helminthum. Vol. I. The Digenetic Trematodes of Vertebrates. Part 1. xi + 979. Interscience Publishers, Inc. New York.

Yeh, James and Kuang Wu. 1951. Progenesis of Microphallus minus Ouchi (Trematoda: Microphallidae) in freshwater shrimps. Peking Nat. Hist. Bull. 19 (2/3): 194-208.

PLATE 1

Figure 1. *Coitocaecum bathygobium* n. sp., ventral view.

LIST OF ABBREVIATIONS

acet. - - - - - acetabulum

a.t. - - - - - anterior testis

ca. - - - - - caecum

d.e. - - - - - ductus ejaculatorius

e. - - - - - egg

e.p. - - - - - excretory pore

eso. - - - - - esophagus

e.v. - - - - - excretory vesicle

g.p. - - - - - genital pore

L.C. - - - - - Laurer's canal

met. - - - - - metraterm

o.s. - - - - - oral sucker

ov. - - - - - ovary

ovid. - - - - - oviduct

ph. - - - - - pharynx

pph. - - - - - prepharynx

p.t. - - - - - posterior testis

ut. - - - - - uterus

vit. - - - - - vitellarium

v.s. - - - - - vesicula seminalis

y.r. - - - - - yolk reservoir

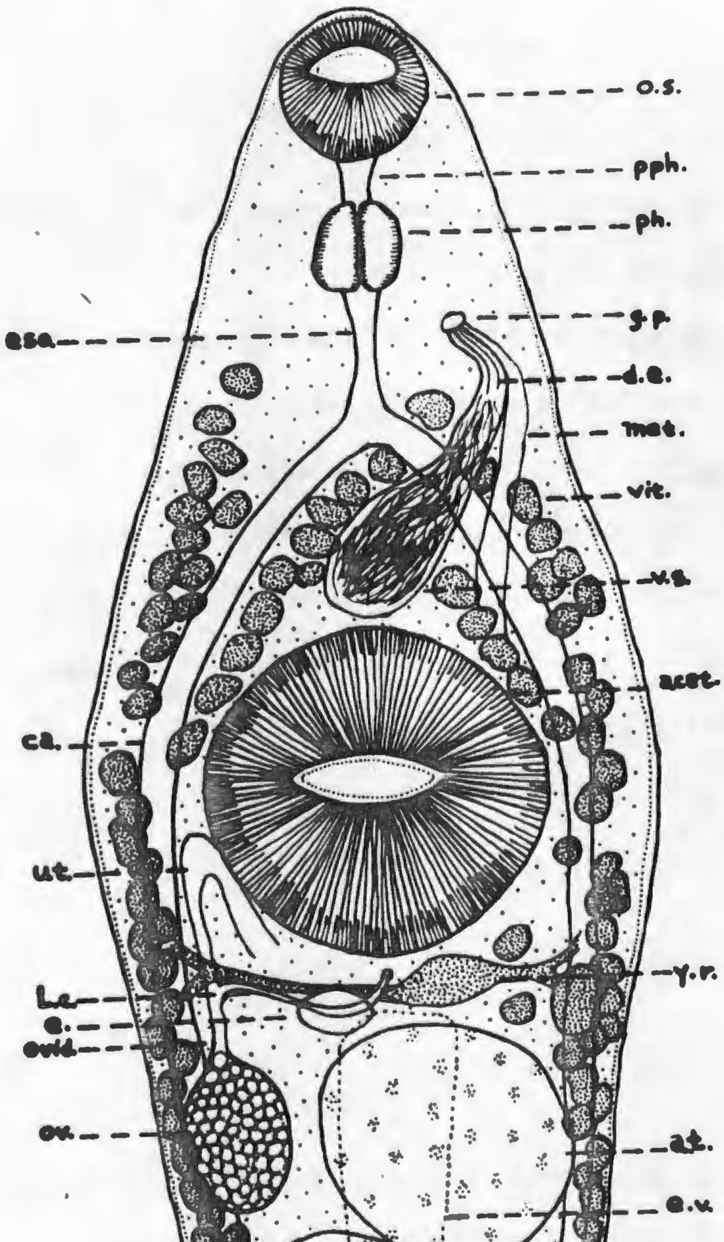

o.s.
pph.
ph.
g.p.
esa.
d.e.
met.
vit.
v.s.
acet.
ca.
ut.
y.r.
L.c.
e.
ovid.
ov.
a.t.
e.v.
p.t.
0.1 mm.
e.p.
Fig.1

PLATE 2

Figure 2. Coitocaecum bathygobium, lateral view. The digestive tract has been omitted.

