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INTERIM REPORT

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# INTRODUCTION

Since 1958, my work has been primarily concerned with the biology of Buprestidae, a family of beetles with habits much like those of Cerambycidae and Scolytidae. Buprestids sometimes cause extensive damage to living trees (forest, orchard, and shade trees); to ornamental, cultivated, and wild shrubs; and to dead wood and wood products. Although other wood-destroying insects have been studied in considerable detail, Buprestidae have been neglected in many respects. For example, there is not sufficient information available to separate the immature stages of the different species. It is important to be able to do this, for the immature stages are generally the only ones found in infested trees or wood, and in order to know what species one is dealing with, some means of identification are necessary. Dr. A.D. Hopkins (in Böving, 1914) was looking toward such means when he said: "It is of the greatest importance that we should be able to identify the immature stages of forest insects because it is the wood and bark boring larvae that are most frequently met with by investigators and sent in by correspondents."

Therefore, the principal objective for undertaking this study of some species of the genus Chrysobothris is to find some means of identification of the larvae encountered in the trees or wood products without the obligation of rearing them.

Since this work on the genus Chrysobothris constitutes the first taxonomy of these larvae, a review of the literature in this connection did not provide much help. However, different works on the

morphology of individual species of Chrysobothris have been a great help. Literature dealing with the taxonomy of the larvae at the family level reveals important names such as MacGillivray (1903) who wrote a key to some common families of Coleoptera, which was later modified and extended by Roberts (1930). Böving and Craighead (1931) have also treated very well the same subject. An important contribution based on Roberts' key was presented by Peterson (1951). Schiødte (1869) was probably the first author to study the morphology of buprestid larvae in some detail. Classifications of larvae at the genus level have been given by Gardner (1929), Théry (1942), Schaefer (1947) and Craighead (1949). Other references to the taxonomy of buprestid larvae are concerned primarily with more or less complete descriptions of individual species. In this respect, mention should be made of the lengthly description of C. mali by Burke and Böving (1929), on which I have drawn extensively for the study of the general morphology of the larvae and for the terminology. Only in that work have I found scientific comparison between two species of Chrysobothris, being in that case C. mali and C. femorata. In that comparison the authors have used the following characters: presence or absence of ocellus; shape of prothoracic asperities; and the number of holes in and the shape of the abdominal spiracles. The other characters mentioned in our key to the identification of the larvae of Chrysobothris are used for the first time to separate the species. This situation is understandable since no one other than Burke and Böving (1929) has studied the larval taxonomy of that genus.

The genus Chrysobothris comprises today about 600 species in the world (513 species in Junk's Coleopterorum Catalogus, 1926-35).

It is cosmopolitan, occuring in all six zoogeographical regions. Following the Coleopterorum Catalogus, there are 285 American species of which 85 are in Canada and the United States (115 in Fisher, 1942); 124 Oriental and Australian species; 81 Ethiopian species; and 23 Palaearctic species. The range of host plants is broad for many of our American species and all parts of the plant are subject to their attacks.

This study comprises only 19 species out of the 115, because they were the only ones of which I was certain of the larval identification. Fisher's monograph on the genus Chrysobothris (1942) has been used extensively in listing the synonymy of each species. Synonyms taken from Obenberger (1934) and Leng (1920) have been added to the list. In a few cases, the synonymy from Fisher and Obenberger has been corrected according to my best judgment.

For a better idea of comparison between the 19 species, a diagnosis is presented before the description of each species. Although only mature or nearly mature larvae were used in the study of the key characters, younger ones were also examined to prepare the descriptions of some species.

The distribution of each species was compiled from Fisher (1942), Obenberger (1926-35) and Leng (1920 Suppl.) plus my own data. The list of host plants has been limited to the various genera of plants and was compiled mostly from Fisher (1942), and also from Burke and Böving (1929). An host-species list would not serve any purpose here (Fisher, 1942, gives such a list; Burke and Böving, 1929, for C. mali) and also because such a list would soon be out of data since new host species are found every year. Moreover, many species of Chrysobothris seem to

be able to live on any available host species within a genus. Therefore, to know the various host genera has greater importance. In addition to the information for each species, the collection number, host, locality and date of collection, when available, are given for each specimen used in describing the species and in constructing a key for their identification. In many cases, only the collection number appears, due to the loss of the information attached to it. In Part II, the species appear in alphabetic order and no phylogenetic sequence is implied.

Although the number of species studied is limited, the results indicate clearly the possibility of identifying the larvae at the species level, and also show possible affinities between certain species. Such study, as a complement to the adult classification, may throw new light on the phylogeny of the species and can be the subject of further critical study. In support of this, I quote from Dr. C.J. Gahan's paper (1911): "Conclusions that may be drawn from a study of the external morphology of the imagines alone are sometimes apt to be upset, or at least not completely borne out by the study of the corresponding larval forms. Certainly it is sometimes very surprising to see what great differences there are between the larvae of certain families which otherwise would be considered to be nearly related." This assertion can apply at the species level as well as at the family level.

I hope, then, that such observations as these will stimulate other taxonomists to study the broad and fascinating field of larval systematics to supplement the incomplete data used in the treatment of phylogeny of insects based on adult characters alone.

## MATERIAL AND TECHNIQUES

Some of the species studied were obtained through rearings at Laniel, Quebec. They are (with hosts) C. adelpha (Carya ovata), C. blanchardi (Picea glauca), C. dentipes (Pinus banksiana, P. strobus), C. femorata (Juglans cinerea, Quercus rubra borealis), C. scabripennis (Pinus strobus, Tsuga canadensis), C. sexsignata (Juglans nigra), C. verdigripennis (Picea glauca). The remaining 12 species were borrowed from the United States National Museum, Washington, D.C. All larvae were preserved in 70% alcohol. Identity of the larvae of all species was verified by the identification of reared adults from the H.E. Burke collection for the larvae of the U.S.N.M. and of adults reared by the author for the others.

For the detailed morphological study of a typical Chrysobothris larva presented in Part I, the following procedures were used: the whole head was removed by inserting a small sharp blade between the parietals and the thoracic plates and cutting the muscles that retained the head; the latter was then pulled out with jeweler's forceps. Then, the head was immersed in 5% KOH for a few hours at room temperature, long enough to loosen the tissues. The head was then cleared of the soft tissues with a bent dissecting needle and jeweler's forceps. Small and delicate parts such as the labrum, the labium, the antennae and the maxillae were mounted in glycerine on hanging drop slides for observation under a compound microscope.

For the description and identification of the individual species (Part II), the head was pulled out from the thorax and only the mandibles were removed to permit the passage of the transmitted light through the thin labrum, labium and maxillae. The width of the head was measured at the widest points of the parietals, and the length was measured from the anterio-lateral angle of the clypeus to the posterior margin of the parietal. The width of the clypeus was taken between its posterio-lateral angles, and its length was taken at the meson.

Descriptions were based on observations made on four to 20 larvae for each species except C. adelpha, C. blanchardi and C. lucana of which I had only one larva. All drawings were made by the author with the help of a grid micrometer inserted in the ocular of a stereoscopic microscope.

PART I.-

## EXTERNAL MORPHOLOGY OF THE LARVAE OF THE GENUS CHRYSOBOTHRIS

This description of the genus Chrysobothris is primarily based on C. scabripennis Castelnau and Gory, but it is kept very broad in order to characterize the genus more correctly. The important taxonomic characters are pointed out as they are discussed.

### General characteristics (Fig. 1).-

The larvae of the species of Chrysobothris are white or creamy-white, apodous, and club-shaped like most buprestids. They are covered with fine, almost invisible short hairs, and are also provided with sparse, longer setae.

In the larval form it is still possible to recognize three distinct regions: the head, the thorax, and the abdomen. The head is prognathous and pale to dark amber with the mandibles and clypeal region brown to almost black. The cranium constitutes the three-fourths of the head and is almost completely hidden in the prothorax. The body, excluding the head, is orthosomatic and composed of thirteen well-defined, more or less flattened segments. Three of the thirteen segments from the thorax and the remainder form the abdomen. The prothorax is the largest segment, after which the body tapers gradually from the mesothorax to the last abdominal segment.

In their burrows, the larvae are most often curved laterally and lie on their dorsum.

Head (Figs. 3 and 4).-

The head is deeply retracted in the prothorax, thereby concealing most of the cranium. The parietals (epicranium of Burke, 1928; Dumbleton, 1932; Rees, 1941) are very thinly chitinized and are deeply emarginate posteriorly. The dorsal region of the cranium is emarginate from the posterior margin to the apex of the frontal region. The ventral region of the cranium is emarginate from the posterior margin to the gula. Generally the head is wider than long, but in the case of C. bacchari, C. dentipes, and some specimens of C. tranquebarica it is as long as wide and in C. lucana it is longer than wide. The frontal area is triangular in shape and its lateral endocarinae end at the basal membrane of the antennae. Anterior to the frontal area lies a broad and heavily chitinized sclerite, the clypeus (Snodgrass, 1928), to which the labrum is attached by a connecting membrane. Both the degree of the emargination of the clypeus and the presence or absence of crenulations on its front margin are important taxonomic characters. Although the ratio width-length of the clypeus is not used as a key character, it is a valuable specific character for C. costifrons and C. tranquebarica.

At this point, I would like to call attention to the misinterpretation of Burke (1928, 1929), Dumbleton (1932), and Rees (1941), well known specialists of buprestid larvae, to clarify a confusing practice followed by some taxonomists of this particular field. These authors recognized two sclerites between the labrum and the frontal area. The connecting membrane between the labrum and the clypeus was taken for the clypeus, and the clypeus for the epistoma. In fact, there is only one

sclerite, the clypeus, which is also the epistoma in this case. Even if there were two sclerites, the terms used by those authors would have to be interchanged, for by definition the epistoma is: "the sclerite immediately above the labrum, whether it be clypeus or an intermediate piece" (Torreo-Bueno, 1950).

In the middle of the clypeus are two large pits known as epistomal or clypeal sensory pits. The width between the clypeal sensory pits is sometimes of taxonomic value. Compound eyes are absent in all buprestid larvae. Ocelli are often wanting, but when they are present in species discussed in this work, there is one on each side of the mouth frame, that is, on the peristoma, below the antenna. The presence or absence of the ocelli is a highly significant character, but sometimes the character has to be used with caution since it is somewhat variable in some species. The apparently two-segmented antennae are inserted at the lateral ends of the clypeus. In reality, the antennae are three-segmented, the third and last segment being minute and hidden in the cup-shaped second segment (Figs. 14, 15 and 16). The shape of the antenna is generally of no taxonomic importance.

Mouthparts.-

Labrum and epipharynx (Figs. 5 and 6).- The labrum is an elongate, flap-like organ hinged to the clypeus by a membrane which permits longitudinal movements. It is longer than wide, although it looks transverse because of its being retracted under the clypeus. The labrum is amber yellow and about three times narrower than the clypeus.

