ABSTRACT

Kenneth Wayne Burris. A MORPHOLOGICAL STUDY OF LERNANTHROPUS RATHBUNI WILSON, 1922 (CRUSTACEA, COPEPODA). (Under the direction of Francis P. Belcik) Department of Biology, August, 1967.

The biology of a marine parasitic copepod, Lernanthropus rathbuni Wilson, 1922, was made the subject of a detailed study. Particular attention was devoted to its internal anatomy and functional morphology. A variety of optical and microtechnical methods were brought to bear on these problems. The external anatomy of both the male and the female were described, that of the male for the first time. The males are different from the female in size, structure of third thoracic legs, reduced dorsal plate, absence of fifth thoracic legs and first maxillae.

Appendages of both sexes include the following: A seven segmented first antenna, a second antenna modified into a clasping structure, a sickle-shaped mandible with a toothed inner margin, prehensile first (absent in male) and second maxillae, first and second maxillipeds of two segments with a terminal claw, first and second pairs of thoracic legs consisting of endopod and exopod, third thoracic legs flipper-like in female and biramous in male, fourth thoracic legs biramous in both sexes, and fifth thoracic legs uniramous

in female and absent in male.

The body wall of both sexes was composed of three layers, an outer thick cuticle, a hypodermis of pavement epithelium, and a mesenchymal layer of spheroid connective cells.

The digestive system was complete in both sexes and consisted of a buccal cavity, esophagus, stomach, intestine, and anus. The stomach is lined with large columnar epithelium and gland cells.

The reproductive system was the major internal system of both sexes. The gonads consist of two ovaries and two testes located in the anterior dorsal region of the thorax. Convoluted oviducts connect to the ovaries and to the base of the cement gland. A seminal receptacle was found ventral to the stomach. Two convoluted vasa deferentia lead away from the testes to the abdominal segments where they become swollen in size and produce the spermatophores. They emerge through openings at the lateral margins of the genital segment.

Neither a nervous nor a vascular system was detected in either sex.

A MORPHOLOGICAL STUDY OF *LERNANTHROPUS RATHBUNI* WILSON, 1922 (CRUSTACEA, COPEPODA)

A Thesis
Presented to
the Faculty of the Department of Biology
East Carolina University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Biology

by
Kenneth Wayne Burris

August, 1967

A MORPHOLOGICAL STUDY OF
LERNANTHROPUS RATHBUNI WILSON, 1922
(CRUSTACEA, COPEPODA)

by

Kenneth Wayne Burris

APPROVED BY:

SUPERVISOR OF THESIS Francis P. Belcik

CHAIRMAN OF DEPARTMENT

Graham J. Davis

DEAN OF THE GRADUATE SCHOOL

John D. Reynolds

ACKNOWLEDGMENTS

Grateful acknowledgment is made to Dr. Stanley N. Wilkes for his helpful guidance in the starting of this project.

To my wife, Peggy, I am deeply indebted because of her strength and love.

Special acknowledgment is made to my thesis supervisor, Mr. Francis Peter Belcik, whose helpful guidance, encouragement, counsel, and criticism has been a constant source of inspiration.

TABLE OF CONTENTS

LIST OF FIGURES

Figure

LIST OF CHARTS

A MORPHOLOGICAL STUDY OF *LERNANTHROPUS RATHBUNI* WILSON, 1922 (CRUSTACEA, COPEPODA)

INTRODUCTION

In this work an attempt is made to study the morphology, both externally and internally, of female and male specimens of *Lernanthropus rathbuni*. Cytological and histological descriptions were not attempted on the internal systems. The main purpose of this study is to redescribe the female morphology and to include for the first time a description on the male of the species. Information concerning the internal anatomy is of particular importance since little work has been attempted in this genus *Lernanthropus*. This may aid future workers in the systematic placement of new copepod parasites.

H. M. E. Blainville (1822) created a new genus, *Lernanthropus*, with his description of *Lernanthropus musca*. Due to characteristic resemblance, the parasitic copepod *Lernanthropus rathbuni* Wilson, 1922, was assigned to this genus. The genus, *Lernanthropus*, was assigned to the family Dichelesthiidae because of its resemblance to the type genus of this family, *Anthosoma*, as described by Leach in 1816. Yamaguti (1963) combined the families Caligidae and Dichelesthiidae to form a new family, Anthosomatidae. This new family is accepted in this work.

Wilson (1922) collected two female parasitic copepods from the gills of the hogfish, Orthopristis chrysopterus (L.) at Beaufort, North Carolina. He named this new species Lernanthropus rathbuni after Richard Rathbun who contributed greatly to the knowledge of parasitic copepods. The two female specimens were made holotypes of the new species with the Catalogue Number 54069 in the United States National Museum. L. rathbuni was reported rarely since Wilson (Bere, 1936; Pearse, 1952; Causey, 1953), and only he made a contribution to the morphology of the species. Since Wilson's preliminary description was based on only two female specimens, he did not give an adequate description of several distinguishing characteristics. For example, he made no mention of the mouthparts and sinus areas which are an important aid in the classification of copepods.

Few papers have dealt with the internal anatomy of parasitic copepods. Of the work attempted, important works included Belcik (1965), Grabda (1958), Bresciani and Lutzen (1961, 1965), and Fahrenbach (1961).

METHODS AND MATERIALS

Six hundred and seventy-two hogfish, Orthopristis chrysopterus L., were collected and examined for copepod parasites during the period from May to December, 1966. The collection was obtained mainly from three sites in the Beaufort, North Carolina area. From May through June, specimens were obtained from sports fishermen at numerous fishing piers along Bogue Banks located off Morehead City, North Carolina. From July through December, specimens were obtained from commercial fisheries at both Beaufort and Morehead City, North Carolina. The larger percentage of these hogfish were caught off Harkers Island at approximately Lat. 34°40'N., Long. 76°36'W. while some were caught off Cape Lookout at approximately Lat. 34°20'N., Long. 76°31'W. Of the hogfish examined, only 16 percent were found to be infested with specimens of L. rathbuni. Males of this copepod are uncommon as only eight specimens were collected as compared to 90 female specimens collected. Dates and places of collection are in the Appendix (see Chart 1).

The majority of the copepods were removed from the hogfish at the site of collection at Beaufort, North Carolina. A few hogfish were returned to the laboratory at East Carolina University, Greenville, North Carolina, where the gill cavities were closely examined under a dissecting microscope for both mature and immature copepods.

No immature forms of the copepod were found.

Copepods discovered were removed, cleaned, preserved, and stored in Ladowsky's (AFA) or Bouin's. Some copepods were removed and studied for mouthparts and external anatomy. For observation of the internal anatomy, some were embedded and sectioned at ten microns. Both transverse and longitudinal sections were obtained by this method. Sections were stained with Delafield's hematoxylin and counter-stained with eosin. The sections were cleared in xylol and mounted in balsam. Several specimens were stained with a one percent solution of methyl blue for observations on the external anatomy, particularly the mouthparts. A few specimens were stained in a five percent solution of methyl blue which penetrated into the internal organs. The stain was removed from the cuticle of the body with a weak solution of lactic acid, thus revealing internal organs. A special attempt was made to stain specifically for the nervous system by use of fast red and fast green.