Figure 3. C. bathygobium, ventral view. The vitellaria is broken in the testicular area on both sides of the body.

Figure 4. C. bathygobium, ventral view. Note the position of the posterior arch of the digestive tract, passing between the two testes rather than immediately posterior to the hind testis. In addition, the ovary is not located intracaecally.

Figure 5. C. bathygobium, dorsal view. The vitellaria is broken on the right side of the body.

Figure 6. C. bathygobium, ventral view. The hind testis is missing and the vitellaria is not confluent in the posterior region of the body.

Figure 7. C. bathygobium, ventral view. The pharynx is constricted in the center and the vitellaria is not confluent behind the posterior testis.

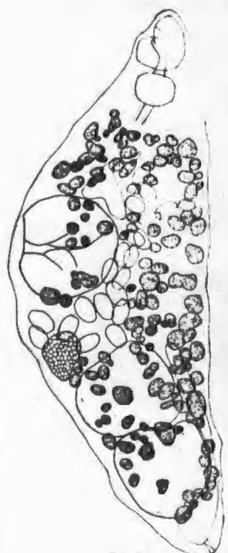


Fig. 2

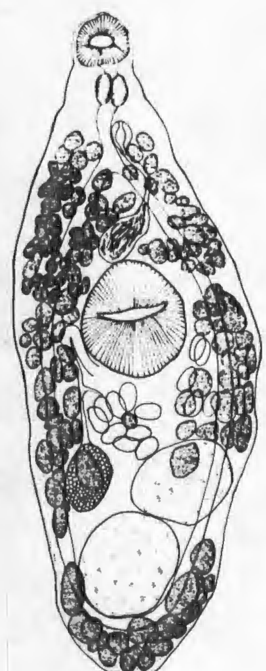


Fig. 3

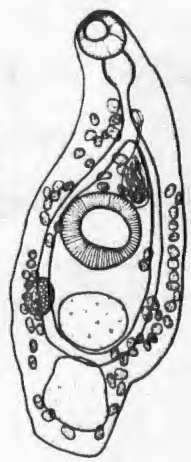


Fig. 4

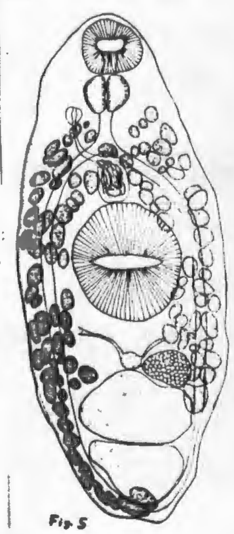


Fig. 5

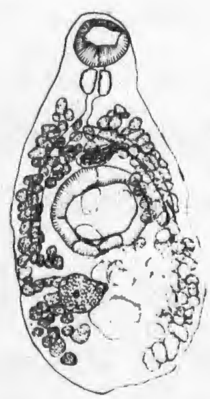


Fig. 6

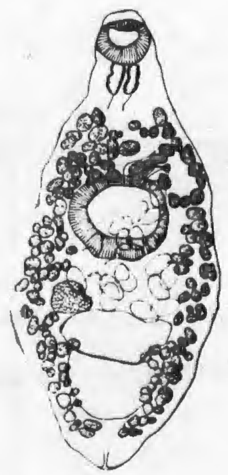


Fig. 7

PLATE 3

Figure 8. C. bathygobium, dorsal view. Typical appearance of a young adult.

Figure 9. C. bathygobium, ventral view. Testes are oblique and the ovary is contiguous with the posterior testis rather than with the anterior testis. The digestive tract is not shown. Compare with Fig. 22, C. parvum.