The anterior margin is usually convex and beset with numerous short setae. Each anterio-lateral angle is rounded and ornamented with two long setae; one lateral and one mesal. Often two brown spots ("pegs" of Burke, 1929) are at the base of the lateral seta and three at the base of the mesal seta. Caudo-mesal to these two long setae is another one, the dorsal seta. Caudal to the anterio-lateral angle is a strong marginal seta. In addition to the setae, there are two sensory pores on each side of the meson at the border of the connecting membrane (when the labrum is neither too extended nor too retracted under the clypeus). To enumerate briefly these characteristics, we have thus: four angular setae, two dorsal setae, two marginal setae, four sets of brown spots at the base of the angular setae and four sensory pores. Most of these characters have been observed in the 19 species studied and are not taxonomically useful.

The inner lining of the labrum (that is, the ental membrane which extends from the labral region through the clypeal region and terminates at its junction with the dorsal wall of the pharynx) is known as the epipharyngeal wall (Du Porte, 1959). The flat anterior area and the anterio-lateral angles are covered with numerous stiff setae. The median lobe of the epipharyngeal wall is bare at its top and clothed with short setae on the sides, that is, from the epipharyngeal sclerites to the anterio-lateral angles. Among these short setae and a little above the marginal seta of the opposite side, are two stronger setae very close to each other and unequal in length (Fig. 6). The epipharyngeal wall is largely the same for all species.

Maxillae (Figs. 9 and 10).- The maxillae are linked to each side of the mentum by the large membranous, trapeziform cardo. The cardo has on its latero-posterior angle a small triangular or oval sclerite bearing two setae and one or two pores. The stipes is thinly chitinized and bears on its ventral face two long sub-apical setae, one near the anterio-lateral angle and the other one near its mid-line. There is often a pore in the central area of the stipes. The ental apical area of the stipes is usually covered with very short and sharp setae. Long setae are present on the anterior margin and on the anterio-lateral angle. The mala, possibly the galea (Burke, 1929), is almost as long as the first palpal segment and bears apically about six setae ranging in length from medium to long. The maxillary palp is composed of two segments; the first one is twice as large as the second, which bears about four apical sensillae and a lateral process on the inner face. The apical sensillae are barely visible at high magnification.

Labium and hypopharynx (Figs. 9 and 10).- The labium is divisible into a distal prelabium (prementum of Anderson, 1936) and a proximal postlabium (postmentum of Anderson, 1936), their separation being represented by a line of flexibility situated caudal of the reduced labial palpi. The semi-membranous postlabium is triangular in shape and is intimately united to the cardo. The prelabium, which is the movable lower lip of the mouth, consists of such parts as the vestigial palpi and a simple, flat organ, the ligula, which is formed by the fusion of the glossae and paraglossae. The glossae are represented by two setose elevations generally present in all species. The latero-

posterior angle of the prelabium shows a brown, chitinous patch with a long seta in its anterio-medial angle; two pores are present in the posterior angle and there is also a third one in the anterio-lateral angle. Anterior to that patch is another small one, semi-circular in shape, which bears one pore in each of the two angles. This small patch is apparently all that is left of the labial palpus.

The hypopharyngeal membrane, or hypopharyngeal lobe, forms the floor of the mouth. It is surrounded on each side by many short setae. The anterior margin is also covered by rather delicate setae. Those of the sub-margin are stouter than the marginal ones in some species.

Mandibles (Figs. 11, 12 and 13).- The mandibles are triangular and heavily chitinized. They are apically bidentate. In addition to those two large teeth, is a small ventral sub-apical tooth, and a still smaller one (not well developed in C. femorata), the dorsal tooth, best seen laterally, located on the dorso-lateral edge of the mandible. The depression on the lateral face between the two large apical teeth reaches about halfway from the apex to the transverse ridge. Still on the lateral face and immediately below the transverse ridge are two large pits. There is a seta in each of these pits. The inner face of the mandible is shallowly concave and bears a longitudinal carina. The features of the mandibles are rather constant throughout the genus and thus are of little importance taxonomically.

Thorax (Figs. 1 and 2).-

The thorax is divided into a prothorax, a mesothorax, and

a metathorax. Each thoracic segment bears, on the ventral side, two pedal spots (sometimes apparently absent in C. costifrons and C. tranquebarica). These spots, present in all species, are the remnants of the thoracic legs, lost in the course of the evolution of the larvae in favor of a better performing mechanism.

The flattened prothorax, distinctly larger than the following thoracic segment and about twice as wide as the average abdominal segment, is covered in large part by a dorsal and ventral pale yellowish-brown chitinized plate (shields of Burke, 1929; sclerites of Rees, 1941). These plates are studded with numerous dash-like (elongate) or dot-like, heavily chitinized asperities (absent or nearly so in C. debilis). The asperities of both plates angle caudad. The variations of the asperities regarding the toothness, number, and shape, are of major taxonomic importance. The dorsal plate shows a reversed "V-shaped" marking in its middle. The midline of the ventral plate shows a straight, longitudinal, depressed marking beginning very close to the anterior margin but not completely bisecting the plate posteriorly. The variations in the width of the dorsal marking and in the length of the ventral marking are important in species recognition.

The mesothorax is much narrower than the prothorax, and hence the transition between those two segments is abrupt. The pleuron bears a large cribate spiracle (Fig. 7). It is kidney-shaped with its concave margin facing forward. The number and arrangements of the holes, and the shape of the posterior margin provide good taxonomic characters.

The metathorax is slightly narrower than the mesothorax and bears no spiracle. Its posterior margin is concave in most species,

and more so on the dorsum than on the ventrum.

Abdomen (Figs. 1 and 2).-

The abdomen is composed of ten segments. The first segment is often narrower than the second segment. Each segment, except the ninth and tenth, has a pair of spiracles which are seen dorsally. The abdominal spiracles are much alike. The left spiracle (Fig. 8) on the first abdominal segment has been used as a basis for comparison between the species. It is much smaller than the mesothoracic spiracle and has many fewer perforations than the latter. Its posterior margin is sometimes crenate. Some species have the area posterior to each spiracle covered with a more or less uniform patch of brown markings, but this character is greatly affected by the state of preservation of the specimens, and is not used in the key to separate the species. The ventrum of the ninth segment shows two small tubercules or shiny, white spots on the central area. In some cases these spots are quite similar to the thoracic pedal spots. Because they are present in all 19 species and their appearance is so variable, I dare say they have no taxonomic significance in this case.

In some species, namely C. bacchari, C. femorata, C. lucana and C. sexsignata, the dorsum and/or the ventrum of the abdomen is provided with distinctive ampullae. However, since the appearance of these ampullae is sometimes lost in preserved larvae, they have secondary taxonomic value and are not used as key characters except for C. lucana whose ampullae are very large and conspicuous.

PART II.-

## DESCRIPTION OF SPECIES

The same characters have been used in all descriptions, except for a few secondary ones which were mentioned in some species only, for they were of no importance for the other species.

### Chrysobothris adelpha Gemminger and Harold

Chrysobothris soror LeConte (not Castelnau and Gory, 1837), 1859, Trans. Amer. Phil. Soc. (n.s.) 11: 232.

Chrysobothris adelpha Gemminger and Harold, 1869, Cat. Coleopt., 5: 1423 (new name for soror LeConte, not Castelnau and Gory).

Chrysobothris femorata Horn (part), 1886, Trans. Amer. Ent. Soc. 13: 77-79.

Diagnosis: This species is distinguished among those without developed ocelli except C. ignicollis and C. sexsignata in having the width between the arms of the dorsal prothoracic marking about half the length of the marking. It has more asperities than C. sexsignata between the arms of the dorsal marking and it is separated from C. ignicollis by its ventral prothoracic marking bisecting as much as the anterior three-fourths of the plate.

Description: Clypeus about a quarter as long as wide; front margin concave. Ocelli not distinctly developed. Mandible a little longer than wide; transverse ridge forming a small process above the ventral con-

dyle. Ligula with two setose elevations on the middle; front margin setose. Dorsal prothoracic asperities conical between arms of dorsal marking, strongly conical and sharply pointed along posterio-lateral border of plate. Greatest width between arms of dorsal prothoracic marking almost half length of marking. About 275 asperities between arms of marking. Ventral prothoracic asperities mostly dash-like; ventral marking bisecting anterior two-thirds of plate. Thoracic spiracle about half as long as wide. Width of thoracic spiracle about four times greater than width of first abdominal spiracle.

Length 11 mm. One specimen from Rondeau Park, Ontario, Canada, June 1960, on Carya ovata.

Distribution: Canada: Ontario. United States: Arkansas, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Maryland, Massachussetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Texas, Virginia, West Virginia.

Host: Carya.

## Chrysobothris bacchari Van Dyke

Chrysobothris bacchari Van Dyke (part), 1923, Bul. Brooklyn Ent. Soc. 18: 38-40.

Chrysobothris mali var. lineatipennis Van Dyke (part), 1919, Jour. Econ. Ent. 12: 328.

Diagnosis: This species is distinguished from the others with ocelli, except C. mali by the holes of the thoracic spiracles being arranged in longitudinal rows. It is separated from C. mali by its toothless prothoracic asperities.

Description: Head about as long as wide. Clypeus about a quarter as long as wide; front margin smooth, not emarginate but with a small notch in the middle. Peristoma bearing well developed ocelli; sides straight. Mandible longer than wide; transverse ridge developing into a short process above ventral condyle. Ligula with two setose elevations in the middle; front margin widely setose. Prothoracic asperities small and toothless. Dorsal prothoracic marking narrow, its greatest width between arms less than half the length of marking. About 100 asperities between arms of marking. Ventral prothoracic marking bisecting anterior four-fifths of plate. Thoracic spiracle about three times wider than long; and three times wider than first abdominal spiracle. Holes in thoracic spiracle arranged in longitudinal rows. Abdominal segments sometimes developing median ventral ampullae.

Length 9 to 17 mm., averaging 13.7 mm. Two specimens Hopk. 14485a (no data); one specimen Hopk. 14529a (no data); one specimen Hopk. 15019a' from Laurel, California, U.S.A., May 26, 1917, on Baccharis pilularis.

Distribution: United States: Arizona, California.

Host: Baccharis.

## Chrysobothris blanchardi Horn

Chrysobothris blanchardi Horn, 1886, Trans. Amer. Ent. Soc. 13: 85, 93-94, pl. 4, figs. 115-119.

Diagnosis: This species is readily separated from all others except C. tranquebarica by its widely separated clypeal sensory pits. It is distinguished from the latter by the presence of well developed ocelli and by the prothoracic asperities not forming staggered lines.

Description: Head a little wider than long. Clypeus about a quarter as long as wide; front margin shallowly emarginate; clypeal sensory pits widely separated, their distance being about one-tenth of width of clypeus. Ocelli well developed. From dorsal view of head, external side of peristoma abruptly changing its curvature, becoming almost parallel to meson in anterior third where it forms a rim surrounding the ocellus. Mandible longer than wide; transverse ridge not forming a process above ventral condyle. Ligula with two setose elevations in its middle; front margin rounded and setose. Dorsal asperities dash-like (often curved in my specimen), toothed in part, especially between arms of dorsal marking. About 65 asperities between arms of marking. Greatest width between arms of dorsal prothoracic marking about two-fifths of length of marking. Ventral prothoracic asperities dash-like. Ventral prothoracic marking bisecting about anterior four-fifths of plate. Thoracic spiracle three times wider than long; and a little less than/or three times wider than first abdominal spiracle. Dorsum and venbrum of metathorax and first abdominal segment covered with dense coat of extremely short

setae (0.007 mm.).

