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THE MORPHOLOGY OF THE ELM BARK BEETLE *HYLURGOPINUS RUFIPES* (EICHHOFF)

B. J. KASTON

Connecticut
Agricultural Experiment Station
New Haven

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FOREWORD

After the discovery of the Dutch elm disease in southwestern Connecticut, late in 1933, it seemed wise for the Station to make a preliminary investigation of the elm trees of the State, to learn whether the destructive disease had become widely distributed. Consequently, although no specific appropriation was available, scouts were employed in July and August, 1934, and paid from general Station funds, under the direction of W. O. Filley, Forester. As it was known that the lesser elm bark beetle, *Scolytus multistriatus* Marsham, was a carrier of the fungus, two entomologists, Dr. B. J. Kaston and Philip P. Wallace, were employed to give particular attention to the entomological phases of the problem.

During this preliminary scouting, a tree at Old Lyme was found to be infested with the Dutch elm disease, some 60 or more miles distant from the nearest known infestation. *Scolytus multistriatus* was not present at Old Lyme, but the native elm bark beetle, *Hylurgopinus rufipes* Eich., was very abundant and was later found to be a carrier of the fungus. As little information had been published regarding this beetle, Dr. Kaston was employed to investigate the life history, habits and structure of the insect, under the direction of the Department of Entomology. His work began on January 1, 1935. Dr. Kaston has made good progress, but his life history studies have not yet been completed. His morphological studies are finished, and he has described the various structures and pointed out their homology in comparison with other insects. It is believed that this is the first time that such studies have been made of this Scolytid beetle. It seems wise to publish the parts separately, as a help to other workers on similar problems.

W. E. BRITTON.

THE MORPHOLOGY OF THE ELM BARK BEETLE,

Hylurgopinus rufipes (Eichhoff)

B. J. Kaston

Since the outbreak of the Dutch elm disease in the United States, much attention has been directed to the insects suspected of being vectors. In this country the smaller European elm bark beetle, *Scolytus multistriatus* (Marsham), is considered to be the principal carrier of the causal fungus *Ceratostomella ulmi* (Schwarz) Buisman. However, as has been pointed out (Britton, 1935; and Britton and Friend, 1935), our native elm bark beetle, *Hylurgopinus rufipes* (Eichhoff), may very easily prove important as a carrier. Large numbers of these were found in a diseased tree at Old Lyme, Connecticut, during the summer of 1934, and it is highly probable that the trees which showed symptoms of the disease in 1935 had been infected by beetles which had emerged the previous year from this tree. Moreover, evidence of disease transmission by this species has been obtained in the laboratory (Clinton and McCormick, 1935). Incidentally, *S. multistriatus* does not occur in the area around Old Lyme.

In the interests of combating the spread of the disease a study is being made of the life history and habits of *H. rufipes*. The results will be published at a future date; the present paper is concerned with morphology only. As there already are extensive accounts of the morphology of two other genera of Scolytids, comparisons will be made with them throughout this paper. They are *Dendroctonus* (Hylesinae), by Hopkins (1909 and 1915), and *Gnathotricus* (Ipinae), by Schedl (1931).

The writer expresses his appreciation to Dr. R. B. Friend, of the Entomology Department, under whose direction the investigations were conducted. He is also under obligation to Mr. W. O. Filley, Station Forester, and Mr. P. Wallace for aid in acquiring material for study, and to Mr. D. S. Riggs for assistance in the field. The illustrations in this paper were prepared by the writer, except for Figures 142, 143, 144, and 153D, which were drawn by Elizabeth Kaston.

HISTORY AND DISTRIBUTION

Hylurgopinus rufipes was first described by Eichhoff in 1868 from "Carolina" and placed in the genus *Hylastes*. Somewhat later in the same year Leconte described it (sub *Hylesinus opaculus* n. sp.) from Pennsylvania. It has since been recorded from the "Middle States" (Leconte and Horn, 1876), "Lake Superior Region" (Hubbard and Schwarz, 1878), Ontario (Caulfield, 1890), Vermont (Perkins, 1890), West Virginia (Hopkins, 1893), Kentucky (Garman, 1899), New Jersey (Smith, 1900), New York (Felt, 1905), Massachusetts (Chapman, 1910), Maine (Johannsen, 1912), Connecticut (Britton, 1920), Virginia, and Indiana (Leng, 1920), Delaware, Maryland, Ohio, Missouri, and Kansas (Knull, 1934) and Michigan (McDaniel, 1935). According to Knull, "This insect seems to be a northern species, as indicated by its greater abundance in the northern sections visited."