Figure 10. C. bathygobium, ventral view. The pharynx is constricted anteriorly and assumes a pear-shape.

Figure 11. C. bathygobium, dorsal view. From Stethojulis axillaris. Compare with Fig. 9 above and with Fig. 22, C. parvum.

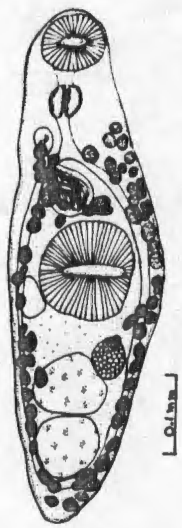


Fig. 8

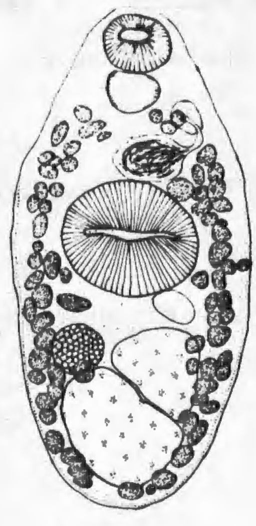


Fig. 9

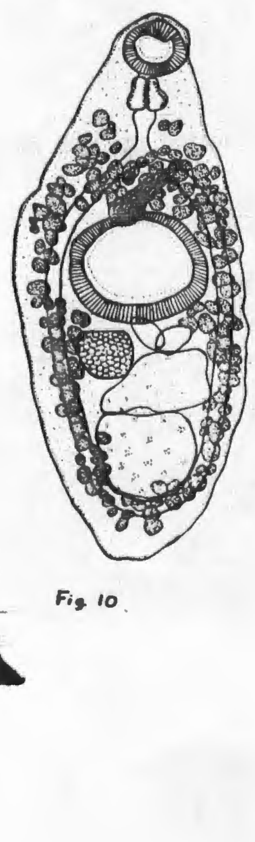


Fig. 10

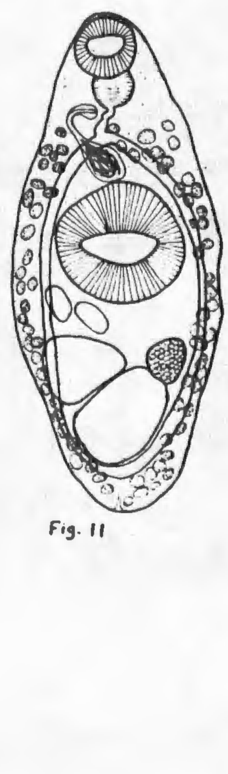


Fig. 11

PLATE 4

Figure 12. Egg of C. bathygobium, one day old. Note the slight thickening at one side at the end opposite the operculum.

Figure 13. Egg containing a fully developed miracidium of C. bathygobium.

Figure 14. Miracidium of C. bathygobium.

Figure 15. Sporocyst of C. bathygobium containing six mature cercariae.

Figure 16. Mature cercariae of C. bathygobium.

Figure 17. Metacercariae of C. bathygobium.