Length 19 mm. One specimen from Ville-Marie, Québec, Canada, August 17, 1959, on Picea glauca.

Distribution: Canada: Manitoba, New Brunswick, Québec. United States: District of Columbia, Indiana, Maine, Maryland, Massachussetts, Michigan, New Mexico, New York, Pennsylvania, South Dakota, Texas.

Hosts: Larix, Picea, Pinus.

## Chrysobothris costifrons Waterhouse

Chrysobothris aerea Horn (not Chevrolat), 1886, Trans. Amer. Ent. Soc. 13: 103, 104-105, pl. 6, figs. 173-177.

Chrysobothris costifrons Waterhouse, 1887, Biol. Cent.-Amer., Coleopt. 3 (1): 45, pl. 3, fig. 19; 1889, p. 184.

Diagnosis: This species is readily separated from all others, except C. octocola and C. tranquebarica by the prothoracic asperities' forming distinct staggered lines. It is separated from C. octocola by the strongly emarginate front margin of the clypeus, and from C. tranquebarica by the ventral prothoracic marking bisecting three-fourths or less of the plate.

Description: Head wider than long. Length of clypeus at mesal line, a little less than a quarter of width; front margin strongly emarginate posteriorly to labrum. Ocelli not developed. Mandible about as long as wide; ventral tooth absent; transverse ridge forming a blunt process

above ventral condyle. Ligula with two small setose patches in the middle; front margin rounded and setose. Ventral front margin of stipes much angulate and with a tuft of setae projecting between mala and maxillary palp. Dorsal and ventral prothoracic asperities dash-like and arranged in pattern of staggered lines in anterior area of plates; asperities between arms of marking, on lateral and posterior areas reduced to short dashes, cone-like or dot-like on dorsal plate. Greatest width between arms of dorsal prothoracic marking less than half length of marking; arms of dorsal marking wavy and making a more or less inverted "Y" and enclosing about 300 asperities. Ventral prothoracic marking bisecting more or less anterior three-fourths of plate. Thoracic spiracle between two and three times wider than long; and three or four times wider than first abdominal spiracle.

Length 20 to 33 mm., averaging 22.5 mm. Nine specimens Hopk. 12600 from Santa Catalina, near Brush Corral, Arizona, U.S.A., March 2, 1914, on Quercus arizonica.

Distribution: Mexico; United States: Arizona.

Host: Quercus.

## Chrysobothris debilis LeConte

Chrysobothris debilis LeConte, 1859, Trans. Amer. Phil. Soc. (n.s.) 11: 236.

Chrysobothris disjuncta LeConte, 1859, Trans. Amer. Phil. Soc. (n.s.) 11: 236-237.

Diagnosis: This species is readily separated from all others by the absence of prothoracic asperities or nearly so, and by the ventral prothoracic marking deeply bisecting the anterior half of the plate.

Description: Head wider than long. Clypeus about a quarter as long as wide: front margin sometimes with a shallow notch at the middle. Peristoma bearing on anterior face a whitish-translucent area that may be an ocellus but which is not well developed. Mandible longer than wide; transverse ridge developing into a process above ventral condyle. Ligula devoid of setose elevations; front margin also bare. Prothoracic plates without asperities or nearly so. Greatest width between arms of dorsal prothoracic marking more than half length of marking. Ventral marking deeply depressed, bisecting anterior half of the plate; marking not always reaching anterior margin of plate. Meso and metathorax with ventro-lateral ampullae. Thoracic spiracle two or three times wider than long; and from three to five times wider than the first abdominal spiracle. Dorsum and ventrum of second to ninth abdominal segment with brown markings.

Length 9 to 15 mm., averaging 12.4 mm. Two specimens Hopk. 14528a from Sabina Canyon, Arizona, U.S.A. December 1917, on Prosopis juliflora; one specimen Hopk. 14538a (no data); two specimens Hopk. 14543a from Sabina Canyon, Arizona, U.S.A., February 1, 1917, on Celtis reticulata; one specimen Hopk. 15393c (no data); one specimen Hopk. 16007b (no data).

Distribution: Mexico (?); United States: Arizona, California, Colorado (?), Nevada, New Mexico (?), Ohio, Texas (?). Utah (?).

Hosts: Celtis, Prosopis.

## Chrysobothris dentipes (Germar)

Buprestis characteristica Melsheimer, 1806, Cat. of Insects of Pennsylvania, p. 45 (no description).

Buprestis dentipes Germar, 1824, Insect. Species Novae, 1: 38-39.

Buprestis ruficornis Sturm, 1826, Cat. Insectekten-Sammlung, p. 105 (no description).

Buprestis characteristica, Harris, 1829, N. Eng. Farmer, 8: 1-3.

Chrysobothris plicata Dejean, 1833, Cat. Coleopt., ed. 2: 80; 1836, ed. 3: 90 (no description).

Chrysobothris dentipes, Mannerhaim, 1837, Bul. Soc. Imp. Nat. Moscou, 10 (8): 76.

Chrysobothris rotundicollis Castelnau and Gory, 1841, Monog. Buprestides, v. 2 Chrysobothris, p. 51, pl. 9, fig. 69.

Chrysobothris posticalis Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 56, pl. 10, fig. 76

Chrysobothris planata Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 56-57, pl. 10, fig. 77.

Chrysobothris ruficornis Sturm, 1843, Cat. Käfer Sammlung, p. 61 (no description).

Chrysobothris maculicornis (LeConte Mss.) Kerremans, 1892, Mém. Soc. Ent. de Belg., 1: 211.

Chrysobothris lata Kerremans, 1899, Ann. Soc. Ent. Belg., 43: 336.

Diagnosis: This species is separated from all others without ocelli, except sometimes C. tranquebarica, by its head usually as long as wide. Its prothoracic asperities do not form staggered lines as in C. tranquebarica.

Description: Head usually as long as wide. Clypeus a little less than/or a quarter as long as wide; front margin of clypeus slightly to distinctly emarginate posterior to labrum and sometimes more or less crenate. Ocelli not developed. Mandible distinctly longer than wide; transverse ridge forming no process above ventral condyle. Ligula with two elongate elevations, setose at their distal end; front margin setose. Prothoracic asperities thin dash-like. Greatest width between arms of dorsal prothoracic marking from one-fourth to one-third length of marking. From 100 to 150 asperities between arms of marking. Ventral prothoracic marking bisecting about anterior three-fourths of plate. Thoracic spiracle two and a half times wider than long; and from two and a half to three times wider than first abdominal spiracle. Abdominal segments with brown markings similar to those of C. scabripennis. Length 17 to 36 mm., averaging 24.8 mm. Twelve specimens from Laniel, Québec, Canada, July 29, 1959, on Pinus banksiana; four specimens Hopk. 5875 from Kentwood, Louisiana, U.S.A., August 1, 1908, on Pinus sp.

Distribution: Almost all of Canada and the United States.

Hosts: Abies, Larix, Picea, Pinus.

## Chrysobothris dolata Horn

Chrysobothris dolata Horn, 1886, Trans. Amer. Ent. Soc. 13: 85, 87, pl. 3, figs. 71-74.

Diagnosis: This specimens is readily separated from all others without developed ocelli, except C. tranquebarica and C. costifrons, by having the length of the clypeus at the mesal line less than a quarter of the width. The prothoracic asperities do not form staggered lines as in C. costifrons and C. tranquebarica.

Description: Head wider than long. Length of clypeus less than a quarter of width; front margin emarginate posterior to labrum. Ocelli not distinctly developed. Mandible a little longer than wide; transverse ridge of mandible forming a process above ventral condyle. Ligula with two setose elevations in the middle. Dorsal prothoracic asperities dash-like anteriorly, dot-like or conical and medially toothed on lateral and posterior areas. Greatest width between arms of dorsal prothoracic marking less than half length of marking. From 170 to 200 asperities between arms of marking. Ventral prothoracic asperities usually all dash-like except on lateral borders. Ventral prothoracic marking bisecting anterior three-fourths of plate. Thoracic spiracle two or three times wider than long; and usually three or four times wider than first abdominal spiracle (six times wider in one specimen).
Length 17 to 25 mm., averaging 20.7 mm. Three specimens Hopk. 3196a (no data); four specimens Hopk. 4992b (no data).

Distribution: United States: California, Idaho, Nevada, Oregon.

Hosts: Abies, Pinus, Pseudotsuga.

## Chrysobothris edwardsii Horn

Chrysobothris edwardsii Horn, 1886, Trans. Amer. Ent. Soc. 13: 71, 74, pl. 2, figs. 11-14.

Diagnosis: This species is distinguished from all others, except C. mali and C. nixa, by the lobed or strongly crenate posterior margin of abdominal spiracles. It has fewer asperities between the arms of the dorsal prothoracic marking than C. mali, and it has strongly developed ocelli, whereas C. nixa has none.

Description: Head wider than long. Clypeus a quarter as long as wide; front margin slightly or not emarginate. Mandible a little longer than wide; transverse ridge of mandible not developing into a process above ventral condyle. Ligula almost flat; front margin slightly rounded and setose. Dorsal prothoracic asperities sparse and partially toothed medially. Greatest width between arms of dorsal prothoracic marking a third of length of marking. From 40 to 80 asperities between arms of marking. Ventral prothoracic asperities sparse and dash-like. Ventral prothoracic marking bisecting about anterior four-fifths of plate. Thoracic spiracles between two and three times wider than long; and about three times wider than first abdominal spiracle. Posterior margin of abdominal spiracles lobed or strongly crenate.

Length 14 to 17 mm., averaging 15.7 mm. One specimen Hopk. 13739b[2] from

Brush Corral, Catalina Mounts, Arizona, U.S.A., July 24, 1914 on Fouquieria splendens; one specimen Hopk. 15397a (no data); one specimen Hopk. 15397b from Sabino Canyon, Arizona, U.S.A., December 6, 1918, on Fouquieria splendens.

Distribution: Mexico: Lower California; United States: Arizona, New Mexico, Texas.

Host: Fouquieria.

## Chrysobothris femorata (Olivier)

Buprestis femorata Olivier, 1790, Entomologie, 2 (Gen. 32): 47-48, pl. 11, fig. 121.

Buprestis femorata, Fabricius, 1801, Syst. Eleut., 2: 208.

Buprestis insculpta Herbst, 1801, Natursystem Insekten, Käfer, 9: 145-146, pl. 146, fig. 10; Schönherr, 1817, Synonymia Insect., 1 (3): 235. (Described from Germany, but placed by Schönherr as a synonym of femorata. The type may be erroneously labeled as to locality or wrongly identified.)

