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A study of the external morphology of the larva of Rhynchophorus palmarum (L.) family, Curculionidae; order, Coleoptera.

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A STUDY OF THE EXTERNAL MORPHOLOGY OF THE LARVA OF RHYNCHOPHORUS PALMARUM L. FAMILY, CURCULIONIDAE; ORDER, COLEOPTERA

WILLIAM H. ZIENER

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DEDICATION

To my mother

Mrs. Isabel H. Ziener

INTRODUCTION

One of the chief justifications for study of morphology of any organism is the significance of form and structure in classification and biological relationships. Morphology is basic in classification because it supplies a reliable index to the relationships between individuals. The discovery and evaluation of these relationships can contribute not only to the field of taxonomy but also to such fields as genetics, physiology, and pathology.

The larvae of the genus Rhynchophorus Herbst (1795) have needed a study of external morphology for some time. Many details of their structure and variation have never been investigated, for early workers were concerned with destructive capacity and distribution. The two species and one variety of this genus that have been described from the American continents have been distinguished only by their geographical distribution.

The genus Rhynchophorus is of economic importance as well as of academic interest because R. palmarum (L.), R. cruentatus (F.) and R. cruentatus variety zimmermanni (Fahr) are pests of the coconut palm (Cocos nucifera L.) and other palms in tropical and subtropical America. The larvae are responsible for damaging the palm by destroying the vascular tissue. Once the larvae have gained access, the death of the palm generally ensues. Damage may result in another fashion, for the adult was shown by Martyn (1953) to be able to transmit the nematode Aphelencoides cocophilus (Cobb) which causes Red Ring disease on palms. It is impossible to assess accurately the actual loss of the palm caused by the species of Rhynchophorus, but undoubtedly the cost to plantation owners is sizable.

The writer first became interested in these insects while writing his thesis (Ziener, 1957) for the degree of Agronomo in Mexico. That thesis dealt with the cultivation of the coconut palm. My interest in this field led to the discovery of the paucity of information on the larva of R. palmarum. A detailed morphological study seemed a worthy contribution to classification in Rhynchophorus and was therefore selected as the subject for a Master's degree thesis.

The purpose of this thesis is to present a detailed morphological study of R. palmarum and to compare it with R. cruentatus and R. cruentatus variety zimmermanni, as a foundation for a better understanding of their classification.

REVIEW OF LITERATURE

In a review of the literature relative to the morphology of Rhynchophorus larvae, it is unnecessary to go back beyond Cotton's (1924) morphologic and taxonomic study of R. cruentatus. Previous to his paper, publications on these insects were concerned with records of distribution or damage. In 1936, Junk and Schenkling cited all the published information on Rhynchophorus in the "Coleopterorum Catalogus".

A relevant contribution was made by Anderson(1947), who proposed a terminology for the anatomical characters useful in the taxonomy of weevil larvae, using the larve of Pissodes strobi as an example (Peck). These terms are used in the present thesis. In the following year, Anderson (1948) published a key to the subfamily Calendrinae separating the two species of Rhynchophorus occuring on the American continents only on the basis of their geographical distribution.

In 1925 Pierce published a comprehensive taxonomic history of the genus Rhynchophorus and related genera. In this publication, he used the spelling "Rynchophorus" as did Herbst in 1795. Apparently, this spelling was a lapsus calami of Herbst. According to Miss Rose Ella Warner of the U.S. National Museum (May 5, 1961, in litt.): "The original spelling by Herbst in his text was Rynchophorus but the plates and figures are labelled Rhynchophorus. The two volumes of plates do not carry any date but in all probability they were, or we can assume they were, published along with the text." At present the accepted spelling by all recent authors is Rhynchophorus.

Landeiro (1941) reported Rhynchophorus politus Gyll. as a new pest of the coconut palm in Brazil, using the synonym of Dynamis politus Gyll. According to Leng (1920, 1927, 1933), Blackwelder (1939, 1948), and Anderson (1948) Dynamis is a closely related but separate genus of the tribe Rhynchophorini, however Anderson (1948) comments: "The genera Dynamis and Rhynchophorus are doubtfully distinct on the basis of the observed characters of their larvae, and the differences indicated below are probably of no more than specific importance".

MATERIAL EXAMINED AND METHODS OF INVESTIGATION

Specimens examined.

The larvae of R. palmarum (L.) which were examined in this study include: (1) five specimens collected by Carles Ballardo in Tecoman, Colima, Mexico, in April, 1959; (2) twenty specimens collected by Miguel Alonso Bautista in Veracruz, Veracruz, Mexico, in April, 1959; (3) four specimens collected by S. Majaraj in Saint Augustine, Trinidad, West Indies, in April, 1959; (4) four specimens collected by Raul Mac Gregor in Acapulco, Guerrero, Mexico, in April, 1959; (5) four specimens furnished by Raul Mac Gregor collected in Cozumel, Quintana Roo, Mexico, in March, 1931; (6) eight specimens collected by Luis Campa Santos in Tecoman, Colima, Mexico, in July, 1959; (7) and seventy-nine specimens collected by William Ziener in Barra de Navidad, Jalisco, Mexico, in August, 1959.

Eleven larvae of R. cruentatus (F.) were furnished by John T. Creighton, collected in Gainesville, Florida, in April, 1959.

Collecting procedures.

The specimens cited above were located initially in the field by searching for palm trees with characteristic symptoms of infestation by *Rhynchophorus* spp. The bud leaves of the palm show wilting and the leaves of the outer whorl show premature drying. It is possible to confirm the presence of larvae in the palm by listening for the sound of their feeding. By placing one's ear to the trunk of an infested palm, one can hear the crunching of the tissue by the actively feeding larvae. The infested palm is cut down and inspected for galleries. The trunk is split lengthwise in order to trace the galleries. Usually the collector can locate the weevil larvae along these pathways.

After removal from the wood, the larvae are boiled in water for five minutes, then preserved in 70% alcohol.

Methods of laboratory examination.

As a first step in the morphological study, the width of the head capsule was measured in thousandths of an inch with a micrometer (Starrett). These data are shown in figure 1.

The larvae were next examined for conspicuous structures by means of a stereo-microscope (American Optical Spencer Model 26 F) with a 12X ocular and 1X, 2X and 3X objectives. For inconspicuous structures that required higher magnification for their study, the method of preparation discussed below was used. A specimen was boiled in dilute KOH for approximately three minutes, then transferred to 70% alcohol for several minutes.

The structure in question was cut out from the whole specimen, arranged in a drop of Hoyer's mounting medium on a slide and covered with a cover glass. The specimen was then examined through a compound microscope (American Optical Spencer Microstar) with a 15X ocular and 5X, 10X, 43X, and 97X objectives and a built-in base illuminator, and observations recorded.