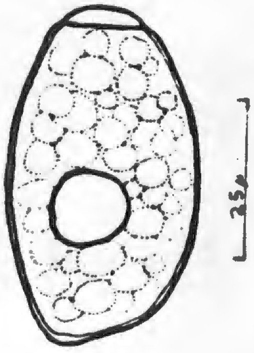


Fig. 12

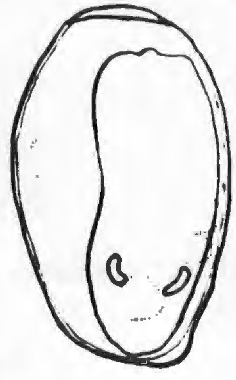


Fig. 13

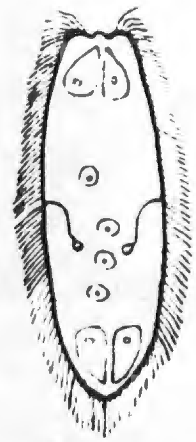


Fig 14

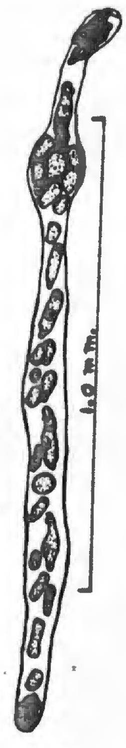


Fig. 15

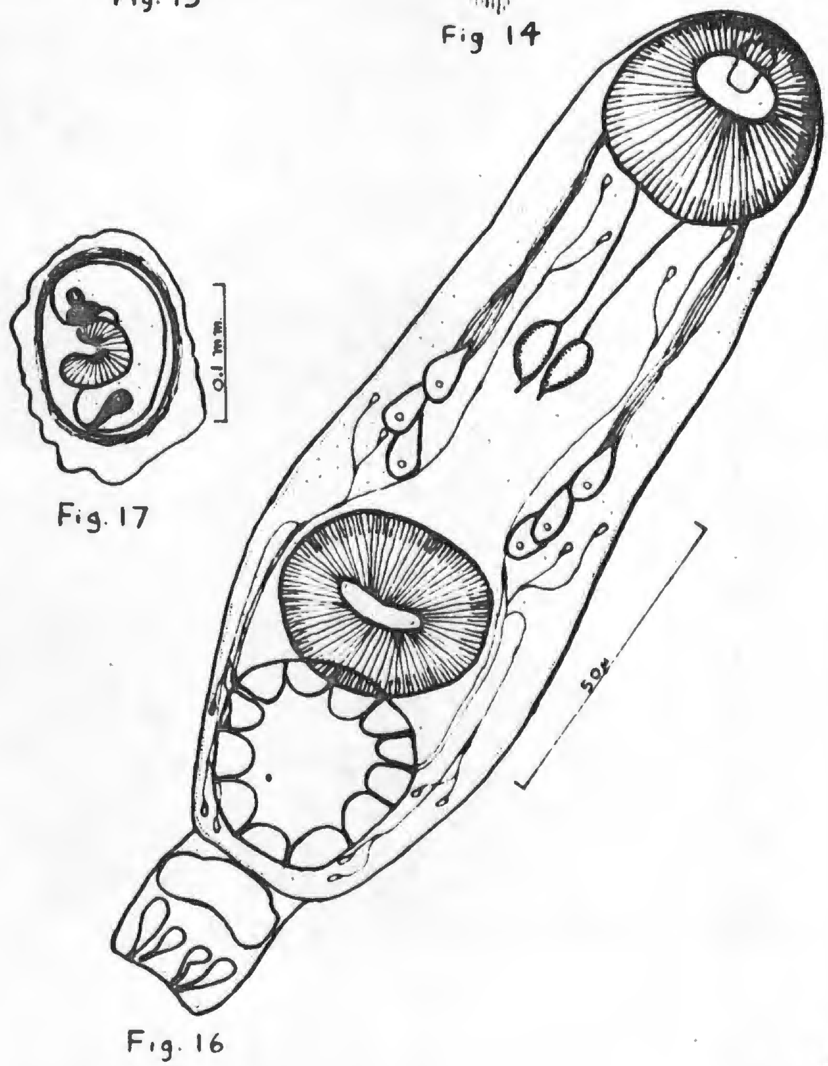


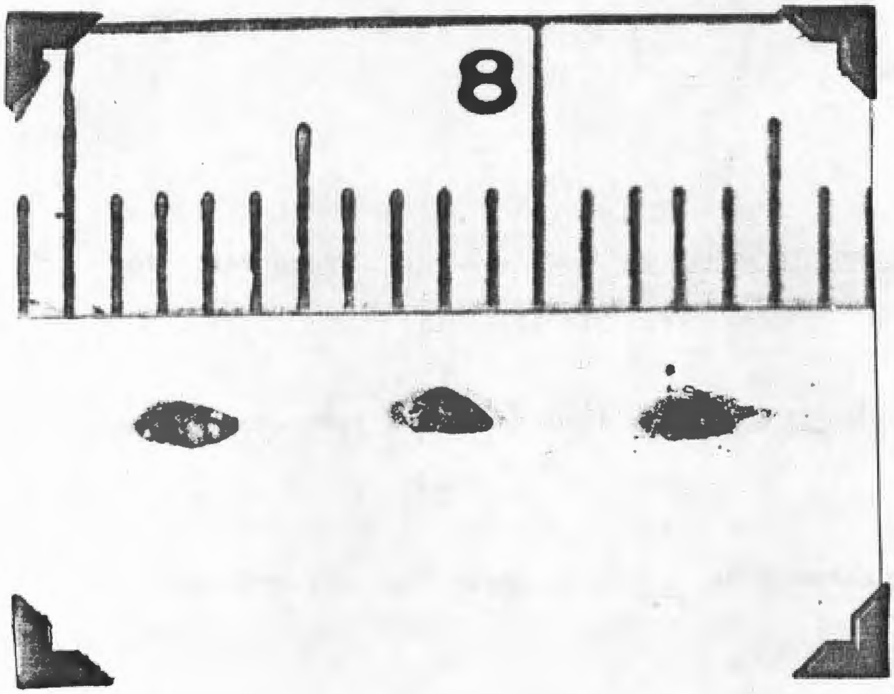
Fig. 17

Fig. 16

PLATE 5

Figure 18. Rissoa sp., The snail intermediate host for C. bathygobium.

Figure 19. Palaemonetes paludosus, the second intermediate host.


8