Chrysobothris femorata, Dejean, 1833, Cat. Coleopt., ed. 2, p. 80; 1836, ed. 3, p. 90.

Chrysobothris cribaria Dejean, 1833, Cat. Coleopt., ed. 2, p. 80; 1836, ed. 3, p. 90. (no description)

Chrysobothris dissimilis Dejean, 1833, Cat. Coleopt., ed. 2, p. 80; 1836, ed. 3, p. 90. (no description)

Buprestis (Odontomus) femorata, Kirby, 1837, Fauna Boreali-Amer., 4: 156.

Chrysobothris quadriimpressa Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 48, pl. 9, fig. 64, addenda p. 7.

Chrysobothris lesueuri Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 49-50, pl. 9, fig. 66.

Chrysobothris dentipes Castelnau and Gory (not Germar), 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 52, pl. 9, fig. 70.

Chrysobothris nigritula Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 54, pl. 10, fig. 73.

Chrysobothris fastidiosa Gory, 1841, Monog. Buprestides, suppl. 4: 180, pl. 30, fig. 176.

Chrysobothris alabamae Gory, 1841, Monog. Buprestides, suppl. 4: 185-186, pl. 32, fig. 183.

Chrysobothris obscura LeConte, 1859, Trans. Amer. Phil. Soc. (n.s.) 11: 232-233.

Chrysobothris misella LeConte, 1859, Trans. Amer. Phil. Soc. (n.s.) 11: 233.

Chrysobothris semisculpta Crotch, 1873, Proc. Acad. Nat. Sci. Phil. (25): 90. (Probably a typographical error for insculpta Herbst.)

Chrysobothris difficilis LeConte, 1873, Proc. Acad. Nat. Sci. Phil. (25): 332. (Credited to Gory. It is probably a typographical error for dissimilis Gory, as no Chrysobothris has been described under the name difficilis.)

Diagnosis: When the larvae are well preserved, this species is dis-

tinguished easily from all others without developed ocelli by the dorsal and ventral abdominal ampullae. C. sexsignata generally has only dorsal abdominal ampullae. The width between the arms of the dorsal prothoracic marking is much greater than in C. femorata.

Description: Head distinctly wider than long. Clypeus about a quarter as long as wide; front margin broadly concave or concave only posteriorly to labrum. Ocelli not developed. Mandible longer than wide; dorsal and ventral tooth not prominent; process above ventral condyle small and not well developed. Ligula with two setose elevations in the middle; front margin setose. Dorsal prothoracic asperities short, thick dashes anteriorly, usually becoming broadly conical on lateral and posterior areas of plate. Greatest width between arms of dorsal prothoracic marking slightly more than one third of length of marking; from about 175 to 225 asperities between arms of marking. Ventral asperities dash-like. Ventral prothoracic marking bisecting about three-fourths of plate. Thoracic spiracle three times wider than long; and about three or a little more than three times wider than first abdominal spiracle. Ampullae developed on both dorsum and ventrum of abdomen.
Length 20 to 25 mm., averaging 22.6 mm. Four specimens from Ste-Foy, Québec, Canada, August 1957, on Quercus rubra borealis; four specimens Hopk. 14567 (no data).

Distribution: West to East of Canada and of the United States; Mexico.

Hosts: Acer, Amygdalus, Castanea, Celtis, Fraxinus, Juglans, Liquidambar, Malus, Platanus, Populus, Prunus, Quercus, Salix, Sorbus, Ulmus.

## Chrysobothris ignicollis Horn

Chrysobothris ignicollis Horn, 1885, Trans. Amer. Ent. Soc. 12: 145.

Chrysobothris scotti Chamberlin, 1938, Pan-Pacific Ent. 14: 11-12, figs. 5-8.

Diagnosis: This species is readily separated from those without developed ocelli, except C. adelpha and C. sexsignata, in having the width between the arms of the dorsal prothoracic marking about half the length of the marking. It has more asperities between the arms of the dorsal prothoracic marking than C. sexsignata and it is distinguished from C. adelpha by its ventral prothoracic marking bisecting only the anterior two-thirds of the plate.

Description: Head wider than long. Clypeus about a quarter as long as wide; front margin sometimes broadly concave. Ocelli not developed. Mandible a little longer than wide; transverse ridge forming a blunt process above ventral condyle. Ligula with two setose elevations in the middle; front margin setose. Dorsal prothoracic asperities dash-like anteriorly, broadly conical or dot-like (according to magnification under which larva is examined) on lateral areas and between arms of dorsal marking; sometimes dorsal asperities dash-like in posterior area between arms of marking. Greatest width between arms of dorsal prothoracic marking about half of length of marking. About 275 asperities between arms of marking. Ventral prothoracic asperities mostly all dash-like except near lateral borders. Ventral prothoracic marking bisecting anterior three-fifths to three-fourths of plate. Thoracic spiracle two

to three times wider than long; and from two to four times wider than first abdominal spiracle.

Length 8 to 20 mm., averaging 16.4 mm. Two specimens Hopk. 5687, near Capitan, New Mexico, U.S.A., July 26, 1907, on Juniperus sp.; three specimens Hopk. 7174, from Santa Catalina, Arizona, U.S.A., December 1907, on Arizona cedar (could be Cupressus arizonica); five specimens Hopk. 11628b (no data).

Distribution: United States: Arizona, California, Colorado, Idaho, Nevada, New Mexico, Texas, Utah.

Hosts: Chamaecyparis, Cupressus, Juniperus, Vauquelinia.

## Chrysobothris lucana Horn

Chrysobothris lucana Horn, 1894, Proc. Calif. Acad. Sci. (ser. 2) 4: 328, 367-368.

Diagnosis: This species is easily distinguished from all others by its broadly constricted abdominal segments, the distinct rectangular ampullae on the dorsum of the second to the eight abdominal segment, and the head which is longer than wide.

Description: Larva broadly constricted between abdominal segments. Head slightly longer than wide. Clypeus about a quarter as long as wide; anterior margin distinctly emarginate. Ocelli largely developed. Mandible longer than wide; transverse ridge forming a small process above

ventral condyle. Ligula with two setose elevations in the middle; front margin setose. Asperities between arms of dorsal prothoracic marking smaller than surrounding asperities. Part of dorsal prothoracic asperities, especially between arms of marking, broadly conical and toothed medially. Greatest width between arms of dorsal prothoracic marking about two-fifths of length of marking. About 350 asperities between arms of marking. Ventral prothoracic asperities all dash-like. Ventral prothoracic marking bisecting about anterior four-fifths of plate. Thoracic spiracle almost three times wider than long; and a little more than twice width of first abdominal spiracle. Dorsum of second to eight abdominal segment inclusively bearing a distinct rectangular ampulla. Length 22 mm. One specimen Hopk. 489930, from San Ysidro, California, U.S.A., June 4, 1948, on mistletoe growing on juniper (probably Arceuthobium pusillum).

Distribution: Mexico: Lower California; United States: Arizona, California.

Hosts: Arceuthobium (?), Cassis, Quercus, Simmondsia.

## Chrysobothris mali Horn

Chrysobothris mali Horn, 1886, Trans. Amer. Ent. Soc. 13: 85, 97, pl. 5, figs. 135-139.

Diagnosis: This species is distinguished from all others with developed ocelli, except C. edwardsii, by the crenate margin of the abdominal

spiracles. C. mali has more asperities between the arms of the dorsal prothoracic marking than C. edwardsii.

Description: Head distinctly wider than long. Clypeus about four times wider than long; front margin shallowly and broadly concave. Peristoma bearing well developed ocelli. Mandible longer than wide; transverse ridge forming a small process above ventral condyle. Ligula with two setose elevations in the middle; front margin setose. Part of dorsal prothoracic asperities toothed medially. Greatest width between arms of dorsal prothoracic marking about a third of length of marking. Number of asperities between arms of marking over 100. Ventral prothoracic asperities dash-like, occasionally slightly toothed medially. Ventral prothoracic marking bisecting about anterior three-fourths of plate. Thoracic spiracle two or slightly more than two times wider than long; and from two to three times wider than first abdominal spiracle. Holes in thoracic and abdominal spiracles arranged in longitudinal rows; posterior margin of abdominal spiracles crenate. Dorsal and ventral abdominal ampullae sometimes present.

Length 13 to 19 mm., averaging 15.2 mm. One specimen Hopk. 11736a, from Placerville, California, U.S.A., December 1, 1914, on Rhammus purshiana; one specimen Hopk. 11744 (no data); two specimens Hopk. 11746a, from Placerville, California, U.S.A., January 21, 1915, on Salix sp.; five specimens Hopk. 15305a, from Los Gatos, California, U.S.A., May 21, 1918, on Prunus americana; one specimen Hopk. 489928, from San Ysidro, California, U.S.A., May 29, 1948, on Adenostoma fasciculata.

Distribution: Canada: Alberta, Manitoba; Mexico: Lower California;

United States: Arizona, California, Colorado, Minnesota, Nevada, New Mexico, Oregon, Texas, Utah, Washington.

Hosts: Acer, Adenostoma, Aesculus, Alnus, Amygdalus, Arbutus, Arctostaphylos, Betula, Ceanothus, Cerasus, Cercocarpus, Corylus, Cotoneaster, Crataegus, Cydonia, Eriobotrya, Eucalyptus, Fagus, Ficus, Juglans, Laurocerasus, Liriodendron, Malus, Osmaronia, Persea, Photinia, Pickeringia, Platanus, Populus, Prosopis, Prunus, Pyracantha, Pyrus, Quercus, Rahiolepsis, Rhamnus, Ribes, Rosa, Rubus, Salix, Sorbus, Ulmus, Wisteria.

## Chrysobothris nixa Horn

Chrysobothris **nixa** Horn, 1886, Trans. Amer. Ent. Soc. 13: 85, 98-99, pl. 5, figs. 145-149.

Diagnosis: Of all the species without developed ocelli, C. nixa is distinguished by the crenations of the posterior margin of the spiracles.

Description: Head wider than long. Length of clypeus usually a quarter of width (one-fifth of width in one specimen); front margin concave posterior to labrum. Ocelli usually not developed. Mandible longer than wide; transverse ridge not forming a process above ventral condyle. Front margin of ligula sometimes slightly concave; setaceous area of ligula continuous from the middle elevations to the front margin, no bare area between former and latter. Anterior half of asperities between arms of dorsal prothoracic marking consisting of normal dashes interspersed with smaller or dot-like ones. Greatest width between arms of dorsal protho-

racic marking about a third of length of marking. From about 200 to 250 asperities between arms of marking. Ventral prothoracic asperities dash-like and often curved. Ventral prothoracic marking bisecting anterior three-fourths of plate. Thoracic spiracle about twice as wide as long; and from two and a half to three times wider than first abdominal spiracle. Posterior margin of spiracles crenate; crenations of abdominal spiracles much fewer but as large as those of thoracic spiracles. Length 16 to 21 mm., averaging 17.4 mm. Two specimens Hopk. 11747a, from Placerville, California, U.S.A., January 1915, on Libocedrus decurrens; three specimens Hopk. 13175a (no data).