In an attempt to observe additional details of R. *palmarum*, eight head capsules were imbedded in celloidin following the method discussed by Kennedy (1932). It was found that by puncturing several parts of the vertex with a needle complete penetration of celloidin took place. The celloidin blocks thus obtained were cut at sixty to ninety microns in thickness. The sections were stained in hematoxylin and eosin and mounted in the manner described by Guyer (1930).

Photographs were taken from slides of the epipharynx, hypopharynx, posterior epicranial seta number two, the antennae, and the ocellus with a Kodak Pony IV 35 millimeter camera mounted on the Microstar compound microscope. The film used was Kodachrome for flash type F. Exposures were of one tenth and one quarter of a second duration. The lateral view of the larva and the dorso-distal end of the abdomen were photographed with a 4 X 5 Linhof press camera using Royal Pan film.

Results of observations are recorded in the following discussion.

Drawings were made freehand from observations of structures through the aforementioned microscopes. Certain parts of the drawings were made by Mr. Joseph Pallazola.

EXTERNAL MORPHOLOGY

The Head (Figure 4)

The head capsule of *Rhynchophorus palmarum* (L.) is heavily sclerotized and dark brown in color. When viewed from above it is roughly semicircular, but when viewed frontally it is obovate.

From a frontal view, the posterior portion of the coronal suture, which divides the vertex into two equal parts, is approximated by two slightly elevated bands extending anteriorly about two thirds the length of the suture. These bands are the external evidence of a huge median sagittal invagination. The frontal sutures or, according to Cook (1943) the clypeo-frontal suture, follow a highly variable course. At times they may form a distinct angle with each other, while other times their course is irregular. Each suture extends anterio-laterad approximately to the point of attachment of the abductor tendon of the mandible, where it becomes incomplete (Anderson, 1947); it ends laterad of the antenna. The point of union between each frontal suture and the adfrontal suture (Cotton, 1924) occurs approximately midlength of the frontal suture. From this point the adfrontal suture extends posteriorly, converging toward the coronal suture, and disappears before reaching the posterior end of the head capsule.

The two adfrontal sutures laterally delimit the so-called adfrontal region of Cotton (1924). Each parietal region bears five dorsal epicranial setae, four posterior epicranial setae and seven foveolae. Anderson (1947) did not number the posterior epicranial setae; I am numbering these setae on this region of the parietals to facilitate their description and location within this thesis, but do not necessarily expect these numbers to be used for any future taxonomic purpose.

The dorsal epicranial setae are located as follows: (1) Seta number one is large and is located on the adfrontal suture, slightly below the level of the anterior end of the elevated bands, which border the coronal suture. (2) Seta number two is relatively small and is located laterad and basad of seta number one. (3) Seta number three is large and is located at the exterior angle formed by the frontal and adfrontal sutures. (4) Seta number four is relatively small and is located laterad, and slightly anterior to seta number three. (5) Seta number five is large in size and is located laterad, and slightly anterior to seta number four.

The posterior epicranial setae are located subparallel to the adfrontal suture, distad of dorsal epicranial seta number two. Seta number one (the anteriormost of this group) is very small, and is sometimes bifurcate, other times simple. Setae numbers two, (see Figure 5), three and four are also very small and are bifurcate (visible only under compound microscope, 150x plus).

The positions of the foveolae are as follows: (1) A foveola is located about two thirds the distance from dorsal epicranial seta number three to dorsal epicranial seta number one. (2) Another foveola is located laterad, and slightly basad to dorsal epicranial seta number four. (3) One foveola is located between dorsal epicranial seta number two and posterior epicranial seta number one. (4) Three foveolae are located in a line approximately perpendicular to the adfrontal suture; this line is located between posterior epicranial seta number two and posterior epicranial seta number three.

Each genal region has three foveolae, and bears dorsal epicranial setae one and two, and ventral epicranial setae one and two.

The parietal, genal and adfrontal regions have a conspicuous reticulated pattern. The shape of the cells on the genal and posterior region of the parietals is more elongate as compared to the facial part. The number of cells has been counted for possible instar differences as shown in Figures 2 and 3. These figures show that the range in variation in one class is essentially similar to the range in variation in another; therefore different instars cannot be separated by differences in number of cells. It is evident that the cells enlarge in size with each instar but apparently do not significantly increase in number.

The Ocelli (Figure 6)

There are two yellow colored ocellar spots, one of which is located laterad of each antenna.

In taxonomic work, according to Anderson (1947): "Unless a convex lens is clearly discernible, even though subcutaneous pigment spot may be visible, the ocellus is considered to be absent." Therefore, since no lens is clearly discernible, the ocelli in the genus Rhynchophorus are considered by Anderson to be absent.

However, because of their location, structure, and external appearance, the two yellow colored spots are considered by the writer morphologically as ocelli.

Celloidin imbedded head capsules were sectioned to study the yellow colored spots internally; but apparently due to aging of the preserved specimens, the internal tissue was found to be deteriorated.

The Frons (Figure 4)

The frons is darkly sclerotized, subtriangular in shape, with two linear, longitudinal, convergent, rugose depressions. These depressions are the external evidence of the attachments of the dorsal arms of the tentorium. The frons bears five pairs of frontal setae. Between frontal setae one and two there is a foveola.

The Antennae (Figure 7)

The antennae are pale yellow in color; they are located on the apices of the lateral angles of the frons. Each antenna consists of a membranous basal article, which bears several minute hairs and an accessory sensory appendage.

The Clypeus (Figure 4)

The clypeus is trapezoidal in outline; the basal half is darkly sclerotized, while the distal half is much paler. It bears at each basal lateral angle a pair of setae, called clypeal setae numbers one and two by Anderson (1947). Clypeal seta number two is located within a small transverse groove or pit.

The Labrum (Figure 4)

From a frontal view the labrum appears unevenly semicircular, with the free edge trilobate. It is darkly sclerotized except for the marginal area of the free edge which is lighter in color. The union of the labrum with the clypeus is strong but allows some movement.

The frontal surface is divided into three nearly equal areas by two longitudinal grooves which start near the basal margin of the labrum, diverge slightly distally, and extend over the anterior edge (producing the trilobation) onto the epipharyngeal surface. Along these grooves the darkened internal <u>labral rods</u> of Anderson (1948) are externally visible. In actuality these are the greatly strengthened invaginations of a suture lying in the grooves, as can be seen in KOH-treated specimens.

Each lateral lobe of the labrum bears eight to thirteen <u>marginal setae</u> and two <u>submarginal setae</u>. Anderson (1948) considers the <u>marginal setae</u> as being located on the antero-lateral portion of the epipharynx and found a minimum of nine. One <u>submarginal seta</u> (lms 2) is located on the anterior portion of the lateral lobe close to the labral rods; the second (lms 3) is located approximately midway between the first seta (lms 2) and the basal lateral angle of the labrum.