Drawings of the internal anatomy were made with the aid of a camera lucida. The drawings of the gross external anatomy were made with the combined use of the camera lucida and a Bausch and Lomb Tri-simplex Micro-projector.

ECOLOGY

Adult parasites can be found attached to gill filaments of the host. The first and second set of gills yielded the greater number of the copepods. The copepods attach themselves to the gill filaments by their second antennae which are modified into clasping organs. The females are usually found attached close to the tip of the gill filament with their egg cases extending beyond the tip and overlapping the posterior gills. The parasite apparently does great harm to the hogfish because a large number of the host were observed to be missing portions of their gill filaments, especially on the first and second sets of gills. This condition may possibly deter respiration of the host.

Males were usually found close to females and in one case a male was found attached to the abdomen of a female. The male was attached to the first abdominal segment of the female and apparently was in the process of depositing its spermatophores. Many females had spermatophores attached to two short spines or lobes extending from the first abdominal segment. These spermatophores were nearly black. No immature or larval stages were found and nothing is known about the life cycle. This area awaits further research.

During the months of May and June 40 percent of the hogfish examined were infested with the copepods whereas during the months of November and December only six percent of the

hogfish examined were found to be infested. The overall percentage for the eight month period of collecting was 16 percent infestation by the copepod.

Lernanthropus rathbuni is not host specific as are the majority of the other members of the genus. Yamaguti (1963) notes that members of this species have been obtained from the following fish: Hogfish, Orthopristis chrysopterus L., Red snapper, Lutianus blackfordi Goode and Bean, Tropical hogfish, Lachnolaimus maximus Walbaum, grouper, Mycteroperca sp. Gill, Pascagoula, Mississippi; Big-eyed herring, Elops saurus L., Sharp-nosed shark, Scoliodon terrae-novae Richardson, Texas.

Several other species of Lernanthropus occur in the same geographic region according to Pearse (1947). Lernanthropus chlamydotus Wilson, 1944, occurs on the weakfish, Cynoscion regalis Holbrook. Lernanthropus pupa Burmeister occurs on the gills of the spadefish, Chaetodipterus faber Broussonet. Lernanthropus pomatomi Rathbun, 1884, occurs on bluefish, Pomatomus saltatrix. He also lists Lernanthropus sp. from a flounder, Poralichthys dentatus.

MORPHOLOGY

External Morphology of the Female

General body of the adult oblong, about three times as long as wide. In dorsal view cephalothorax appears slightly narrowed both anteriorly and posteriorly. Broad lateral flaps extending from dorsal to ventral surface. Cephalothorax projecting as rounded lobes anteriorly and posteriorly. Posterior lobe covering abdomen from the dorsal view. Five sinus areas present on cephalothorax. Two small shallow sinuses at the tip of the anterior lobe. The sinus between anterior lobe and antennal area laterally, narrow and deep. The sinus between anterior lobe of the cephalothorax and thorax broad, depth depending on the angle of the lateral flaps of the anterior lobe. In Fig. 3, the sinus appears deep due to the flaps being spread. Broad shallow sinus in the posterior portion just behind the third pair of legs. Broad shallow sinus at the posterior tip of the posterior lobe through which the anal laminae can be seen. Genital segment much wider than long with convex sides covered by posterior lobe. Egg strings attached to sides of the genital segment. Egg strings approximately the same width as the rami of the fourth legs and about the same length as the body including the fourth legs. Abdomen width three fourths the width of the genital segment, composed of two segments; segments slightly wider than long. Anal laminae attached to the last abdominal

segment; slightly convex laterally and three times longer than wide; tips attenuated.

First antennae attached close to frontal margin of cephalothorax and lying within anterior sinus; distinctly segmented with seven segments (Fig. 4). Basal segment enlarged and distal segment tipped with five long setae; several segments have numerous setae.

Second antennae distinctly modified into clasping structure. Basal segment strong, swollen terminating in a strong semi-circular claw (Fig. 4).

Mandibles on ventral surface, posterior to base of second antennae. Mandibles curved like a saber or sickle,with the convex side outward; widened toward the tip and flattened dorso-ventrally and margins which face each other finely toothed (Fig. 4).

First maxillae palp-like consisting of two joints; distal joint biramous with the rami opposing one another. Maxillae probably prehensile in function (Fig. 4).

Second maxillae considerably larger than first, consisting of three distinct segments. Basal segment swollen while second segment slender and elongate; distal segment biramous with unequal rami. The larger of the two rami with two rows of small teeth on its concave margin; smaller rami claw-like and opposes the two rows to teeth. Second maxillae prehensile in function (Fig. 5).

KEY TO THE FIGURES

Figure 1: Female ventral view. Scale, 1 mm.

Figure 2: Female dorsal view. Scale, 1 mm.

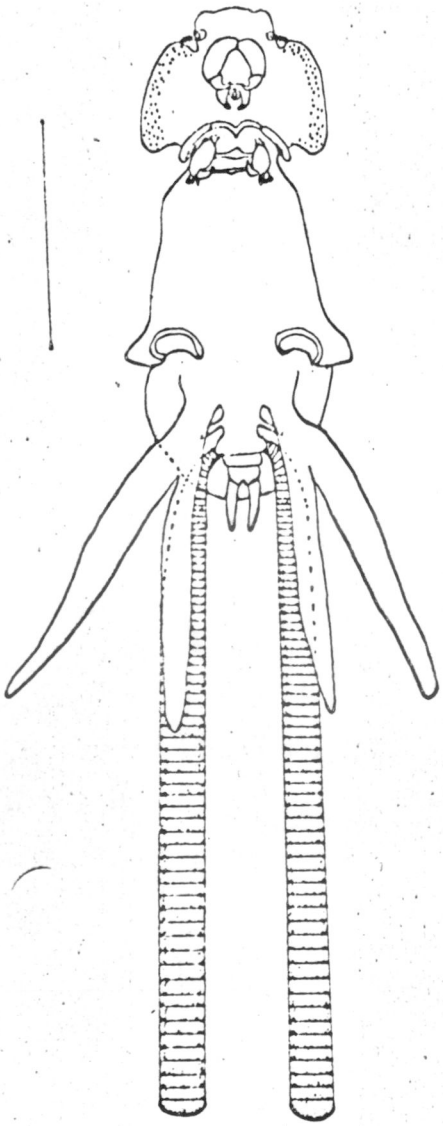


Figure 1

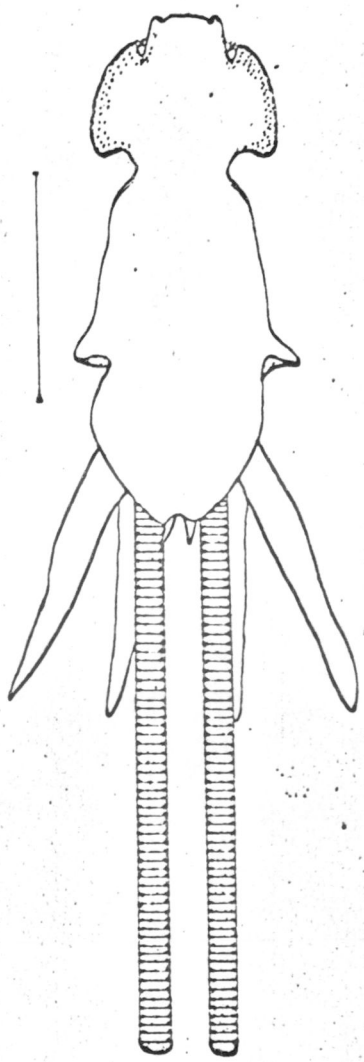


Figure 2

KEY TO THE FIGURES

Figure 3: Female lateral view. Scale, 1 mm.