Distribution: United States: California, Nevada, Oregon.

Hosts: Cupressus, Juniperus, Libocedrus.

## Chrysobothris octocola LeConte

Chrysobothris octocola LeConte, 1858, Proc. Acad. Nat. Sci. Phila. (10): 67.

Chrysobothris octopunctata Kunze, 1904, Ent. News 15: 242 (misidentification).

Chrysobothris caviventris Abeille (in litt.) vide Théry, 1926, Bul. and Ann. Soc. Ent. Belg., 66: 165.

Diagnosis: This species along with C. costifrons and C. tranquebarica is distinguished from all others by the prothoracic asperities forming distinct staggered lines and a definite pattern. It is readily

separated from the two species mentioned by the broadly and shallowly concave front margin of the clypeus.

Description: Head wider than long. Clypeus about a quarter as long as wide; front margin broadly and shallowly concave. Ocelli absent. Mandible longer than wide; transverse ridge forming a process above ventral condyle. Ligula with two widely separated setose elevations; front margin setose. Dorsal and ventral prothoracic asperities dash-like and arranged into a pattern of staggered lines in anterior area of plates; asperities of lateral and posterior areas reduced to half the size of those of anterior area of both plates. Greatest width between arms of dorsal prothoracic marking less than half length of marking. From about 300 to 400 asperities between arms of marking. Ventral prothoracic marking bisecting anterior two-thirds of plate. Thoracic spiracle from two to two and a half wider than long; and from three to four times wider than first abdominal spiracle.

Length 15 to 26 mm., averaging 21 mm. Two specimens Hopk. ?, from Sabinal, Texas, U.S.A., May 17, 1910, on mesquite (probably Prosopis juliflora); one specimen Hopk. 12649a, from Catalina Mounts, Arizona, U.S.A., May 24, 1914, on mesquite (probably Prosopis juliflora); two specimens Hopk. 12690, from Palo Verde, Arizona, U.S.A., July 1, 1915, on Cercidium floridum; one specimen Hopk. 18955a, from Death Valley, California, U.S.A., November 17, 1937, on Prosopis sp.

Distribution: Mexico; United States: Arizona, California, Colorado, New Mexico, Texas.

Hosts: Acacia, Cercidium, Prosopis.

Chrysobothris scabripennis Castelnau and Gory

Chrysobothris consimilis Dejean, 1833, Cat. Coleopt., ed. 2: 80.

Buprestis (Odontomus) proxima Kirby, 1837, Fauna Boreali-Amer., 4: 157-158.

Chrysobothris scabripennis Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 53, pl. 9, fig. 71.

(?), Chrysobothris scabra Gory, 1841, Monog. Buprestides, suppl.4: 182, pl. 31, fig. 178.

Diagnosis: Among the species with developed ocelli, this species is distinguished from the others in having the dorsal and ventral prothoracic asperities tocthed medially in part.

Description: Head wider than long. Clypeus about a quarter as long as wide; front margin almost straight to shallowly and broadly concave; external side of peristoma enclosing developed ocellus on anterior face by an elevated rim; external side of peristoma changing its curvature in anterior third where it becomes almost parallel to meson. Mandible a little longer than wide; transverse ridge not developing into a process above ventral condyle. Ligula almost semicircularly rounded anteriorly and beset with numerous short setae; middle area bearing two elongate elevations setose at distal ends. Dorsal prothoracic asperities dash-like anteriorly; dorsal and ventral asperities toothed medially in part. Greatest width between arms of dorsal prothoracic marking a third or less of length of marking. From about 90 to 115 asperities between arms of marking. Ventral prothoracic marking bisecting anterior three-fourths to four-fifths of plate. Thoracic spiracle from about two

and a half to three times wider than long; and three times wider than first abdominal spiracle. Meso and metathorax sometimes with small ventro-lateral ampullae. Dorsum and ventrum of second to ninth abdominal segments with brown markings.

Length 12 to 28 mm., averaging 18.5 mm. Twenty specimens from Laniel, Québec, Canada, August 1959, on Picea glauca.

Distribution: Canada: Alberta, British Columbia, New Brunswick, Ontario, Québec, Yukon; United States: Alaska, California, Colorado, Maine, Massachussetts, Michigan, Minnesota, New Hampshire, New York, Oregon, Pennsylvania, Washington, New Virginia, Wisconsin.

Hosts: Betula, Picea, Pinus, Tsuga.

## Chrysobothris sexsignata (Say)

Buprestis quadrimaculata Melsheimer, 1806, Cat. Insects Pennsylvania, p. 45 (no description).

Buprestis sexguttata Say, 1823, Jour. Acad. Nat. Sci. Phila., 3: 161 (name preoccupied).

Buprestis sexsignata Say, 1836, Trans. Amer. Phil. Soc. (n.s.) 6: 158 (new name for sexguttata Say 1823, not Herbst 1801).

Chrysobothris germari Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 50, pl. 9, fig. 67.

Chrysobothris ignipes Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 50-51, pl. 9, fig. 68.

Chrysobothris sexsignata, Melsheimer, 1853, Cat. Coleopt. U.S.A., p. 64.

Diagnosis: This species, along with C. adelpha and C. ignicollis, is distinguished from all others without ocelli by having the width between the arms of the dorsal prothoracic marking about half or greater than half of the length of the marking. It is separated from the two species mentioned in having less than 250 asperities between the arms of the dorsal prothoracic marking.

Description: Head distinctly wider than long. Clypeus a quarter as long as wide; front margin broadly and shallowly concave. Ocelli not developed. Mandible longer than wide; transverse ridge forming a small process above ventral condyle. Ligula with two setose elevations on the middle; front margin rounded and setose. Dorsal prothoracic asperities medially toothed; dorsal asperities conical and sharply pointed on latero-posterior border. Greatest width between arms of dorsal prothoracic marking at least half length of marking. Less than 250 asperities between arms of dorsal marking. Ventral prothoracic asperities wide dash-like in middle area. Ventral prothoracic marking bisecting anterior two-thirds or three-fourths of plate. Thoracic spiracle from two to three times wider than long; and about three times wider than first abdominal spiracle. Dorso-abdominal ampullae sometimes present. Length 10 to 15 mm., averaging 12.6 mm. One specimen from Port Rowan, Ontario, Canada, April 29, 1960, on Juglans nigra; three specimens number B 1813 (Hopk. ?), from Hummelstown, Pennsylvania, U.S.A., February 6, 1916, on Fraxinus sp.; one specimen Hopk. 8102, from Brookland, D.C., U.S.A., September 1908, on Acer sp.

Distribution: Canada: Ontario, Québec; United States: Arizona, Colorado, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Massachussetts, Michigan, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, Virginia, West Virginia.

Hosts: Acer, Betula, Carya, Castanea, Fagus, Fraxinus, Juglans, Larix, Pinus, Quercus, Tsuga.

## Chrysobothris tranquebarica (Gmelin)

Buprestis impressa Fabricius, 1787 (not Fabricius 1775), Mantissa Insect., 1: 182.

Buprestis tranquebarica Gmelin, 1788, Systema Nat., 1(4): 1932 (new name for impressa Fabricius 1787).

Buprestis excavata Olivier, 1790, Encyc. Méthodique, Insectes, 5: 232 (new name for impressa Fabricius 1787).

Chrysobothris impressa, Escholtz, 1829, Zool, Atlas, 1: 9, (separate, p. 8),

Chrysobothris rugosa Mannerheim, 1837, Bul, Soc. Imp. Nat. Moscou, 10 (8): 74-75.

Chrysobothris fraterna Mannerheim, 1837, Bul. Soc, Imp. Nat. Moscou, 10 (8): 75-76.

Chrysobothris denticulata Castelnau and Gory, 1841, Monog. Buprestides, v. 2, Chrysobothris, p. 46, pl. 8, fig. 62; addenda p. 7.

Chrysobothris denticollis Gory, 1841, Monog. Buprestides, suppl. 4: 178, pl. 30, fig. 173.

Chrysobothris chalcophoroides Smith (not Horn), 1887, Ent. Amer. 3: 39 (misidentification).

Chrysobothris tranquebarica, Fisher, 1919, Proc. Ent. Soc. Wash. (1918), 20: 173-177.

Diagnosis: This species is readily separated from all others, except C. costifrons and C. octocola, by the prothoracic asperities' forming definite staggered lines. It is distinguished from the latter by the strongly emarginate front margin of the clypeus, and from the former by the ventral prothoracic marking bisecting as much as the anterior four-fifths of the plate.

Description: Head usually wider than long, but sometimes as long as wide. Length of clypeus at mesal line less than a quarter of width; front margin strongly emarginate posterior to labrum; clypeal sensory pits widely separated, their distance being equal or greater than diameter of one pit. Ocelli not developed. Mandible longer than wide; transverse ridge forming a process above ventral condyle. Ligula with two setose elevations in the middle; front margin setose. Stipes with a tuft of long setae in middle of front ventral margin, projecting between mala and maxillary palp. Prothoracic plates very large, occupying almost entire dorsal and ventral surfaces of prothorax. Dorsal and ventral prothoracic asperities dash-like and arranged in a pattern of staggered lines in anterior area of plates; asperities of lateral and posterior areas reduced to almost half the size of those of anterior area on both

plates. Greatest width between arms of dorsal prothoracic marking less than half length of marking. From about 300 to 400 asperities between arms of marking. Ventral prothoracic marking bisecting anterior four-fifths of plate. Thoracic spiracle usually three times (occasionally less than three times) wider than long; and about three times wider than first abdominal spiracle.

Length 19 to 27 mm., averaging 22.7 mm. Three specimens Hopk. 14911, from Miami, Florida, U.S.A., September 1, 1916, on Pinus palustris; one specimen Hopk. 14960, from Miami Beach, Florida, U.S.A., March 1917, on Rhizophora mangla.

Distribution: Antilles: Dominican Republic, Grenada, Guadeloupe, Haiti, Puerto Rico, St-Thomas, Tranquebar; Bahamas Islands; Surinam; United States: Florida.

Hosts: Cassia, Casuarina, Conocarpus, Pinus, Rhizophora.

## Chrysobothris trinervia (Kirby)

Buprestis (Odontomus) trinervia Kirby, 1837, Fauna Boreali-Amer., 4: 157, pl. 2, fig. 9.

Chrysobothris trinervia, White, 1848, Nomencl. Coleopt. Insects Brit. Mus., pl. 3: 34.

Chrysobothris cicatricosa Motschulsky, 1852, Etudes Ent. 1: 77.

Diagnosis: This species is immediately distinguished from all others, except sometimes from C. dentipes, by its crenate front clypeal margin.

In this respect it is much like C. blanchardi which has the sub-margin of the clypeus crenate, but its clypeal sensory pits are not widely separated as in the latter. The presence of ocelli separates it from C. dentipes.