The middle lobe is evenly rounded at margin and bears two large setae (lms 1) which are located in the line between the posteriormost <u>submarginal setae</u> of the lateral lobes. These midlabral setae are distinctly separated, at least in this species, from the marginal setae. The latter are six in number, four of them being nearly equally spaced and easily seen from the front. The remaining two are concealed by and lie closely behind the middle two of the four mentioned above. About midway between each mid-labral seta and the outermost marginal seta on the same side is a <u>sensillum</u> (Anderson, 1948). The size of the sensillum is approximately the same as the basal diameter of any of the aforementioned setae.

The Epipharynx (Figure 8)

The epipharynx is the adoral surface of the labrum and the clypeus; it is composed of hairy, papillate and bare areas. Invaginated beneath the epipharyngeal surface is a pair of dark, conspicuous, longitudinal epipharyngeal rods (Cotton, 1924). These are the adoral continuation of the so-called labral rods. Covering the middle third of the surfaces between the epipharyngeal rods is an elevated surface. Located lateral to the epipharyngeal rods are two longitudinal pale bands converging toward the base of the epipharyngeal rods. These and other color features do not necessarily bear any relationship to the distribution of hairs and papillae.

The distribution of hairy, papillate and bare areas, describing first the central region, is as follows; (1) The basal third of the area between the epipharyngeal rods is bare. (2) The lateral areas of the elevated surface, except distally, are also bare. (3) The top of the elevated surface is densely covered with long hairs. (4) The distilateral areas of the elevated surface and the areas laterad of these bear papillae. (5) Immediately anterior to the distal end of the elevated surface is located a small papillate area. (6) Just anterior to the above (number 5) lies the apex of a subtriangular bare area the base of which is the free anterior edge of the middle lobe of the epipharynx. (7) The surfaces bounding the aforementioned triangle laterally bear papillae. (8) The distal third of each longitudinal pale band bears papillae. (9) The basal two thirds of the pale longitudinal bands are bare. (10) Lateral to the pale longitudinal bands the epipharynx is hairy.

Between the distal ends of the epipharyngeal rods are two pairs of conspicuous setae called median spines of epipharynx by Anderson (1947), of which the anteriormost pair is the larger. A pair of similarly spaced light-colored spots, which are probably sensory in function (called sensillae by Hayes, 1928, and epipharyngeal sensory pores by Anderson, 1947), is located about midway between the aforementioned pairs of setae (Figure 9). Each of these light-colored spots is divided into three compartments. Two more light-colored spots (sensillae) are located on each side of the elevated surface close to the inner margin of the epipharyngeal rods (Figure 10) at about midlength of these rods. These sensillae are at varying distances from one another in different specimens.

The Mandibles (Figure 4)

The mandibles are of the typical chewing type; they are heavily sclerotized and black in color. When viewed frontally each mandible appears subtriangular in shape. On the frontal surface each has a large tuberosity, where the abductor tendon is applied, and bears two setae, called mandibular setae numbers one and two by Anderson (1947). Mandibular seta number one is situated within a round pit; number two is situated within a longitudinal pit. Laterad of mandibular seta number one is located a foveola. Distally the mandibles usually terminate in a single blunt tooth, yet sometimes they are bifid. Aborally, Böving (1921) has termed the proximal region the manductorial region, or the grinding area (also called the molar area), and the distal part, the scissorial region, or cutting area. The molar area appears to be flat except for a mesally elevated surface and two longitudinal grooves (Figure 11). The scissorial area has two longitudinal concave areas. When the mandible is removed from the head capsule, one can see the abductor and aductor tendons, and a dicondylic hinge joint. The anterior part of the dicondylic hinge joint is a socket and its posterior part, a condyle.

The Labium (Figure 12)

The labium of insects in its simplest generalized form consists of two major divisions, the basilabium and the distilabium, separated by a suture. The basilabium is a single sclerite; the distilabium bears the palpi and the ligula. The criteria to separate these areas are location, shape, color, and presence or absence of sutures.

The basilabium or submentum, which is sclerotized and light yellow in color, is the largest part of the labium. The basal margin assumes the shape of an obtuse angle, its apex being approximately on the midline of the labium and pointing in the direction of the thorax. The lateral margins of the basilabium converge slightly anteriorly. The distal margin is subparallel to the base. The submentum has two equally spaced, longitudinal, paramedial depressions which run approximately two thirds of the distance from the base to the distal end. Basally, these longitudinal paramedial depressions are white, but they gradually shade toward a darker color distally. Their distal halves are darkly sclerotized. Approximately the distal third of the basilabium is divided mesally by an inconspicuous suture. There are three pairs of basilabial setae and one pair of foveolae. The setae are located on each side as follows: Seta number one is located about midway between the mid-line of the basilabium and the longitudinal depressions and approximately two thirds the distance from the base to the distal margin. Seta number two is located about midway between the longitudinal depressions and the lateral margin of the basilabium at about the level of the basal tip of the distilabium. Seta number three is located about midway between seta number two and the lateral extremity of the plica described below. Each foveola is located slightly mesad and distad of seta number three. Distally, each lateral area has a transverse plica, which is incomplete mesally. The areas of the basilabium which border with the maxillae are whitish with darkly pigmented spots.

The distilabium is sclerotized, basally brown and distally yellow in color. The line delimiting the junction of these two colors is highly variable. Axially the brown colored area protrudes both forward and backward. Both of these mesal sections vary in shape and in length in different specimens, but always within certain limits. The distal acute protrusion is always longer and more acute then the basal protrusion. On each side of the base of the distal acute protrusion there is , either on the brown or on the yellow area, a foveola. The yellow colored area bears one pair of large setae. These are located basad of the lateral edges of the ligula. Between the two-segmented labial palpi, the distilabium bears a unipartite ligula. Distally the ligula bears a pair of setae on each side. About midway between the setae of each pair is a "sensory" spot (Cotton, 1924). The small two-segmented labial palpi are borne on a membranous base. The proximal segment in each is cylindrical and darkly sclerotized, and has a foveola on the aboral surface. The distal segment is much the smaller in size and is also darkly sclerotized. It is ovoid in shape and has a round membranous papillate portion distally on the aboral surface.

The Hypopharynx (Figure 13)

The hypopharynx is sclerotized although lightly colored, distally bilobed and mesally bare. Both apical lobes are densely covered with dark hairs. There are two subparallel rows of dark hairs on each side of the axis on the basal half of the hypopharynx. On each side, the two hairy rows converge and meet basally; distally they join the hairy areas of the apical lobes. The hairs in the subparallel rows are of variable size, but always longer than the hairs on the apical lobes. The apical portions of the hairs of both pairs of subparallel rows overlap each other mesally. This is especially so at the base of the rows where they overlap so densely that it appears as though the rows of one side of the hypopharynx converge basally and meet those of the opposite side (Figure 14). Although the tips of most of the hairs are blunt, a few terminate sharply. Two small, slightly darkened areas are located on the base of the hypopharynx; on each of these are two light-colored spots (sensillae). The mouth (Snodgrass, 1935 p.114) is subcylindrical, and is surrounded by light-colored hairs. Each side of the hypopharynx is strengthened by two darkly sclerotized bars (Snodgrass, 1935). One bar is located transversely on the lateral surface, slightly basad of the hairy apical area. For a complete view of it, one must observe the hypopharynx laterally. The other bar is longer, with one end located basad of the lower end of the aforementioned bar; it extends posteriorly to the groove that separates the labium from the maxillae. The posterior wall of the hypopharynx is extensively fused to the labium, with a small salivary pocket or salivarium being formed.