Figure 4: A. Second antenna. B. First Antenna. C. Mandible and first Maxilla. Scale, 0.2 mm.

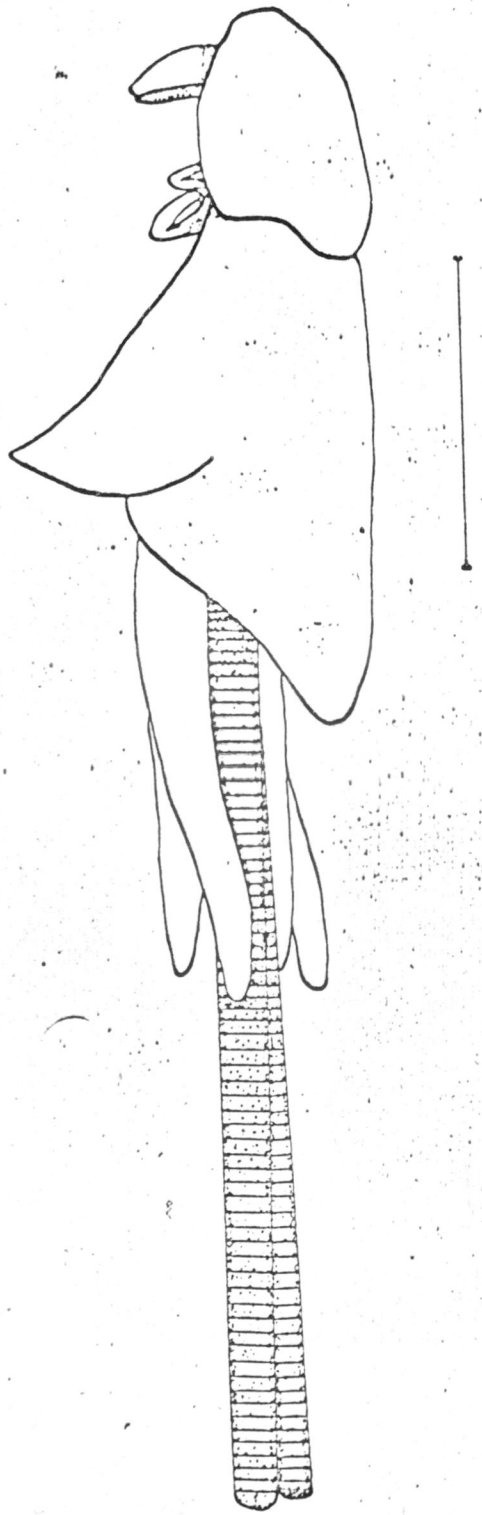
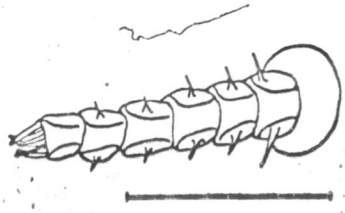
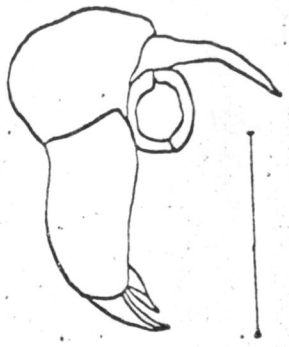


Figure 3

A.



B.



C.

Figure 4

First maxilliped large, strong, consisting to two segments; first segment swollen and stoutly reinforced with muscle tracts; second segment modified into a strong terminal semi-circular claw.

Second maxilliped essentially like the first except for the size difference and claw not bent to the extent of the first (Fig. 5).

First thoracic legs with broad flattened exopod tipped with five large spines, four spines found along the distal margin of the exopod, the fifth located between the distal margin and the base of attachment. Endopod elongate, conical, ending in a single slender spine. A single large spine adjacent to endopod. Area between spine and endopod bordered with a row of minute setae (Fig. 5).

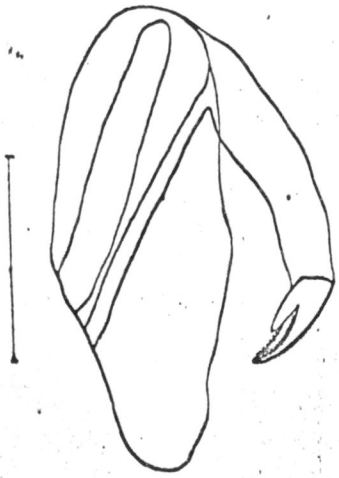
Second thoracic legs posterior to the first legs. Exopod elongate, tipped with a semi-circular spine. Endopod with five spines at distal margin, three outer spines considerably larger than inner two (Fig. 5).

Third thoracic legs large, extending from the ventral surface at right angles, stout, flipper-like in design due to fusion of endopod and exopod (Fig. 2 and 3).

Fourth thoracic legs biramous, divided nearly to base. Rami stout, unequal, blunt at tips, and approximately two thirds total body length. Rami covered with rows of very minute setae (Fig. 2).

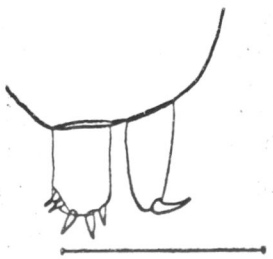
KEY TO THE FIGURES

Figure 5: A. Second maxilla. B. Second Maxilliped. C. First thoracic leg. D. Second thoracic leg. Scale, 0.2 mm. E. Lower abdomen of female showing cement glands and seminal receptacle. Scale, 0.5 mm. cg, cement gland; sr, seminal receptacle; v, vagina or canal of seminal receptacle.

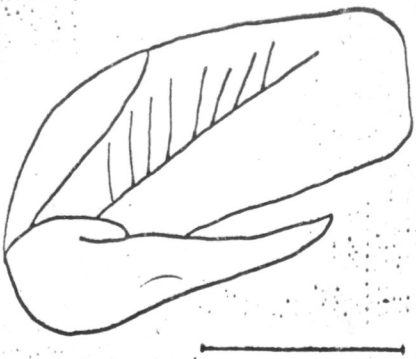


A.

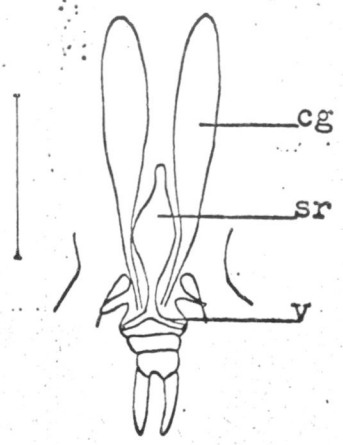
C.



D.



B.



E.

Figure 5

Fifth thoracic legs exist as short tapering rami extending laterally from the body just anterior to genital segment.