Description: Head a little wider than long. Length of clypeus about a quarter of width; front margin crenate; clypeal sensory pits not widely separated. Peristoma bearing well developed ocelli; external side smoothly and only slightly changing its curvature in anterior fourth. Mandible longer than wide; transverse ridge not forming a process above ventral condyle. Ligula with two setose elevations in the middle; front margin largely setose. Dorsal prothoracic asperities distinctly toothed medially. Greatest width between arms of dorsal prothoracic marking about one-third length of marking. From 50 to 100 asperities between arms of marking. Ventral prothoracic asperities toothless. Ventral prothoracic marking bisecting about anterior three-fourths or four-fifths of plate. Thoracic spiracle from two to three times wider than long; and from three to five times wider than first abdominal spiracle. Length 15 to 18 mm., averaging 17 mm. One specimen Hopk. 11650a, from Garden of Gods, Colorado, U.S.A., January 14, 1914, on yellow pine (probably Pinus ponderosa); two specimens Hopk. 12746b (no data); two specimens Hopk. 13095a (no data).

Distribution: Canada: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Québec, Yukon; United States: Alaska, Arizona, California, Colorado, Idaho, Kansas, Maine, Michigan, Minnesota, Montana, New Hampshire, New Mexico, New York, North Carolina, Oregon,

Pennsylvania, South Dakota, Utah, Vermont, Washington, Wyoming.

Hosts: Picea, Pinus, Pseudotsuga.

## Chrysobothris verdigripennis Frost

Chrysobothris verdigripennis Frost, 1910, Jour. New York Ent. Soc., 18: 43-45.

Diagnosis: This species is readily separated from all others, except C. ignicollis, by its irregularly toothed prothoracic asperities. It is distinguished from the latter in having well developed ocelli.

Description: Head usually a little wider than long. Clypeus about a quarter as long as wide; front margin emarginate. Peristoma bearing well developed ocelli; external side abruptly changing its curvature, becoming almost parallel to meson in anterior third. Mandible slightly longer than wide; no process above ventral condyle. Ligula with two setose elevations; front margin also setose. Dorsal prothoracic asperities toothed irregularly, that is, there is often more than one tooth per asperity and also the only present tooth is often at right or at left of the asperity (Fig. 22). Greatest width between arms of dorsal prothoracic marking less than half length of marking. From about 70 to 130 asperities between arms of marking. Ventral prothoracic asperities toothed irregularly in part. Ventral prothoracic marking bisecting anterior four or five-sixths of plate.

Length 16 to 23 mm.s averaging 18.8 mm. Ten specimens from Ville-Marie,

Québec, Canada, August 17, 1959, on Picea glauca.

Hosts: Abies, Fagus, Picea, Pinus, Tsuga.

PART III.-

## KEY TO THE IDENTIFICATION OF SOME SPECIES OF CHRYSOBOTHRIS

From the preceding descriptions of species it is possible to extract some characteristics useful in constructing a taxonomic key to all 19 species. Although the small number of species studied here limits the application of the key, definite evidence is presented that the identification of larvae is practicable. The key has been prepared using mature or almost mature larvae, except that C. adelpha and C. sex-signata were probably of a medium age.

1- Prothoracic asperities absent or nearly so; ventral prothoracic marking bisecting only the anterior half of the plate ..... debilis

1- Prothoracic asperities abundant, covering the entire surface of the plates; ventral prothoracic marking bisecting at least the anterior two-thirds of the plate ..... 2

2- Ocelli distinctly developed (Fig. 17) ..... 3

2- Ocelli not distinctly developed (Fig. 18) ..... 10

3- All dorsal prothoracic asperities dash-like and toothless (Fig. 20) ..... bacchari

3- Dorsal prothoracic asperities dash-like in part and toothed in part, sometimes becoming dot-like or conical on the lateral borders and posterior part of the plate (Figs. 21, 22) ..... 4

4- Dorsal prothoracic asperities with a median tooth (Fig. 21) ..... 5

4- Dorsal and ventral prothoracic asperities toothed irregularly in part (Fig. 22) (examined at 100x) ..... verdigripennis

5- Ventral prothoracic asperities toothed (examined at 100x) ..... ..... scabripennis

5- Ventral prothoracic asperities not toothed ..... 6

6- Front margin or sub-margin of clypeus crenate (Figs. 23, 24) .... 7

6- Front margin or sub-margin of clypeus smooth (Fig. 25) ..... 8

7- Clypeal sensory pits widely separated, their distance being about $1/10^{th}$ of the width of the clypeus; from dorsal view of the head, external side of peristoma abruptly changing its curvature, becoming almost parallel to the meson in the anterior third (Fig. 26) ..... ..... blanchardi

7- Clypeal sensory pits narrowly separated, their distance being about $1/15^{th}$ or less of the width of the clypeus; from dorsal view of the head, external side of peristoma smoothly and only slightly changing its curvature in the anterior fourth (Fig. 27) ..... trinervia

8- Dorsal prothoracic asperities sparse, fewer than 80 between the arms of the marking ..... edwardsii

8- Dorsal prothoracic asperities more numerous, more than 100 between the arms of the marking ..... 9

9- Dorsal abdominal ampullae distinctly rectangular (Fig. 19); head longer than wide; holes in spiracles randomly scattered .... lucana

9- Dorsal abdominal ampullae different when present; head wider than long; holes in spiracles arranged in longitudinal rows (Fig. 29) ... ..... mali

10- Greatest width between the arms of the dorsal prothoracic marking about half or greater than half of the length of the marking .. 11

10- Greatest width between the arms of the dorsal prothoracic marking distinctly less than half of the length of the marking ..... 13

11- Number of asperities between the arms of the dorsal prothoracic marking less than 250; thoracic spiracle about three times wider than first abdominal spiracle ..... sexsignata

11- Number of asperities between the arms of the dorsal prothoracic marking about 275 or more; thoracic spiracle from two to four times wider than first abdominal spiracle ..... 12

12- Ventral prothoracic marking bisecting the anterior $3/5^{th}$ to $3/4^{th}$ of the plate; anterior dorsal dash-like asperities irregularly and faintly toothed (examined at 100x) ..... ignicollis

12- Ventral prothoracic marking bisecting the anterior two-third of the plate; anterior dorsal prothoracic asperities not irregularly toothed and rather conical ..... adelpha

13- Prothoracic asperities forming obvious staggered lines and a definite pattern (Fig. 28) (examined at 10x) ..... 14

13- Prothoracic asperities not forming staggered lines or a definite pattern (examined at 10x) ..... 16

14- Front margin of clypeus very broadly and shallowly concave (Fig.32) ..... octocola

14- Front margin of clypeus strongly emarginate posteriorly to the labrum (Figs. 33, 34) ..... 15

15- Ventral prothoracic marking bisecting the anterior four-fifths of the plate; dorsal prothoracic asperities short dash-like producing short staggered lines; arms of dorsal marking straight (Fig. 30) .. ..... tranquebarica

15- Ventral prothoracic marking bisecting three-fourths or less of the plate; dorsal prothoracic asperities arranged in a mixture of dashes and dots, and producing staggered and wavy lines; arms of dorsal marking wavy and making a more or less inverted "Y" (Fig. 31) .... ..... costifrons

16- Head usually as long as wide, with maximum variation of 0.2 mm. in width or length ..... dentipes

16- Head usually distinctly wider than long ..... 17

17- Anterior half of asperities between arms of dorsal prothoracic marking consisting of normal dashes interspersed with smaller or dot-like ones (Fig. 35) (examined at 50x) ..... nixa

17- Anterior half of asperities between arms of dorsal prothoracic marking without interspersed smaller or dot-like ones ..... 18

18- Number of holes in thoracic spiracle over 100; number of holes in first abdominal spiracle over 15 ..... femorata

18- Number of holes in thoracic spiracle less than 75; number of holes in first abdominal spiracle less than 15 ..... dolata

PART IV.-

## PHYLOGENETIC CONSIDERATIONS

It is probable that the genus Chrysobothris, whose larvae excavate galleries in the wood of dead or dying trees, is more primitive than North American genera like Agrilus, Brachys, Eupristocerus, and Pachyschelus, whose larvae mine in living trees, in leaves or in herbaceous stems, because its overall structure is more buprestid-like and more generalized. Moreover, many species of Chrysobothris live in coniferous trees which are supposedly more primitive than the broad-leaved trees or herbaceous plants, in general. However, the fossil records do not give us any clue as to whether the habit of burrowing in coniferous plants was practised before the birth of the first angiosperm plants or whether this habit has been acquired secondarily.

The preceding exposé points out certain characteristics that seem to indicate possible diversions and affinities between some species. For instance, it is possible to divide the species into three groups according to their host species. C. blanchardi, C. dentipes, C. dolata, C. nixa, and C. trinervia excavate only in conifer woods, while C. adelpha, C. bacchari, C. costifrons, C. debilis, C. edwardsii, C. lucana, C. mali, and C. octocola excavate in the wood of deciduous trees or any angiosperms. Among these species, C. lucana seems the most specialized in its habits for it is found on the roots of its host plants. Between these groups is a third one, of six species, which is intermediate in its habits, i.e. the species belonging to this group thrive on

both coniferous and deciduous plants. In this intermediate group, C. ignicollis, C. scabripennis, and C. verdigripennis are mostly found on conifers while the remaining species, C. femorata, C. sexsignata, and C. tranquebarica are mostly found on angiosperm plants.

Groups of species can also be recognized on the basis of morphological features, but since the species studied form an heterogeneous group, only a few species appear to be closely related. I am inclined to place C. debilis as the most specialized among the 19 species and it is readily separated from the others for the reasons which follow: larva rather bare; ocelli absent; prothoracic asperities absent or nearly so; first antennal segment almost twice as long as wide; labrum bare on its front margin; labium devoid of setose elevations in the middle and front margin bare; and ventral prothoracic marking deeply bisecting the anterior half of the plate.

The first obvious group among the species lacking ocelli comprises C. costifrons, C. octocola and C. tranquebarica. All have the dorsal prothoracic marking narrow, the prothoracic asperities forming staggered lines, and live on angiosperm plants (C. tranquebarica is found occasionally on conifers). Of these three species, C. costifrons and C. tranquebarica have yet stronger affinities to each other on account of their strongly emarginate clypeus and their angulate ventral front margin of the stipes bearing a tuft of setae.

C. adelpha has some close similarities with C. sexsignata which occasionally excavates in conifers. The number of asperities between the arms of the dorsal prothoracic marking is so far the best distinguishing character between those two species. The small number of

specimens available did not permit to find better specific characters.

The remaining five species lacking ocelli do not show close relationship between each other, nor with any group.

Among the species with developed ocelli only C. scabripennis and C. verdigripennis share a few characteristics like the absence of a mandibular process above the ventral condyle, the curvature of the peristoma and the presence of abdominal brownish markings. That whole group is quite heterogeneous and shows no real affinities between the species. I am strongly inclined to believe that the morphological groupings more accurately reflect true relationship than do groupings on the basis of host plant.