The Maxillae (Figure 12)

When viewed aborally each maxilla is seen to be composed of a cardo, a stipes, a two-segmented palpus, and a mala. The cardo is light brown, with darkly pigmented spots, except for the areas bordering the submentum and the stipes which are whitish. The stipes is darkly sclerotized, having many darker pigmented spots on the areas bordering the cardo. It has two foveolae and three setae; the bases of these setae are surrounded by pale rings. One foveola is located near the base of the stipes, while the other is located near the base of the palpus. One of the setae is located about one third the distance from the base of the stipes to the palpus, and the other two are located beside each other near the base of the palpus. The two-segmented labial palpus is borne on a membranous base. Its proximal segment is cylindrical in shape and darkly sclerotized; it has two foveolae and bears one small seta. The foveolae are variously located but always on the aboral surface. The small seta is located between the two aforementioned foveolae distad of the line joining them. The distal segment of the palpus is much smaller in size and is also darkly sclerotized. It is ovoid in shape and has a round membranous papillate portion distally, on the aboral surface. The mala is distally truncate with subparallel sides. It has two foveolae, one relatively small seta, and two large ones. One of the foveolae and the small seta are located in a line slightly below the level of the membranous base of the palpus, with the seta mesad. The other foveola and the two large setae are located on the distal portion of the mala, with the foveola more laterad. The tips of some of the adoral simple and branched setae described below are visible.

Adorally the maxilla is pale yellow. The mala bears two irregular rows of setae which are branched unless otherwise specified below. These irregular rows of setae converge and meet basally. The setae in both rows are highly variable in number and in size. One of the rows divides the mala mesally. Some of the setae on the distal end of this row are simple. Along the above mentioned row of setae the mala bears small hairs. The other irregular row of setae runs to the base of the palpus. The adoral surface of the stipes is papillate.

The Tentorium

The inner framework or tentorium of the head capsule is of the specialized type discussed by Anderson (1936) in which the chief structures are: <u>posterior arms</u>, <u>anterior arms</u>, <u>dorsal arms</u>, and the body of the tentorium.

When a head capsule is cleared with diluted KOH and subsequently viewed posteriorly, one can see that the posterior tentorial arms and the body of the tentorium have fused into a flattened structure. The base of this structure is straight and subparallel to the hypopharyngeal bracon, while its apex is crescent-shaped. The anterior tentorial arms branch from the anterobasal portion of the tentorium and are vestigial. The dorsal arms branch from the anterior tentorial arms and go to the frons, where they are attached.

The posterior tentorial pits are very large, and are located transversely on the postgena. The anterior wall of each posterior tentorial pit is continuous with the postgena, while its posterior wall is continuous with the prothorax.

<u>Hypopharyngeal Bracon</u>

The <u>hypopharyngeal bracon</u> is a pliable chitinous cord, whitish in appearance, and cylindrical in shape. It is located in a transverse position in front of the tentorium and immediately behind the cavity of the mandibles. Its extremities are attached to the genae internally. The hypopharyngeal bracon is visible in a ventral view of the head capsule, after removal of the labium.

The Prothorax (Figure 15)

Dorsally the prothorax is composed of a transverse scerite. Its posterior margin emarginates mesally by about forty percent, and terminates laterally at the mid-lateral line. This sclerite bears five large and six small setae on each side.

Laterally, the pronotal sclerite exhibits a conspicuous curved spiracle, which has been studied in detail by Cotton (1924). Around this spiracle there are nine small setae which are variously located. Anterior to the lateral edge of the pronotal sclerite there are two small, nearly horizontal lobes. Below the lateral edge of the pronotal sclerite are three horizontal lobes. The first and second lobes are pleural lobes, the third is the pedal lobe. The first pleural lobe is sclerotized, and bears two pleural setae; the second pleural lobe is membranous and bears one pleural seta. The pedal lobe is sclerotized and bears six setae.

The prosternum is divided into two transverse, membranous lobes. The anterior lobe bears one sternal seta on esch side, the posterior lobe none.

The Mesothorax (Figure 15)

The mesonotum is divided by a transverse groove into two transverse folds, the prodorsum a nd postdorsum. The prodorsum, bears three prodorsal setae on each side.

Prodorsal setae two and three are sometimes concealed anteriorly. The prodorsum is subequal to the postdorsum in length mid-dorsally; laterally it tapers acutely and terminates mesad of the lateral edge of the postdorsum. The second fold, or postdorsum, extends laterally to the mid-lateral lines; this area is slightly expanded laterally. It bears four postdorsal setae on each side. Postdorsal setae numbers one, two, and three are relatively large in size, while postdorsal seta number four is very small.

Below the lateral edge of the expanded postdorsal fold, the lateral region is divided by five longitudinal grooves, producing six longitudinal lobes. Except for the second, these lobes are nearly square in shape. The upper (presumably the alar lobe of Anderson, 1947, 1948) lobe is membranous, and bears one seta. The second or spiracular lobe is sclerotized, and is larger then the other five lobes; it is subtriangular in shape, and bears one large seta of spiracular area surrounded by six smaller setae. Postero-laterad of this lobe is a spiracle. The third, fourth and fifth lobes make up the pleural region. The third and fifth lobes are membranous, and bear no setae; the fourth lobe is sclerotized and bears one pleural seta. The sixth or pedal lobe, is also sclerotized in part, and bears four setae.

The mesosternum is divided into two transverse lobes. The anterior lobe bears one sternal seta on each side; the posterior lobe is normally concealed and bears none.

The Metathorax (Figure 15)

The metathorax is similar to the mesothorax with regard to its dorsal folds, lateral and sternal folds and lobes, and number and location of setae.

The metathoracic pleural region differs from the mesothoracic pleural region only in the shape of the second lateral or spiracular lobe which, on this part of the thorax, is nearly rectangular instead of triangular.

The First Abdominal Segment (Figure 15)

Dorsally, the first abdominal segment is divided by three grooves, producing four folds. On each side the anteriormost or fold II bears two or three prodorsal setae; fold III laterally bears two setae; fold IV bears five postdorsal setae; fold V is the smallest and bears no setae.

Laterally, a small, transverse, abdominal spiracle "without air tubes" (Anderson, 1948) is located near the anterior margin of the segment. The spiracular area bears two setae of spiracular area. Based of those on poorly distinguishable second pleural lobe are located two pleural setae. The pedal area bears one seta.

When viewed ventrally the first abdominal segment is seen to be divided into three transverse folds. The anterior of these, or eusternum, is the largest and bears two sternal setae on each side. The sternellum and poststernellum are smaller in size, and bear no setae.