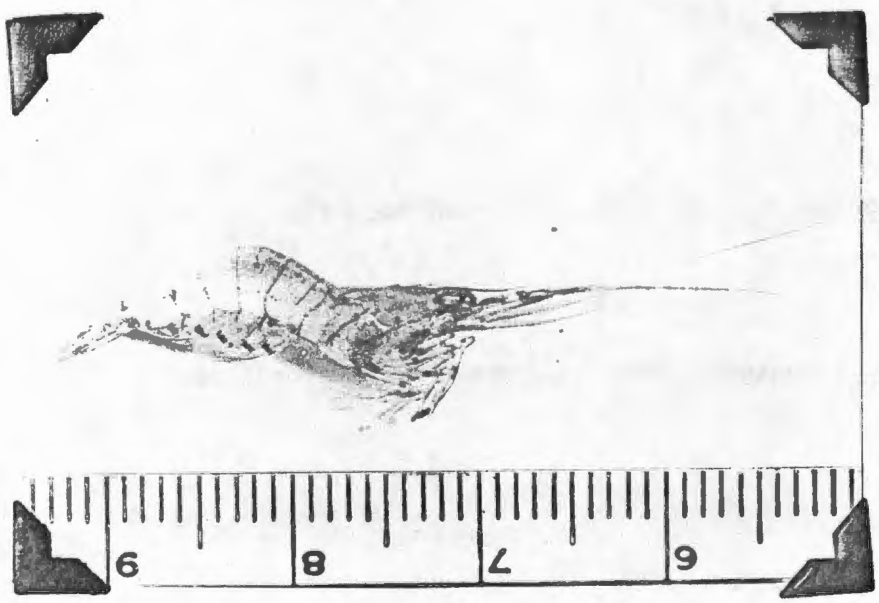

9 8 7 6

PLATE 6

Figure 20. Coitocaecum gymnophallum Nicoll, 1915. Type species for the genus. Redrawn from Nicoll, 1915.

Figure 21. C. glandulosum Yamaguti, 1934. Redrawn from the original drawing.

Figure 22. C. parvum Crowcroft, 1945. Redrawn from the original drawing.

Figure 23. C. tylogonium Manter, 1954. Redrawn from the original drawing.

Figure 24. C. tropicum Manter, 1940. Redrawn from the original drawing.