Color of preserved material yellowish brown or cream; living specimens reddish.

Total length 3.20 mm. (Average of six specimens measured ranging in size from 2.60 mm. to 3.8 mm.); cephalothoras 1 mm. long, 1 mm. wide; greatest width of body 1.15 mm.; length of fourth thoracic leg 2 mm.; length of egg strings 3-4 mm.

EXTERNAL MORPHOLOGY OF THE MALE

Adult male somewhat smaller than female. General body form of male differing from that of female in shape of third thoracic legs, absence of first maxillae and fifth thoracic legs, and few body modifications. Cephalothorax oblong, wider than the body, with broad lateral flaps, each of which projecting into a rounded lobe anteriorly and posteriorly. The sinus between the lobe and the anterior antennal area broad and shallow unlike that of the female; posterior lobe smooth. Cephalothorax gradually narrowing toward the anterior portion. Anterior and posterior portions of thorax about the same width. On either margin between the two, a broad shallow sinus adjacent to the area from which third pair of thoracic legs project. Posterior portion flaring out to a point where it sharply indents to meet abdomen. Abdomen single segmented, half as wide as the thorax, fused with thorax and with a broad shallow depression on either margin, abdomen as long as it is wide. Genital segment oblong. Anal laminae elongate, four times as long as wide.

First antennae attaching close to frontal margin of cephalothorax and lying within anterior sinus. First antennae distinctly segmented with seven segments. Basal segment enlarged and distal segment tipped with five long setae (Fig. 9 and 10).

KEY TO THE FIGURES

Figure 6: Male ventral view. Scale, 1 mm.

Figure 7: Male lateral view. Scale, 1 mm.

Figure 8: Male dorsal view. Scale, 1 mm.

Figure 9: First antenna enlarged to show seta. Scale, 0.1 mm.

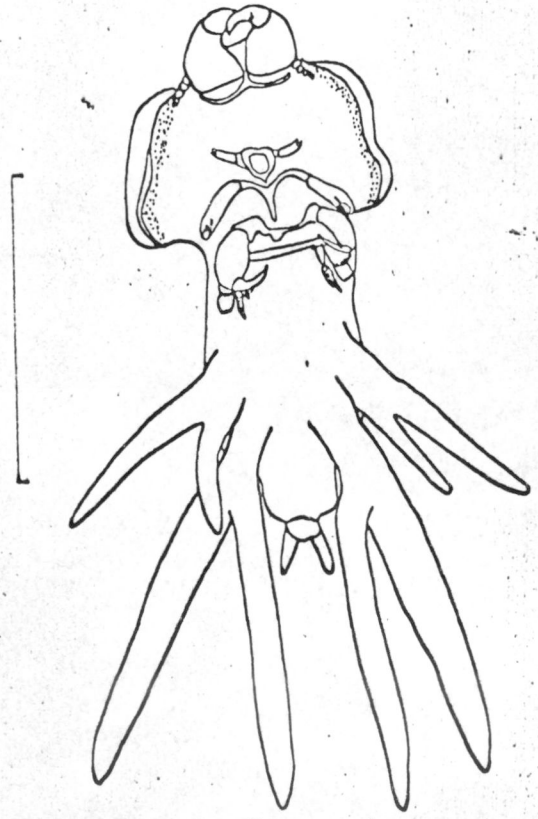


Figure 6

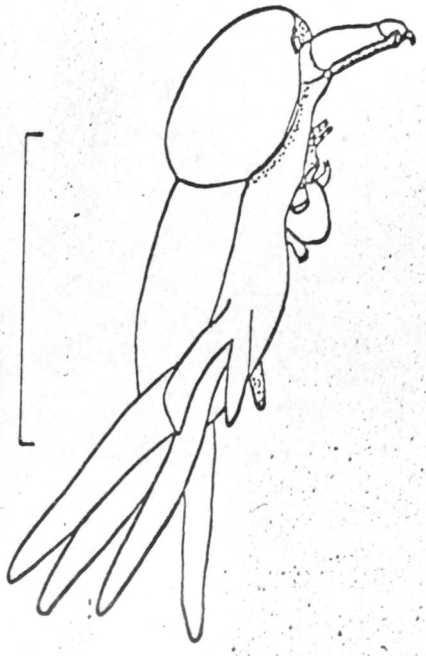


Figure 7

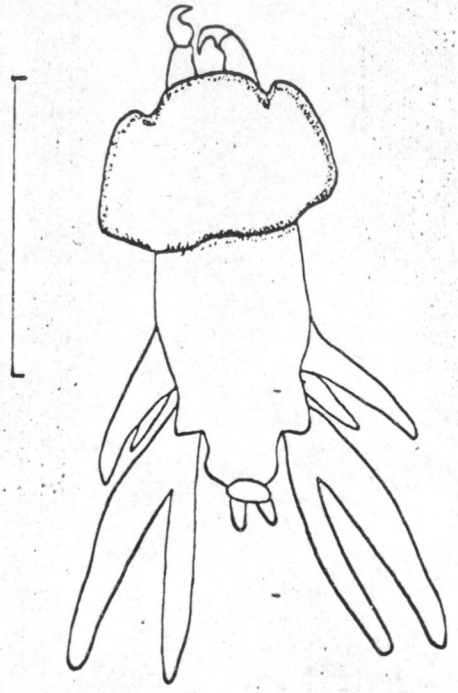


Figure 8

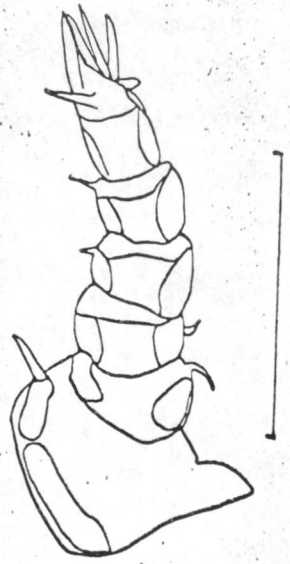


Figure 9

KEY TO THE FIGURES

Figure 10: A. Second antenna. Scale, 0.2 mm. B. First maxilla. C. Second thoracic leg. D. First antenna. E. First thoracic leg. F. Second maxilliped. G. First maxilliped. Scale, 0.1 mm.

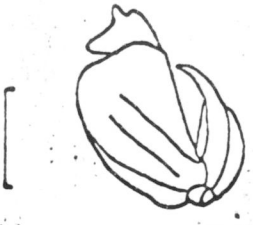
A.

B.

C.

D.

E.



F.

G.

Figure 10

Second antennae similar to those of female, with a swollen basal segment and a strong terminal semi-circular claw (Fig. 10).

Mandible very similar to those of female, sickle shaped, convex, and bearing a row of minute teeth on inner margin (Fig. 6).

First maxillae absent.

Second maxillae two jointed with a stout basal joint. Each with terminal semi-circular claw near tip. A small tooth located near the base. Between the base and the tip are two rows of minute teeth, one along each side of inner margin. Maxillae like those of female with the exception of being two segmented (Fig. 10).

First maxillipeds large, strong, bearing two curved terminal claws, each with two rows of minute teeth, one along each side of inner margin. Two small teeth at the base of each claw (Fig. 10).