Second to the Sixth Abdominal Segment

The second to the sixth abdominal segments are similar to the first abdominal segment with regard to number and location of setae, transverse dorsal and ventral grooves, transverse dorsal and ventral folds, and size and location of spiracles.

Seventh Abdominal Segment (Figures 16 and 17)

At its mid-dorsal line the seventh abdominal segment is divided by two transverse grooves, producing three folds. Fold II bears two or three prodorsal setae; fold III bears laterally two setae, while fold IV which is fused with the eighth abdominal segment, bears five postdorsal setae. The areas surrounding the aforementioned setae are sclerotized.

Laterally the seventh abdominal segment has the same structures as discussed for the first abdominal segment.

Eighth Abdominal Segment (Figures 16 and 17)

A dorsal view of the eighth abdominal segment is shown in Figure 16. Its most conspicuous feature is the elevated crescent-shaped posterior margin which is darkly sclerotized and distinctly divided mesally. On each of these divisions can be found a small seta, two large setae, and a distinctly curved spiracle surrounded by variously located minute setae. The latter are not constant in number, varying from eight to twelve with usually a mean of ten for any given instar as shown in table number one. Recessed in the mesal areas is a flat sclerotized plate. The base of the segment has a transverse fold.

Laterally this segment bears the two setae of spiracular area, and one seta on the pedal area.

In the ventral region the segment narrows mesally by fifty percent or more, has a transverse sternal fold, which invaginates mesally, and bears two sternal setae on each side.

Ninth Abdominal Segment (Figures 16 and 17)

The ninth abdominal segment , when viewed from above, appears as a flattened plate, markedly concave; its outer edge is darkly sclerotized and undulated, producing four lobes, each of which bears two large setae (one dorsal and one ventral) surrounded by smaller ones. The number of smaller setae on

Table I. Number of small setae on spiracular areas of eighth abdominal segment.

Head capsule width (in inches)	Spiracular area**	Spiracular area
.128	12	10
	9	10
.128*	8	9
.351	9	8
	11	10
	10	11
.385	8	12
	10	9
	11	8
.404	12	10
	9	11
.404*	10	12
.410	8	10
	9	11
	10	10
	12	8
.411	10	9
	10	12
	11	8

* R. cruentatus

** Spiracular area from left to right.

each lobe varies from one to seven with usually a mean of five, regardless of instar, as shown in table number two. (It is assumed that insects with identical head capsule width are in the same instar).

Ventrally the base of the segment has two sternal transverse folds. The anterior fold bears two sternal setae on each side. The posterior fold tapers mesally and bears no setae. On the caudal darkened sclerotized edge one can distinguish the same characters as are seen from dorsal view.

Tenth Abdominal Segment (Figure 17)

The tenth abdominal segment is highly atrophied; it is located ventrally basad of the ninth abdominal segment, and consists of two transverse anal lobes which are separated by the anus. The anterior lobe is invaginated mesally, and bears two setae on each side. The posterior fold is usually subdivided into three lobes, one mesal and two lateral.

Table II. Number of small setae on lobes of ninth abdominal segment

Head capsule width	Lobe 1**	Lobe 2	Lobe 3	Lobe 4
.128	1	2	1	2
	4	1	2	6
.128*	4	4	3	2
.351	4	5	4	4
	4	4	3	5
	5	2	6	3
.385	4	4	3	4
	5	4	5	4
	4	4	2	6
.404	5	5	4	4
	6	3	4	4
.404*	4	2	6	3
.410	4	4	4	4
	4	4	4	5
	5	4	3	5
	5	4	5	6
.411	4	5	5	5
	5	3	3	6
	6	4	4	7

* _R_. _cruentatus_.

** Lobe number from left to right (dorsal view).

SUMMARY AND CONCLUSIONS

1.- It has not been possible to distinguish the larvae of R. palmarum, R. cruentatus, and R. cruentatus variety zimmermanni by means of the external anatomical characters discussed within this thesis.

2.- Stable structures which might be of taxonomic significance for Curculionid larvae and have not been discussed by previous workers include:

(a) Number and location of foveolae on the head capsule and mouthparts.

(b) Bifurcation of posterior epicranial setae numbers three, four, and five.

(c) Shape of the groove or pit in which the mandibular setae are located.

(d) Longitudinal rows of hairs on the hypopharynx.

(e) Sensory spots on the base of the hypopharynx.

(f) Small seta on the basal segment of each maxillary palpus.

3.- The following features are subject to variation:

(a) Number of cells on the adfrontal and parietal regions.

(b) Structure of posterior epicranial seta number one (bifid or simple).

(c)* Number of marginal setae on the labrum.

(d)* Number of setae on the aboral surface of the mala.

(e) Distance between the light colored spots on the epipharynx.

(f) Shape of the dark area of the distilabium.

(g) Location of setae on prothoracic spiracle.

(h) Number of setae on dorsal abdominal fold II.

(i) Number of small setae on the spiracular sclerotized area of the eighth abdominal segment.

(j) Number of small setae on each lobe of the caudal edge of the ninth abdominal segment.

* (variations reported by prior workers)

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ABBREVIATIONS

Ant	- antenna
BL	- basilabium
bls 1 to bls 3	- basilabial setae
cls 1, cls 2	- clypeal setae
CS	- coronal suture
des 1 to des 5	- dorsal epicranial setae
DL	- distilabium
Fr	- frons
FS	- frontal suture
fs 1 to fs 5	- frontal setae
LbP	- labial palpus
les 1, les 2	- lateral epicranial setae
lms 1 to lms 3	- labral setae
mds 1, mds 2	- mandibular setae
MxP	- maxillary palpus
pes 1 to pes 4	- posterior epicranial setae
ves 1, ves 2	- ventral epicranial setae