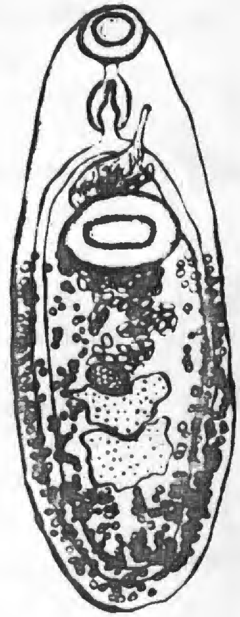


Fig. 20

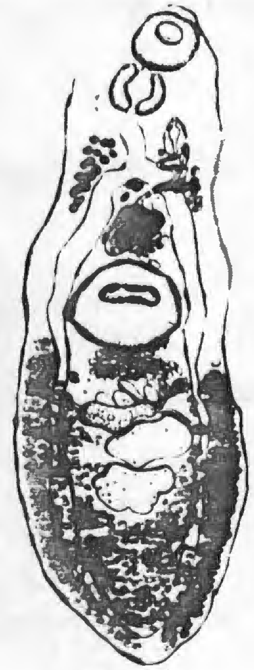


Fig. 21

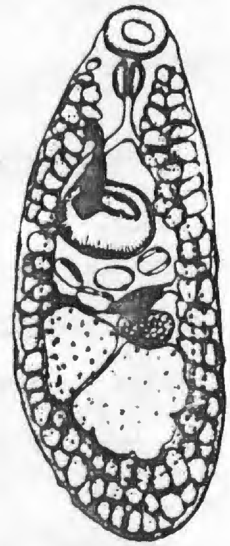


Fig 22

Fig. 23

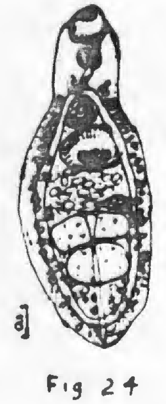


Fig 24

PLATE 7

Figure 25. C. orthorchis Ozaki, 1926. Redrawn from the original drawing.

Figure 26. C. plagiorchis Ozaki, 1926. Redrawn from the original drawing.

Figure 27. C. diplobulbosum Ozaki, 1929. This is the form of this species showing the constricted pharynx. Redrawn from the original drawing.

Figure 28. C. diplobulbosum. This form is the synonym C. unibulbosum. Redrawn from the original drawing.

Figure 29. C. ovatum Pigulewsky, 1931. Redrawn from the original drawing.

Figure 30. C. latum Ozaki, 1929. Redrawn from the original drawing.

Fig. 25

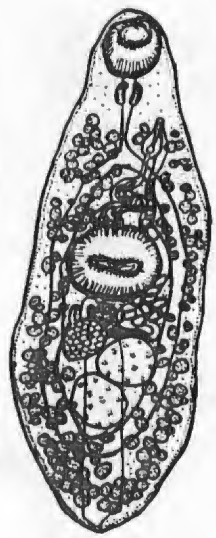


Fig. 26

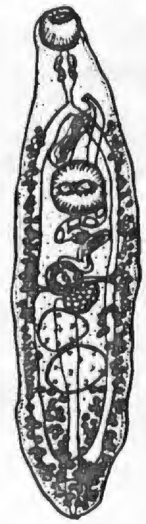


Fig. 27

Fig. 28

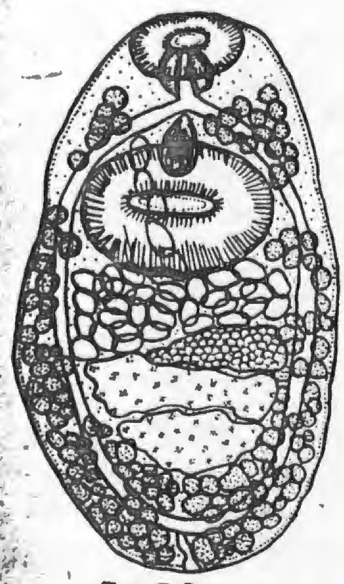


Fig. 29

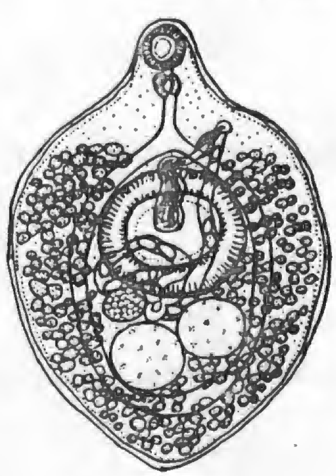


Fig. 30

PLATE 8

Figure 31. C. macrostomum Pigulewsky, 1931. Redrawn from the original drawing.