Second maxillipeds with strong and considerable reinforced curved terminal claw (Fig. 10).

First thoracic legs with broad flattened exopod tipped with five large spines of approximately the same size. Endopod elongate, conical, and ending in a single, long, slender spine. Adjacent to the endopod, a single large spine. Area between spine and endopod bordered with a row of numerous setae (Fig. 10).

Second thoracic legs with an oblong flattened exopod with a single row of minute teeth located dorsally on the distal end. Five spines, located ventrally, three smaller than the other two. Endopod elongate, conical, and ending in a long slender spine. Endopod covered with numerous minute setae (Fig. 10).

Third thoracic legs biramous, divided nearly to the base. Rami stout, unequal in size, blunt at tips, approximately one half the length of the fourth thoracic legs. Rami covered with numerous very minute setae.

Fourth thoracic legs biramous, divided nearly to base. Rami stout, unequal, blunt at tips, approximately one half the total body length. Rami with numerous minute setae.

Fifth thoracic legs absent.

Color of preserved specimens yellowish brown or cream; living specimens reddish.

Total length 2.38 mm. (Average of four specimens measured ranging in size from 2.0 mm. to 2.53 mm.); cephalothorax 0.650 mm. long, 0.750 mm. wide; greatest width of body 0.53 mm.; length of third thoracic legs 0.683 mm.; length of fourth thoracic legs 1.17 mm.

Internal Anatomy of the Female

Integument. Body wall of three layers. Outer layer of thick chitinous cuticle. This layer not uniform in its thickness; thicker in such areas as dorsal plate, appendages, and mouthparts. Middle layer or hypodermis composed of pavement epithelium. Hypodermis thin in region of appendages but thicker elsewhere. Inner layer of connective tissue surrounding organs like fill in tissue. This layer referred to as mesenchyme. Loose spheroid cells filling entire body cavity and rami of third and fourth thoracic legs.

Musculature. Musculature composed mainly of two ventral and two dorsal longitudinal bands. Bands extending from base of fourth thoracic legs into head region. Head region containing many muscle tracts which radiate from the lateral margins to the bases of the appendages. Largest muscle tracts in head extending to base of second antennae. Transverse bands occur between mouthparts and first and second pairs of thoracic legs (Fig. 16).

Digestive System. Digestive system complete in female and composed of buccal cavity, esophagus, stomach, intestine, and anus. Esophagus passes inward from buccal cavity on ventral surface and passes backward into the ventral surface of the anterior portion of the stomach. Stomach large and of uniform size head region to abdomen. Stomach wall thick and covered externally with a thin cuticle or basement membrane.

Internally, large projections of columnar epithelium extend into lumen. Gland cells also present between columnar epithelium. Stomach narrows abruptly on entering abdomen forming intestine. Intestine emptying through anal opening located between bases of anal laminae (Fig. 13, 14, and 16).

Vascular System. No circulatory vessels, sinuses or corpuscles observed.

Nervous System. No nervous system observed.

Reproductive System. Reproductive system largest in body. System composed of two ovaries situated in the anterior dorsal region of the thorax just dorsal and lateral to the stomach. Oviducts extending away from anterior portion of ovaries, turning medially and passing posteriorly, dorsal to the stomach (Fig. 13 and 16). Posterior to the ovaries, the oviducts convolute from right to left between stomach and body wall before entering base of cement glands. Cement glands elongate with thick walls composed of glandular cells. Cement glands extend to posterior region of ovaries and between body wall and stomach. Club-shaped seminal receptacle found ventral to stomach and extends anteriorly half the length of cement glands. Two canals observed leading away from seminal receptacle to lateral margins of genital segment, the openings of which serve as base of attachment for egg strings. No vagina was observed in either the serial or longitudinal sections, but they are thought to be synonymous with the canals of the seminal receptacle.

KEY TO THE FIGURES

Figure 12: Longitudinal section of male showing testes, vasa deferentia, intestine, and spermatophores. Scale, 1. mm.

Figure 13: Longitudinal section of female showing ovaries, oviducts, cement gland, seminal receptacle, and intesting. Scale, 0.5 mm.

Figure 14: Cross section through upper abdomen of female showing ovaries. Scale, 0.5 mm.

Figure 15: Cross section through lower abdomen showing ovaries, oviducts, and cement glands.
a, anus; cg, cement gland; cu, cuticle; es, esophagus; i, intestine; ms, muscle; ov, ovary; ovd, oviduct; s, stomach; t, testis; sr, seminal receptacle; v, vagina or canals of seminal receptacle; vd, vasa deferentia; sph, spermatophore.