Figure 1 Head capsule width measurments in inches

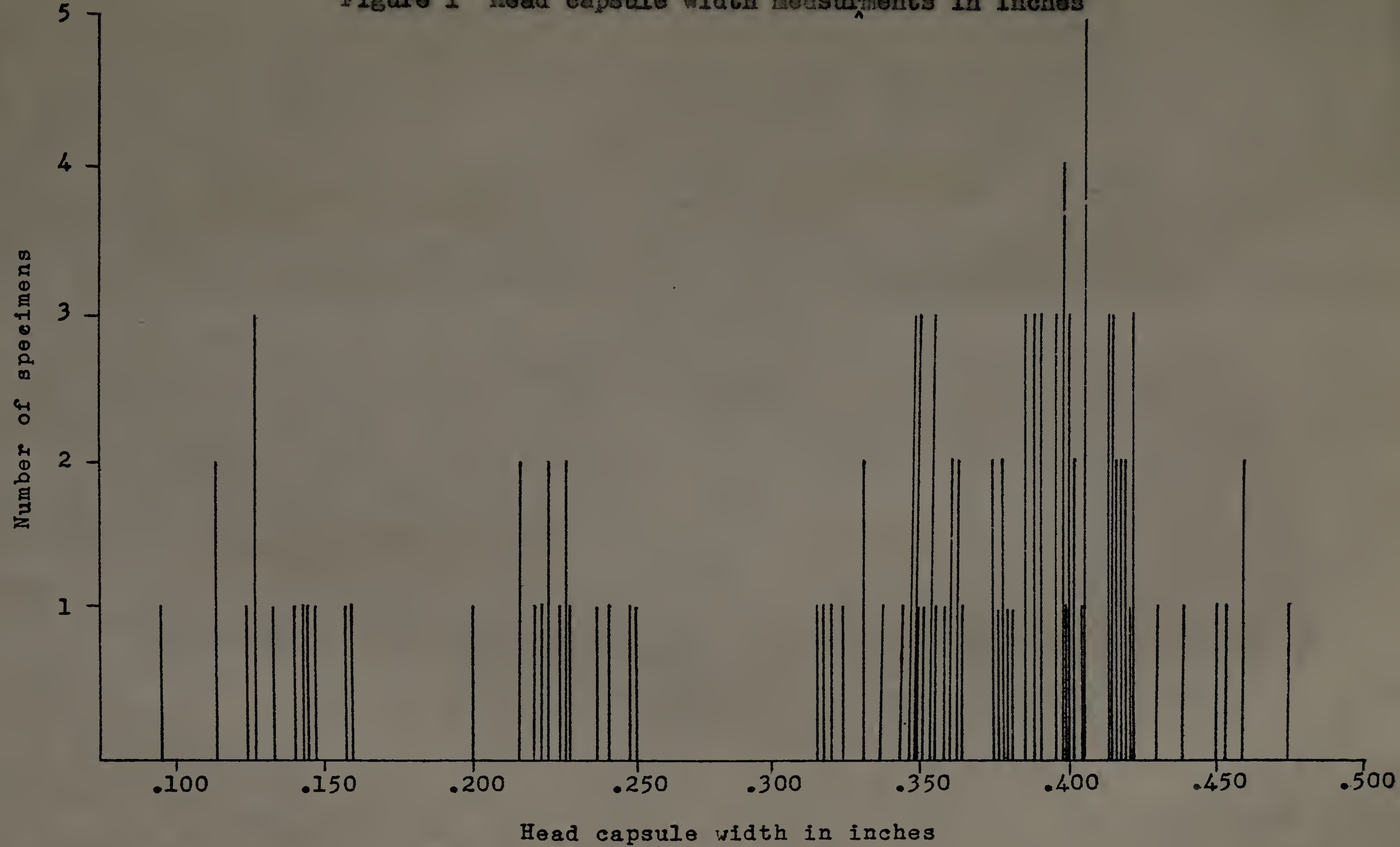


Figure 2 Number of cells on