Figure 32. C. leptoscari Yamaguti, 1940. Redrawn from the original drawing.

Figure 33. C. xesuri Yamaguti, 1940. Redrawn from the original drawing.

Figure 34. C. anaspidis Hickman, 1934. Adult specimen. Redrawn from MacFarlane, 1939.

Figure 35. C. anaspidis Hickman, 1934. Progenetic metacercariae. Redrawn from the original drawing.

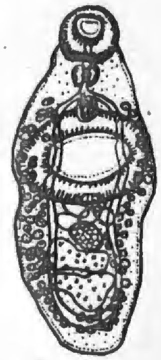


Fig. 31

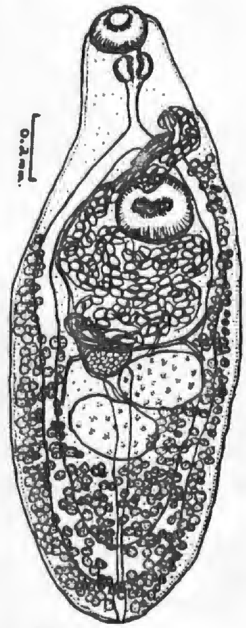


Fig. 32

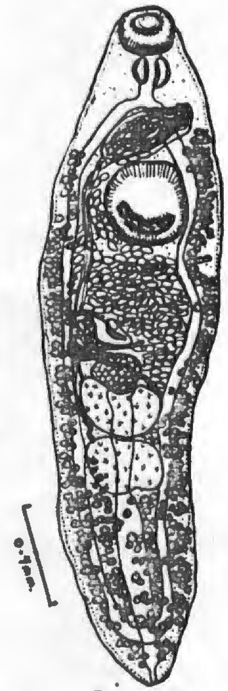


Fig. 33

Fig. 34

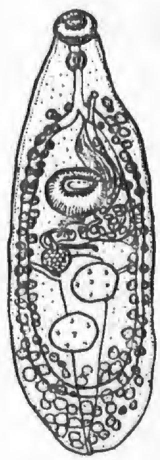


Fig. 35

PLATE 9

Figure 36. *C. callyodontis* Yamaguti, 1942. Redrawn from the original drawing.

Figure 37. *C. proavitum* Wiśniewsky, 1933. Redrawn from the original drawing.

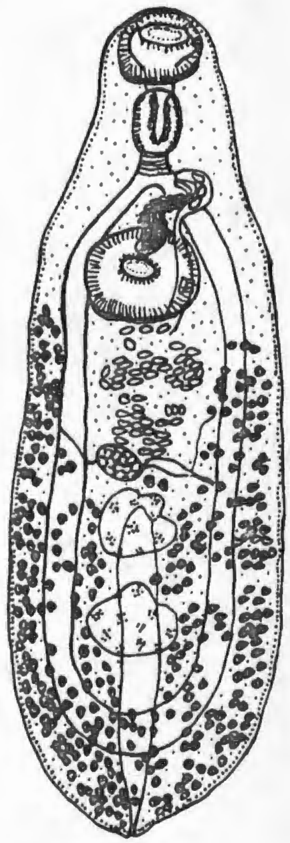


Fig. 36

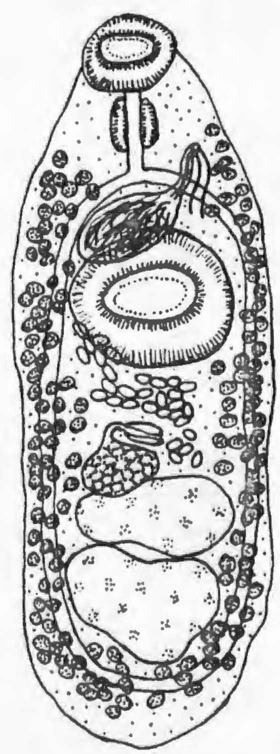


Fig. 37