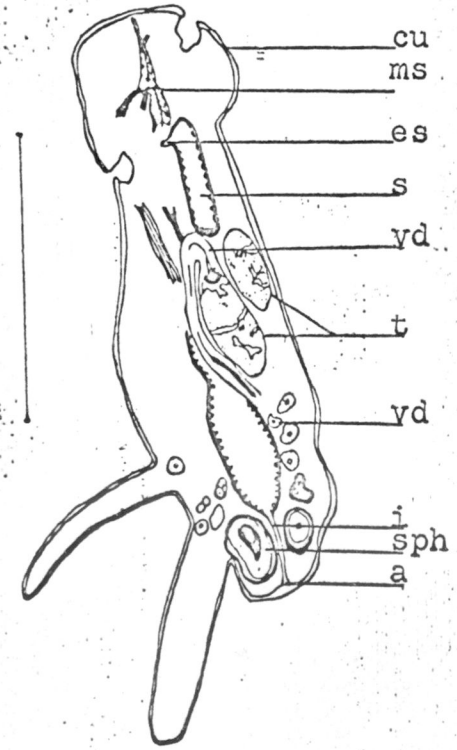


Figure 12

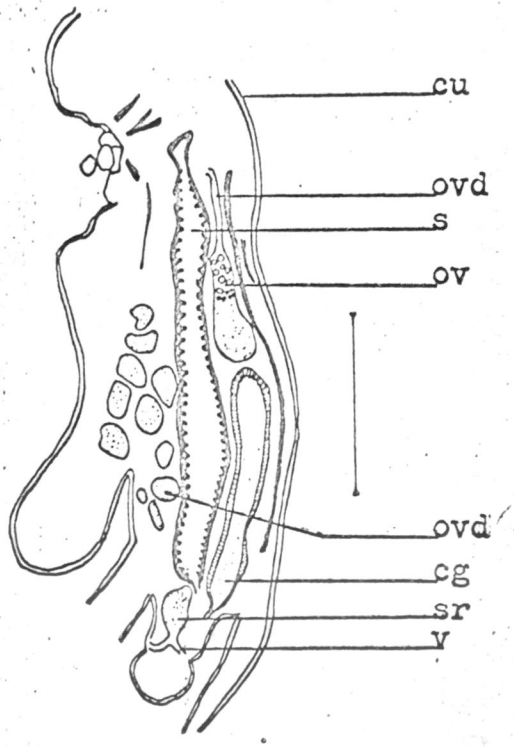


Figure 13

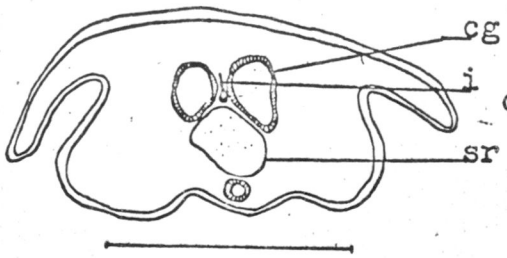


Figure 14

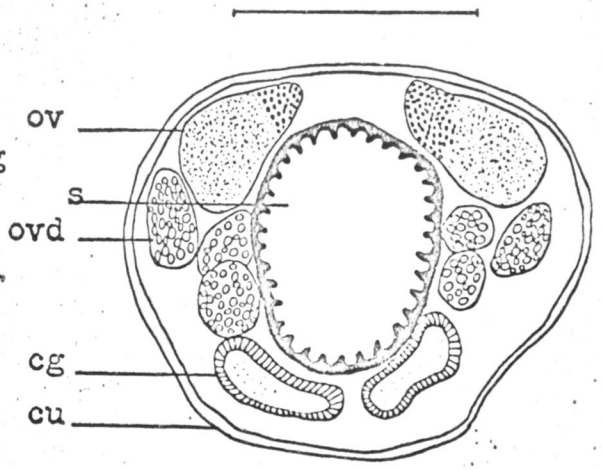


Figure 15

KEY TO THE FIGURES

Figure 16: Female composite showing intestinal and reproductive systems. Muscle tracts shown in solid black. Scale, 1 mm.

Figure 17: Male composite showing intestinal and reproductive systems. Muscle tracts shown in solid black. Scale, 1 mm.

a, anus; cg, cement gland; i, intestine; m, mouth; ov, ovary; ovd, oviduct; s, stomach; sph, spermatophore; sr, seminal receptacle; t, testis; v, vagina or canals of seminal receptacle; vd, vasa deferentia

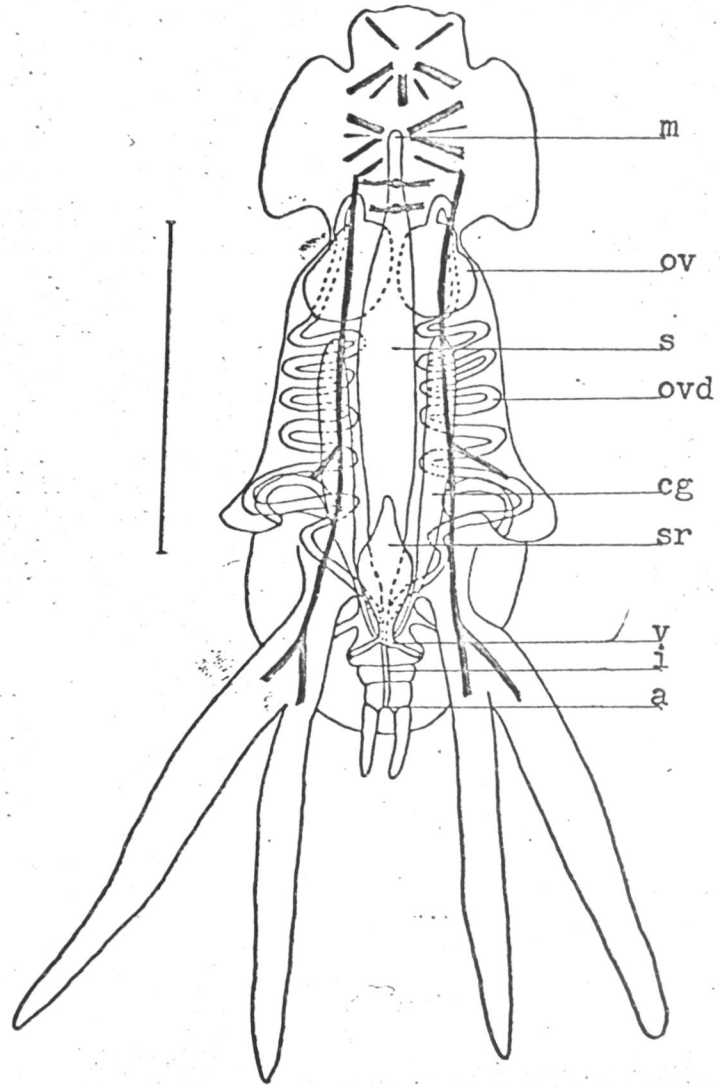


Figure 16

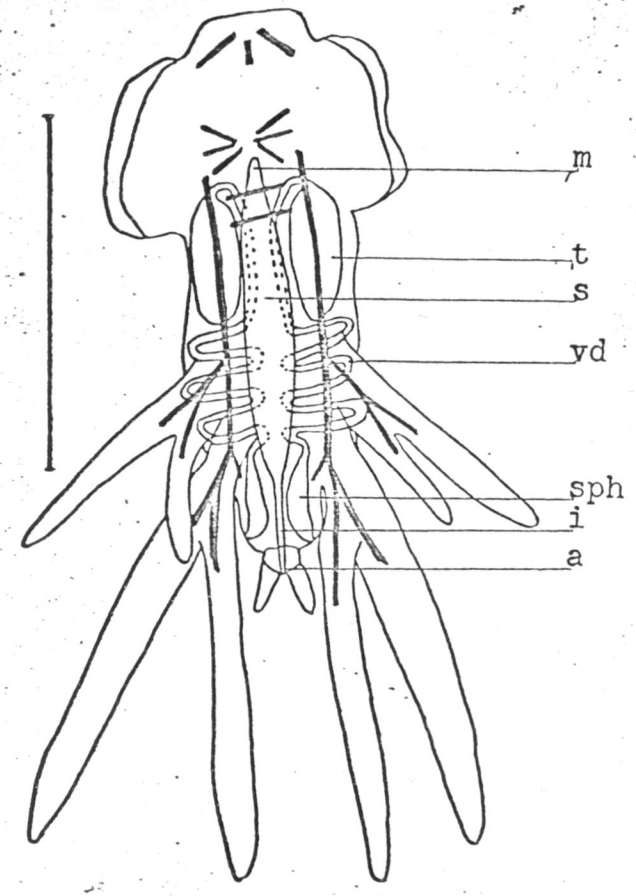


Figure 17

Internal Anatomy of the Male

Integument. Like the female, the body wall composed of three layers. Outermost layer or cuticle thick and pliable. Middle layer or hypodermis composed of pavement epithelium. Inner layer or mesenchyme composed of spheroid cells filling the general body cavity as well as the lumen of the third and fourth thoracic legs.

Musculature. Musculature very similar to that of female with two dorsal and two ventral longitudinal bands with extensions into the third and fourth thoracic legs. Many muscle tracts in head region connected with appendages. Several transverse muscle tracts between mouthparts and first and second thoracic legs (Fig. 17).

Digestive System. Digestive system complete consisting of buccal cavity, short esophagus, stomach, intestine, and anus. Esophagus connects buccal cavity to anterior portion of stomach. Stomach like that of female, uniform in size, with an outer cuticle or basement membrane, and an inner layer of columnar epithelium projecting into lumen. Intestine arising in abdomen as stomach narrows sharply and empties through anus located between anal laminae (Fig. 12).

Vascular System. No evidence of a vascular system was observed.

Nervous System. No evidence of a nervous system was observed in the material studied.