parietal region of the head capsule

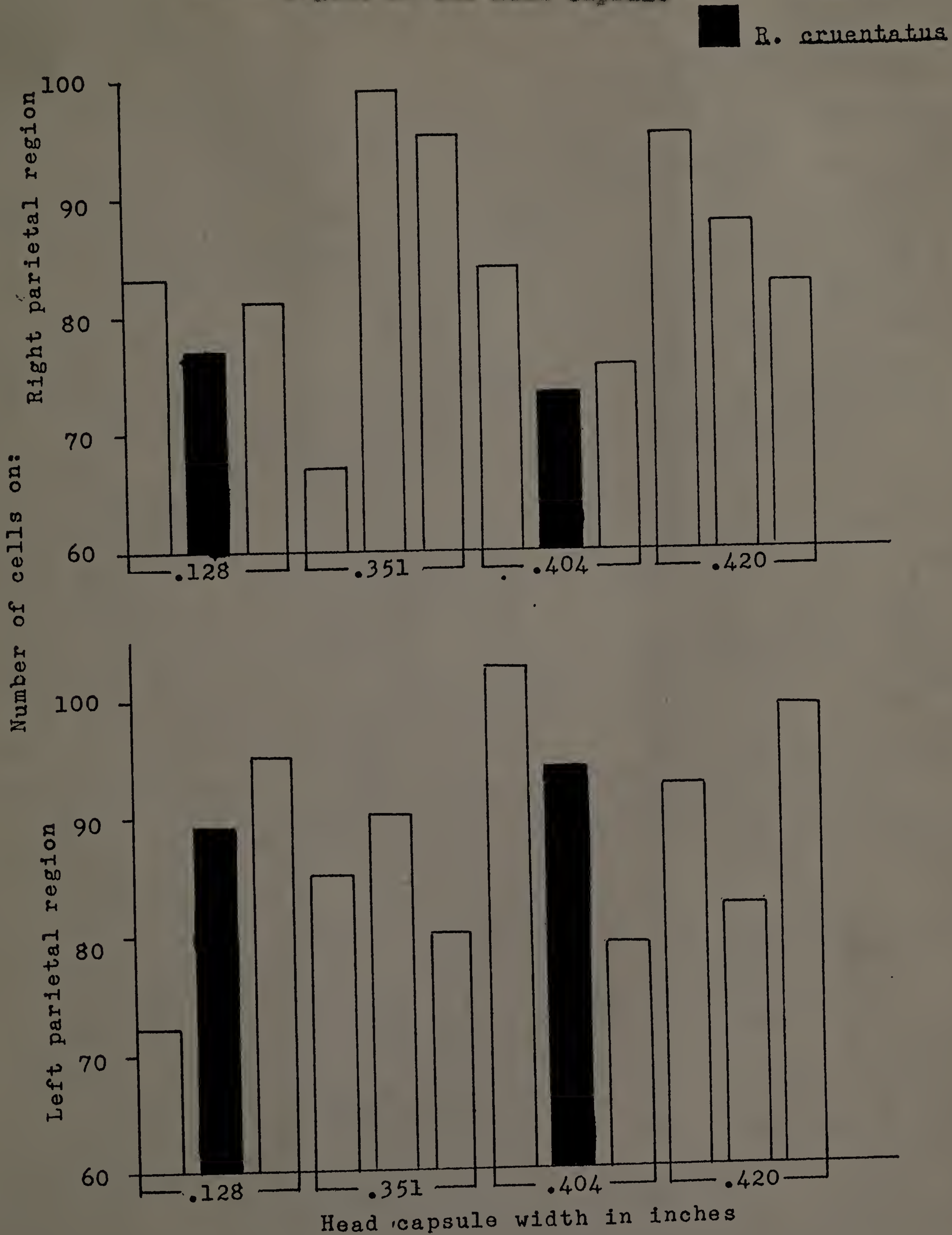
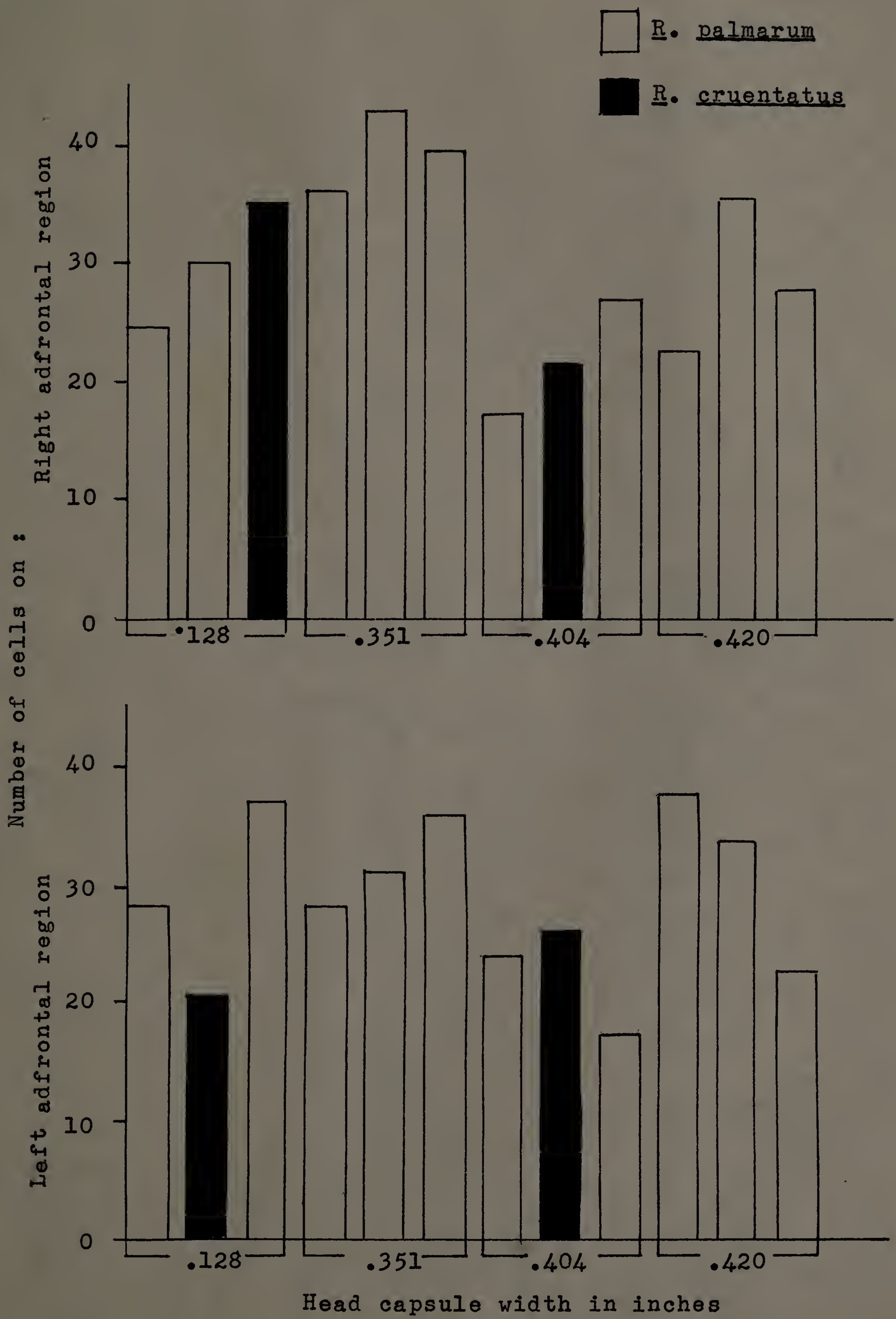