Because the number of species is limited it is difficult to see how the classification of the larvae compares with the classification of the adult specimens of the same species. However, some differences exist. For example, in the adult classification, C. octocola is far removed from C. costifrons and C. tranquebarica; C. debilis shows some relationship with C. edwardsii; C. adelpha ressembles much to C. femorata; and C. verdigripennis shows more affinities with C. dentipes than with C. scabripennis.

This situation shows contradiction between the two classifications, and the reason is that holometabolous insects have evolved differently in their various developmental stages. Therefore, the use of only one source of information to figure a phylogenetic tree may lead to wrong conclusions.

Thus it is clear that the study of phylogeny should be based on as many sources of information as possible, from palaeozoology to genetics, plus a great deal of judgment.

## SUMMARY

The principal objective of the present investigations was to find means for direct identification of some Chrysobothris larvae (Coleoptera: Buprestidae) encountered in trees, shrubs and wood products. This study bears on 19 nearctic species, seven of which were reared by the author, the remainder being loaned by the United States National Museum, Washington, D.C. The usual techniques were used in the preparation and examination of the material. All drawings were made by means of a microscope equipped with an ocular grid micrometer.

Chrysobothris scabripennis Cast. & Gory was used as a guide to the general morphology of the genus Chrysobothris. The synonymy, diagnosis, description, distribution, and host plant genera are given for each species. A key to the identification of the 19 species was prepared by using the most differential characters of each species. Some phylogenetic considerations for a few species showing an apparent contradiction between the larval and adult classifications are discussed.

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Chrysobothris scabripennis Cast. & Gory

Figure 1 : Dorsal view of entire larva (6.5x).

Figure 2 : Ventral view of anterior and posterior part of larva (6.5x).

Abbreviations:

a.sp. ..... abdominal spiracles

asp. ..... asperity

d.p. ..... dorsal plate

d.p.m. ..... dorsal prothoracic marking

ms ..... mesothorax

mt ..... metathorax

p ..... prothorax

t.sp. ..... thoracic spiracle

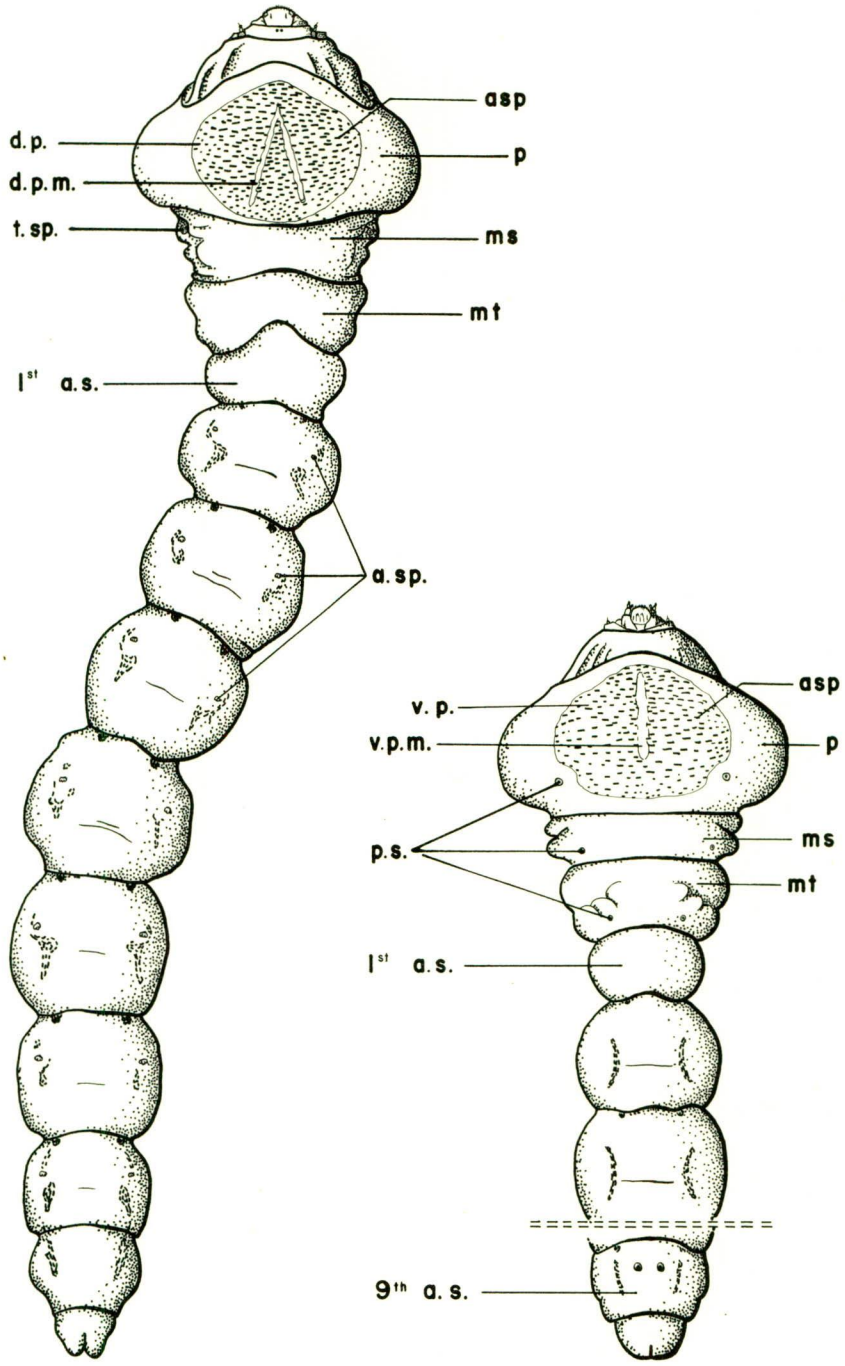
v.p. ..... ventral plate

p.s. ..... pedal spots

v.p.m. ..... ventral prothoracic marking

1st a.s. ..... first abdominal segment

9th a.s. ..... ninth abdominal segment

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Chrysobothris scabripennis Cast. & Gory

Figure 3 : Dorsal view of head (21.5x).

Figure 4 : Ventral view of head (21.5x).

Abbreviations:

a ..... antenna

ca ..... cardo

cl ..... clypeus

cl.s.p. ..... clypeal sensory pit

f.r. ..... frontal region

gu ..... gula

lb ..... labrum

lm ..... labium

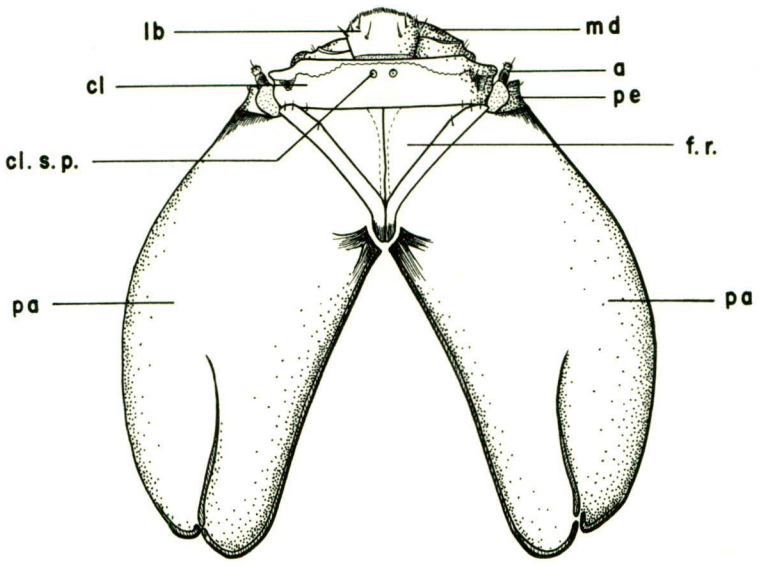
ma ..... mala

md ..... mandible

pa ..... parietal

pe ..... peristoma

st ..... stipes

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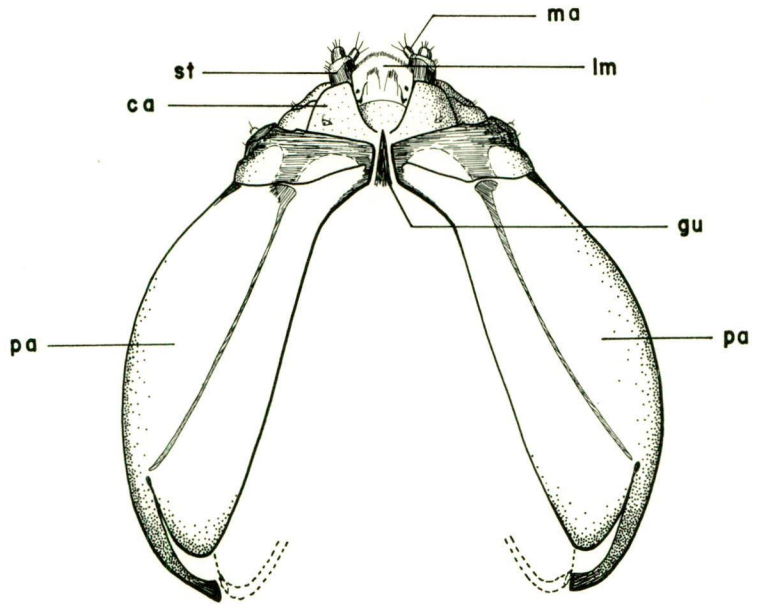


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Chrysobothris scabripennis Cast. & Gory

Figure 5 : Labrum (60x).

Figure 6 : Epipharyngeal wall (60x).

Figure 7 : Left thoracic spiracle (100x).

Figure 8 : Left first abdominal spiracle (200x).

Figure 9 : Labium and dorsal view of maxillae (50x).

Figure 10 : Hypopharyngeal membrane and ental view of maxillae (50x).

Figure 11 : Dorsal view of right mandible (38x).

Figure 12 : Externo-lateral view of right mandible (38x).

Figure 13 : Ventral view of right mandible (38x).

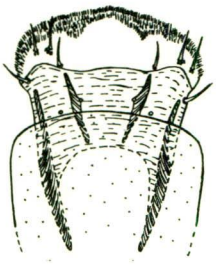
Figure 14 : Dorsal view of left antenna (150x).

Figure 15 : Ventral view of left antenna (150x).

Figure 16 : Externo-lateral view of left antenna (150x).