KEY TO THE FIGURES

Figure 11: A. Cross section of male through upper abdomen showing testes. B. Cross section of male through middle abdomen. C. Cross section of male through head region showing second antennae and muscle tracts. D. Cross section of male through lower abdomen and spermatophores. Scale, 0.2 mm.

a-2, second antenna; cu, cuticle; i, intestine; me, meschymatous tissue; ms, muscle; s, stomach; sph, spermatophore; t, testis; th-4, fourth thoracic leg; vd, vasa deferentia

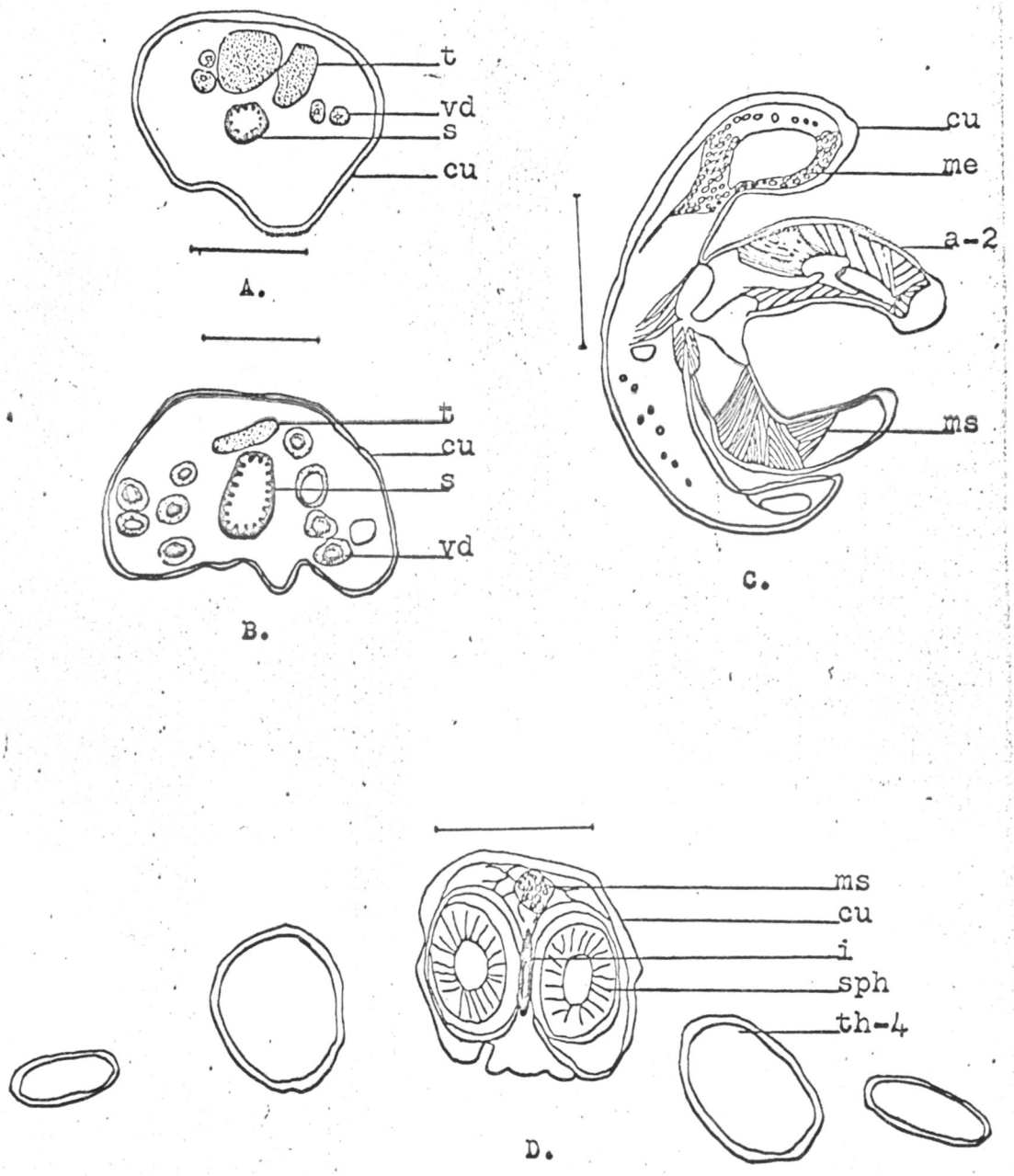


Figure 11

Reproductive System. As in the female, the reproductive system of the male the largest internal system of the body. Composed of two testes located in the dorsal anterior region of the thorax and laterally to the stomach. Vasa deferentia leading away from anterior end of testes toward midline and posteriorly. Posterior to the testes, the vasa deferentia convolutes to the right and left between the body wall and stomach. In the lower abdomen the walls of vasa deferentia become swollen and thicker in size. In this region, the vasa deferentia forming the spermatophores. In the spermatophores the sperm become closely packed together and are surrounded by a layer of cuticle from the glandular cells of the vasa deferentia. The spermatophores possibly released from an opening in the lateral margins of genital segment. (Fig. 11, 12, and 17).

DISCUSSION

L. rathbuni is a parasitic copepod that has been found in two locations, the Beaufort, North Carolina and Texas Gulf Coast areas. The copepod was found primarily on the hogfish, *Orthopristis chrysopterus*. Only female specimens were found in the past and these were very sparse in number. Ninety female specimens and eight male specimens were obtained from 672 hogfish. Of these hogfish, only sixteen percent were found to be infested with the copepod; thus, one can conclude that this parasitic copepod is uncommon and the male more so. The specimens were obtained from the gill filaments of the branchial chamber. The specimens were easily removed with the aid of forceps; thus, they were not imbedded in the filaments, but they definitely appear to be fixed ectoparasites due to gill filament damage at site of attachment and structure of clasping second antennae.

The nervous system was not observed by the methods used. Others (Belcik, 1965) have had a similar problem.

In the study of the external morphology, it was found that *L. rathbuni* closely follows the generic diagnosis as set forth by Blainville. *L. rathbuni* closely resembles another species of *Lernanthropus*, which was also collected in this same region. *L. pomatomi* Rathbun (1887) occurs in large numbers (seventy four percent infestation on the bluefish, *Pomatomus saltatrix*. Three hundred and eleven females

and eight male specimens were obtained from the gills of 28 of 38 bluefish examined. Thus it can be seen in this comparsion that the number of males are drastically reduced in proportion to the number of females found.

L. rathbuni differs from L. pomatomi in the following respects: The lack of the large sinus between the cephalothorax and abdomen, the position of the second thoracic legs, the presence of a fifth pair of thoracic legs, the presence of biramous third thoracic legs on the male. L. rathbuni also resembles L. longipes Wilson (1932) in the position and number of segments of the first antennae, but there is a basic difference in the general body shape.

The integument of both males and females was found to be composed of three layers. The outer layer is composed of a chitinous cuticle which appears to be consistant with other parasitic and non-parasitic copepods. Bresciani and Lutzen (1965) reports that the parasitic copepod Aphanodomus terebellae Levinsen, has a single layer cuticle that varies in thickness and is produced by the squamous epithelium that underlies it. Fahrenbach (1962) reports that the harpacticoid copepod Diarthrodes cystoecus Fahrenbach, has a cuticular layer made up of two layers and secreted by the underlying epidermis.