Figure 3 Number of cells on adfrontal regions of the head capsule



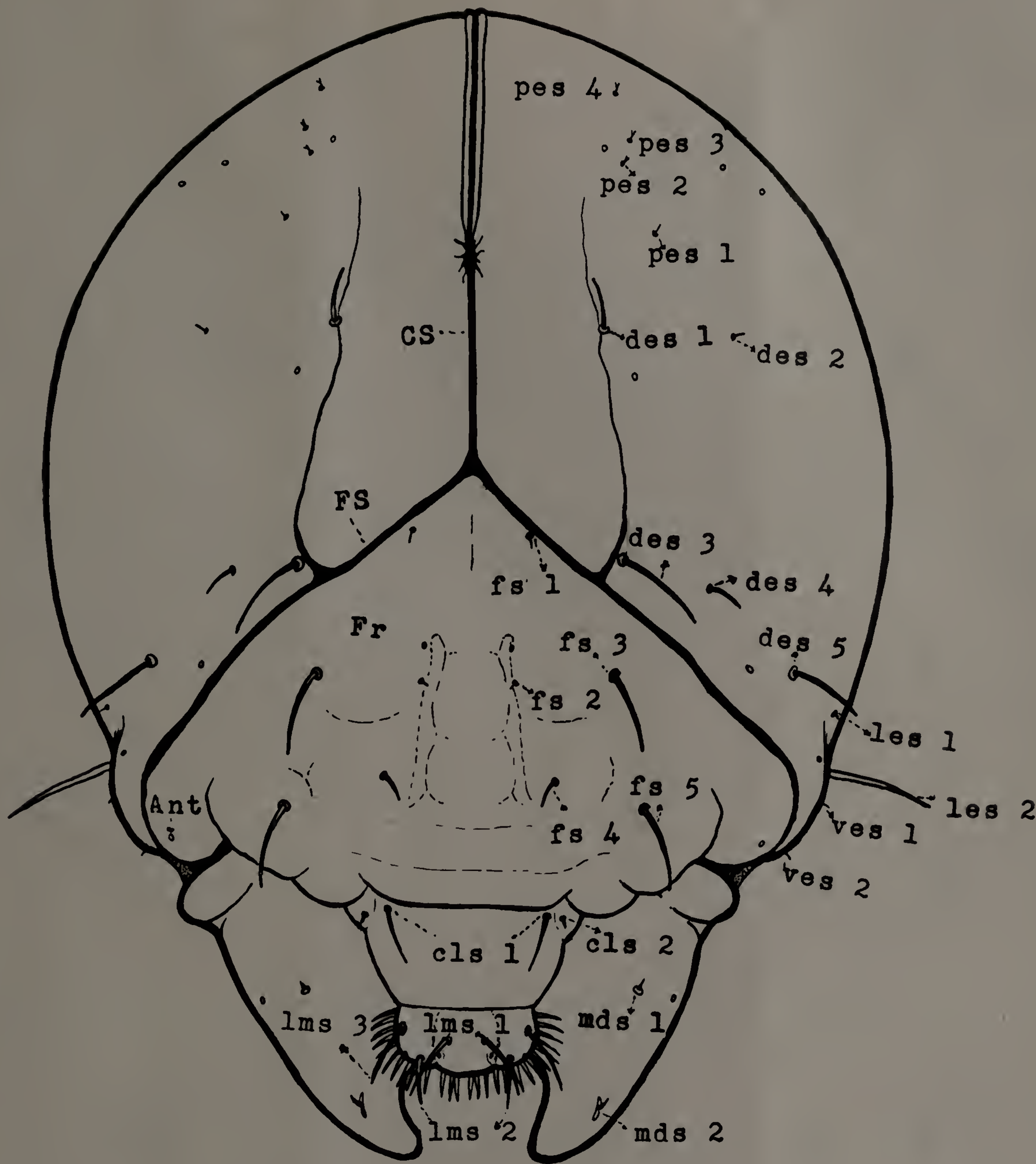


Figure 4 Head

Figure 5 Posterior epicranial seta number two

Figure 6 Cross-section of ocellus

Figure 7 Antenna

Figure 8 Epipharynx

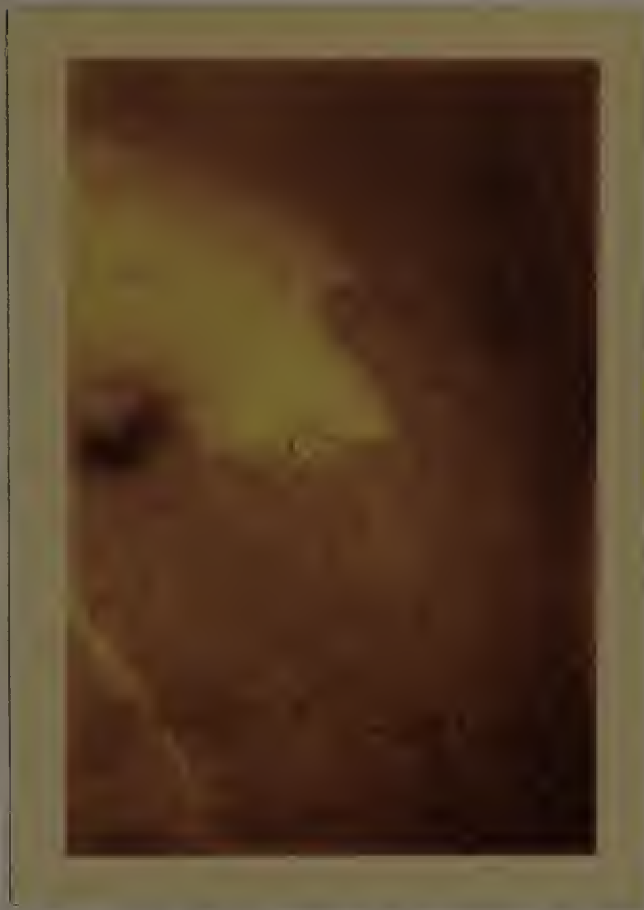


Figure 9 Epipharyngeal sensory pores

Figure 10 Mesal sensillae of epipharynx

Figure 11 Mandible (addoral view)

Figure 12 Labium and Maxilla

Figure 13 Hypopharynx

Figure 14 Rows of hairs on hypopharynx (basally)

Figure 15 Lateral view of the larva of R. palmarum

Figure 16 Dorsal view of caudal end of the larva of R. palmarum

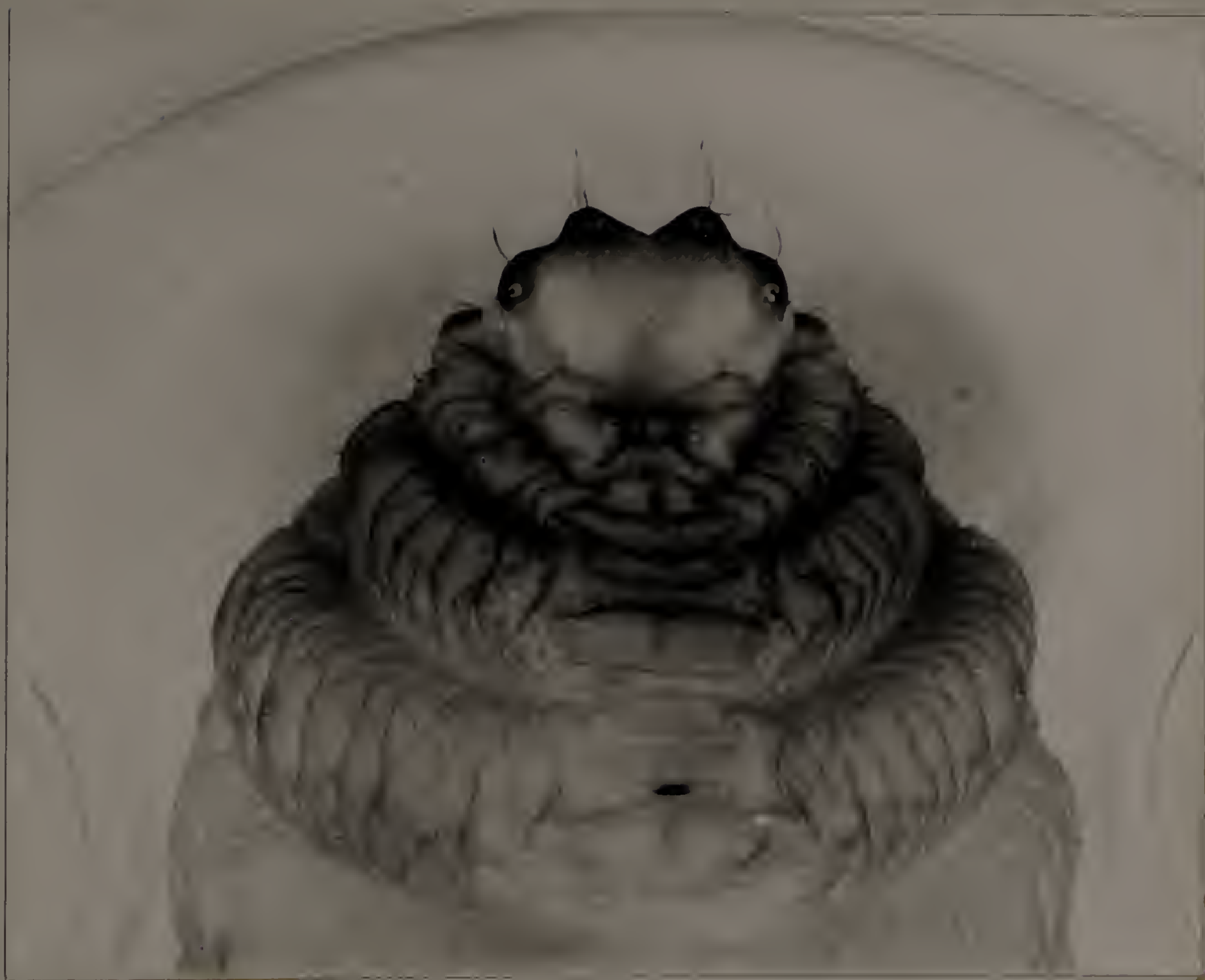


Figure 17 Ventral view of caudal end of the larva of R. palmarum

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