Abbreviations:

a.t. ..... apical teeth
ca ..... cardo
d.t. ..... dorsal tooth
ep. sc. ..... epipharyngeal sclerites
ep.w. ..... epipharyngeal wall
gu ..... gula
hyp.m. ..... hypopharyngeal membrane
li ..... ligula
l.p. ..... labial palp
ma ..... mala
m.car. ..... middle carina
prlm ..... prelabium
pslm ..... postlabium
s.e. ..... setose elevation
st ..... stipes
tr.rd. ..... transverse ridge
v.c. ..... ventral condyle
v.t. ..... ventral tooth
1st s. ..... first segment
2nd s. ..... second segment
3rd s. ..... third segment



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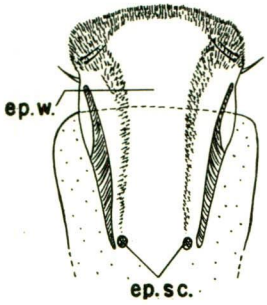


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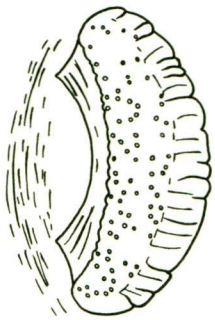

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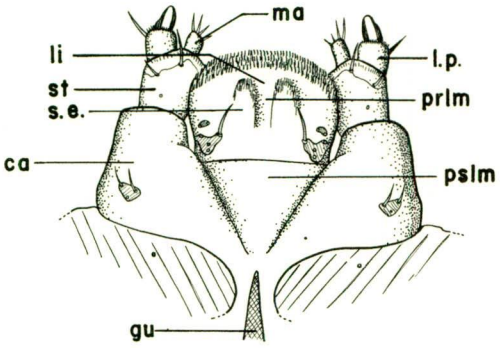


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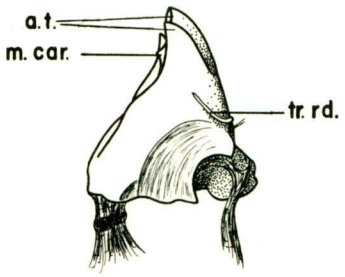


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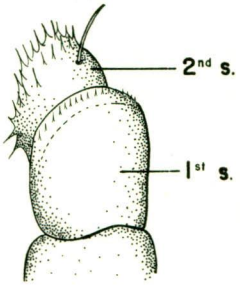


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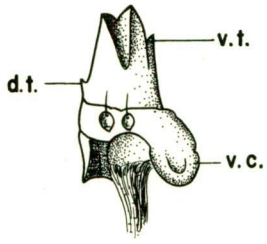


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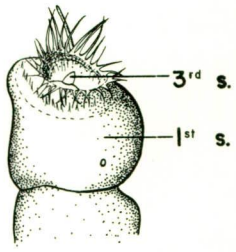


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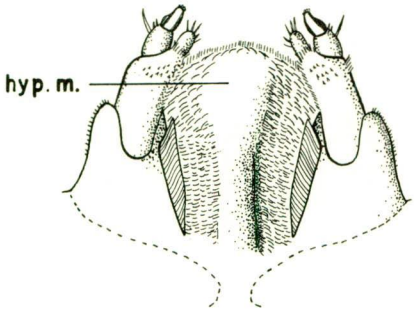


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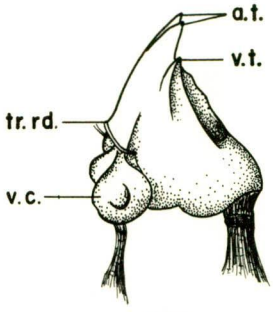


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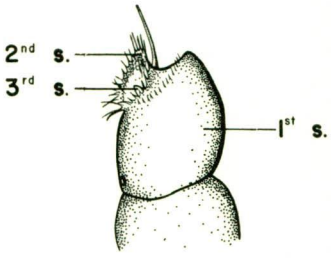


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Figure 17 : C. lucana - ventral view of left ocellus and peristoma (80x).

Figure 18 : C. dentipes - ventral view of left ocellus and peristoma (80x).

Figure 19 : C. lucana - dorsal abdominal ampullae (9x).

Figure 20 : C. bacchari - part of the dorsal prothoracic asperities (80x).

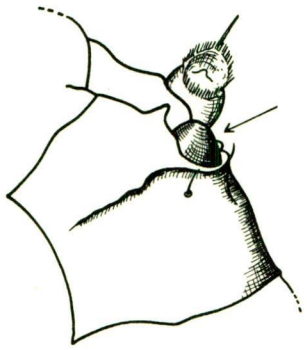
Figure 21 : C. scabripennis - part of the dorsal prothoracic asperities (80x).

Figure 22 : C. verdigripennis - part of the dorsal prothoracic asperities (80x).

Figure 23 : C. blanchardi - dorsal view of clypeus (31x).

Figure 24 : C. trinervia - dorsal view of clypeus (31x).

Figure 25 : C. edwardsii - dorsal view of clypeus (31x).



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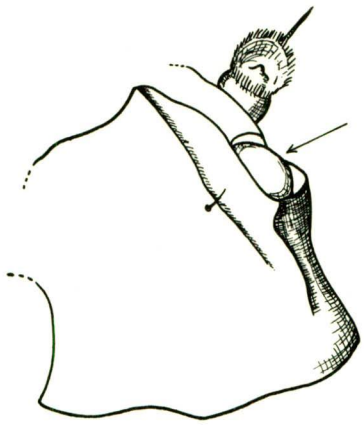

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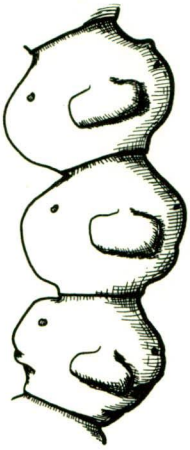

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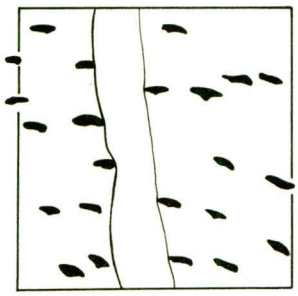

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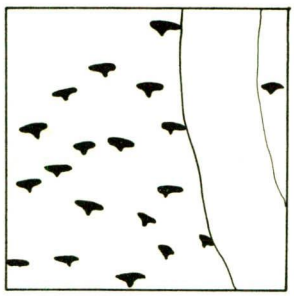

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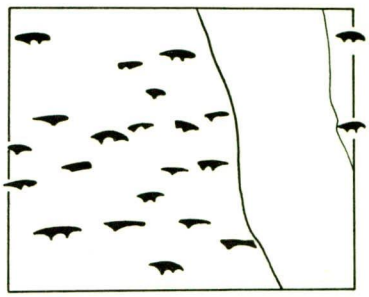

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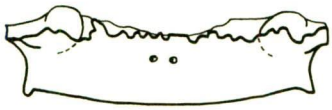

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Figure 26 : C. blanchardi - dorsal view of right peristoma (120x).

Figure 27 : C. trinervia - dorsal view of right peristoma (120x).

Figure 28 : C. costifrons - part of dorsal prothoracic asperities (10x).

Figure 29 : C. mali - left thoracic and first abdominal spiracles (150x).

Figure 30 : C. tranquebarica - dorsal prothoracic marking (9x).

Figure 31 : C. costifrons - dorsal prothoracic marking (9x).

Figure 32 : C. octocola - dorsal view of clypeus (16x).

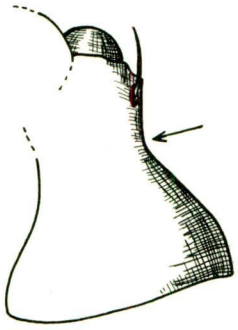
Figure 33 : C. tranquebarica - dorsal view of clypeus (16x).

Figure 34 : C. costifrons - dorsal view of clypeus (16x).

Abbreviations:

a.sp. ..... abdominal spiracle

t.sp. ..... thoracic spiracle



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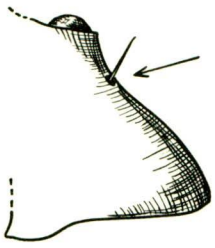

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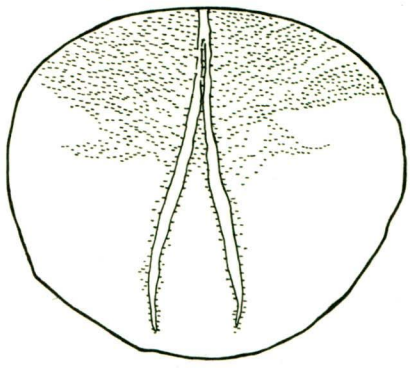

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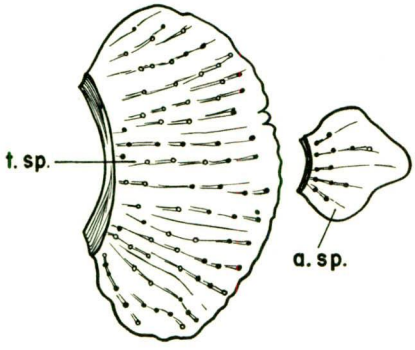


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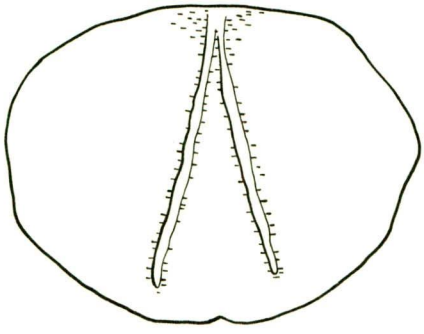

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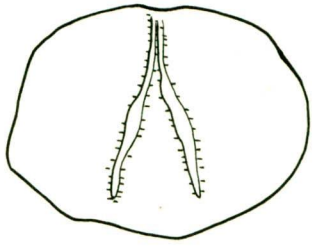

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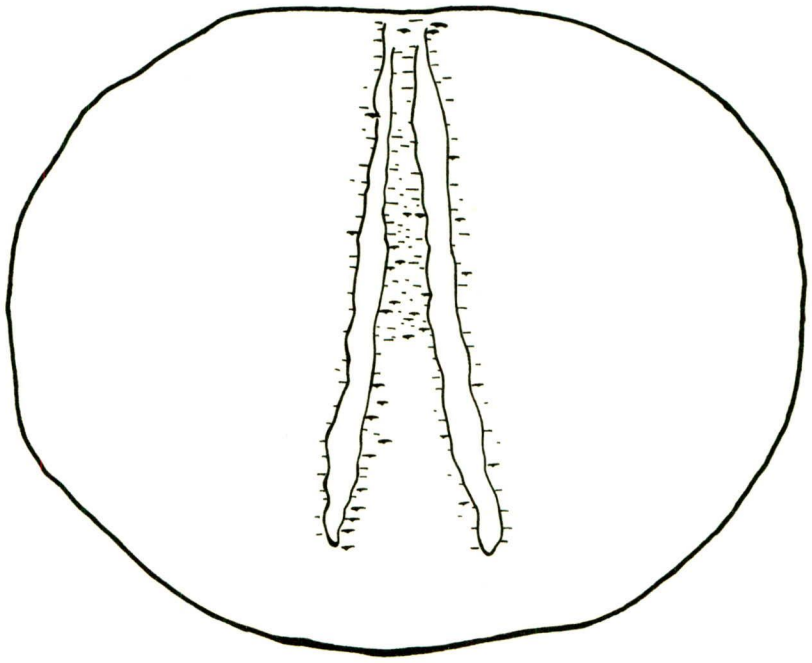
Figure 35 : C. nixa - part of dorsal prothoracic asperities between the arms of the marking (31x).



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