The digestive system is complete. A minority of parasitic copepods appear to have an incomplete digestive system.

Bresciani and Lutzen (1961) report that the parasitic copepod Saccopsis steenstrupi Brensciani, has a muscular digestive tract that is incomplete having no anal opening. Also reported was that "The internal wall of the stomach, namely, shows large tongue-shaped diverticula lined by thick chitin under which, strangely enough, there does not seem to be any epithelium." These diverticula may correspond to the cells which in this study were concluded to be columnar epithelium, protruding into the lumen of the stomach. The digestive system of L. rathbuni is complete in having a mouth, esophagus, stomach, intestine, and anus.

No nervous system was found in this parasite. In other copepods, the nervous system has been found as a supraoesophageal and suboesophageal ganglia. Since these ganglia are found under and above the esophagus, a differential stain would be needed to detect them. Methyl blue, fast red, fast green, hematoxylin, and eosin were all unsuccessful in this work.

No vascular system was found in this parasite. This system is probably absent. Baer (1951) states that the respiratory mechanism is controlled by the peristalic movements of the gut and gasous exchange probably takes place through the integument.

As is characteristic of most parasitic copepods, the reproductive system in both sexes constitutes the major

internal system of the body. The reproductive system of both the male and the female were easily observed with the exception of the reproductive anatomy of lower abdomen of the female. Grabda (1958) reported that the oviduct and cement glands of Actheres percarum (Nordm) open into the vaginae and that the canals or ducts of the vaginae are synonymous with the canals of the seminal receptacle. Thus it is concluded that the canals leading away from the seminal receptacle that were observed and the vagina are one and the same. It is also concluded that the oviducts and cement glands empty into the vaginae. The egg strings are found attached to the openings of the vaginae. Copulation apparently takes place in the spring and summer due to more female specimens having spermatophores attached during this period. The dark spermatophores are usually attached to the rami of the fifth thoracic legs of the female and due to their size extend over the genital segment.

This study only initiates the understanding of the parasitic copepod, L. rathbuni. Many questions both scientific and interesting await future consideration. For example: What number and kinds of larval stages are involved in the life cycle? How does ecdysis or molting occur? Are the males completely parasitic? Do the males transform into females after the formation of spermatophores? How does fertilization take place? These and may other questions await future research and study.

SUMMARY

Between May and December, 1966, 90 female and eight male specimens of Lernanthropus rathbuni were collected in the Beaufort, North Carolina area. The morphology of both sexes was described, that of the male for the first time.

Externally the males differed from the female in size, structure of third thoracic legs, reduced dorsal plate, and absence of first maxillae and fifth thoracic legs. Descriptions of each appendage were included.

A standard microtechnique was applied to the study of internal anatomy. Delafield's hematoxylin and eosin were employed as stains. Special stains such as methyl blue, fast red, and fast green were used in an attempt to observe nervous tissue. Internal anatomy of both sexes contained the following: a body wall of three layers, a muscular system, and a complete digestive system, and a well defined reproductive system which fills a major portion of the body cavity. Neither a nervous nor a vascular system was detected in either sex.

Drawings of both internal and external anatomy were made with the combined use of camera lucida and micro-projector.

The external and internal anatomy was discussed in relation to that of other species and other genera.

REFERENCES CITED

Baer, J.G. 1951. Ecology of animal parasites. The University of Illinois Press, Urbana, Illinois. 223 pp.

Belick, F.P. 1965. "The morphology of Ismalia monstrosa Bergy (Copepoda)." Unpublished masters thesis from Oregon State University. 1-36.

Bere, Ruby. 1936. Parasitic copepods from Gulf of Mexico fish. American Midland Naturalist 17: 577-625.

Blainville, H. M. E. 1822. Memoire sur les Lernees (Lernaea Linn.). Jour. Phys. Chim. et d'Hist. Nat. 437-447.

Bresciani, J. J. and Lutzen, J. 1961. The anatomy of a parasitic copepod, Saccopsis steenstrupi N. Sp. Crustaceana 3 (1): 2-23.

_____. 1965. The anatomy of Aphenodomus terebellae (Levinsen) with remarks on the sexuality of the family Xenocaelomidae N. Fam. (parasitic copepoda). Bulletin Du Museum National D'Histoire Naturelle 37: 787-806.

Causey, D. 1953. Parasitic copepoda of Texas coastal fishes. Publication of the Institute of Marine Science, University of Texas 3: 5-16.

Fahrenbach, W. H. 1961. The biology of a Harpacticoid copepod. La Cellule 62: 305-376.

Grabda, J. 1958. Structure of the sexual organs in some representatives of the family Lernaeopodidae (copepoda parasitica). Zoologica Poloniae 9: 153-160.

Jordon, D. S. and Evermann, B. W. 1963. The fishes of North and Middle America. Smithsonion Institution T. F. H. Publications Inc., Jersey City, New Jersey. Vol. 1-4: 3313 p.

Pearse, A. S. 1947. Parasitic copepoda from Beaufort, North Carolina. Journal of the Elisha Mitchell Scientific Society 63(1): 1-16.

_____. 1952. Parasitic Crustacea from the Texas coastal fishes. Publication of the Institute of Marine Science, University of Texas 3: 5-16.

Rathbun, R. 1887. Description of new species of parasitic copepods belonging to the genera Trebius, Perissopus, and Lernanthropus. Proceedings of the United States Natural Museum. 10: 559-571.

Wilson, C. B. 1922. North American parasitic copepods belonging to the family Dichelesthiidae. Proceedings of the United States Natural Museum. 28: art. 5, 100 p.

_____. 1932. The copepods of the Woods Hole region, Massachusetts. United States Natural Museum Bulletin. 158: 635 p.

Yamaguti, S. 1963. Parasitic copepods and branchiura of fishes. Interscience Publishers, New York. 1104 p.

APPENDIX

CHART ONE

DATE	LOCATION	NUMBER OF FISH EXAMINED	FEMALES COLLECTED	MALES COLLECTED	% INFECTION
May 26, 1966	Atlantic Beach, North Carolina	25	8	1	36%
June 11, 1966	Atlantic Beach, North Carolina	26	9	3	46%
June 25, 1966	Salter Path, North Carolina	19	6	1	37%
July 8, 1966	Beaufort, North Carolina	40	8	0	20%
August 19, 1966	Morehead City, North Carolina	30	4	0	13%
September 23, 1966	Beaufort, North Carolina	70	5	0	6%
October 7, 1966	Morehead City, North Carolina	86	11	1	14%
October 21, 1966	Morehead City, North Carolina	104	16	1	16%
November 4, 1966	Morehead City, North Carolina	114	13	0	11%

DATE	LOCATION	NUMBER OF FISH EXAMINED	FEMALES COLLECTED	MALES COLLECTED	% INFECTION
November 18, 1966	Morehead City, North Carolina	91	0	0	0%
December 2, 1966	Morehead City, North Carolina	126	8	1	7%
December 16, 1966	Morehead City, North Carolina	81	2	0	2%
December 23, 1966	Morehead City, North Carolina	50	0	0	0%
TOTAL		672	90	8	16% average