The first reference to the host plant of this bark beetle was made by Riley in 1879. It was stated that Schwarz had found it infesting elm and ash. Other workers referred to its feeding on various species of *Ulmus* and *Fraxinus*, and Swaine includes basswood (*Tilia*), though practically all extended accounts of damage have been on the elm. It had been thought, as for example by Harrington (1884, 1885), that tamarac was also attacked by this species, but Schwarz (1889b) has shown that this report was due to an incorrect determination. Conversely, as pointed out by Fletcher (1894), Schwarz has also shown (1888, 1889a) that records on elm of the peach bark borer, *Phthorophloeus liminaris* (Harris), are erroneous, *H. rufipes* having been mistaken for the latter, which it resembles superficially.

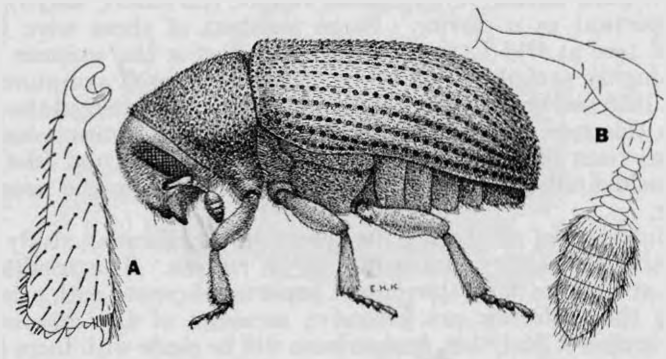

Figure 142. Lateral aspect of the native elm bark beetle, *Hylurgopinus rufipes* × 23 about. A, posterior aspect of left prothoracic tibia. B, lateral aspect of left antenna. A and B × 76 about.

SYSTEMATIC POSITION AND SYNONYMY

The genus *Hylurgopinus*, the type of which is *rufipes*, was erected by Swaine (1918) to include the sole species[1] in our fauna. It belongs in the subfamily Hylesinae of the family Scolytidae (Ipidae).

Although originally placed in the genus *Hylastes* Erichson by Eichhoff, it was considered such only by Chapuis (1873), Schwarz (in Eichhoff 1896), and (sub *opaculus*) Blandford (1898). The latter believed *opaculus* Leconte to have priority because Leconte's description appeared in September 1868, while he states that "pp. 177–312, which include Eichhoff's descriptions, were not published till March, 1869." But as a matter of fact Eichhoff's description was given on page 147, which appeared in May, 1868. Most American authors prior to Swaine (1918) followed Leconte (1868) who placed it in the genus *Hylesinus* Fabricius. However,

[1] Herrick (1935) lists as an additional species the dark elm borer, *Hylurgopinus opaculus*, but it is evident that this is a synonym of *rufipes*.

Leconte himself had already seen Eichhoff's description but failed to recognize it. This is evidenced by the fact that only a few pages after his own description he appends a list of species unknown to him, including *H. rufipes* Eichhoff, with complete reference to place and time of publication. In 1876 Leconte placed Eichhoff's species in the newly erected genus *Hylurgops*, and it is so listed in Blatchley and Leng (1916) who followed Schwarz (in Eichhoff 1896) in relegating the name *Hylesinus opaculus* to the synonymy. The reader is referred to Swaine (1909) for the complete synonymy to that date. In Swaine's key (1918) the group containing *Hylurgopinus* is separated from that containing *Hylastes* and *Hylurgops*, the former having the fore coxae rather widely separated. *Hylesinus* (*sensu strictu*) does not appear to be represented in our fauna.

From the other bark beetle (*Scolytus multistriatus*), commonly occurring in elm, *H. rufipes* can be easily distinguished (Figures 142 and 143) by the structure of the antennae, fore tibiae, elytra and abdominal sternites.

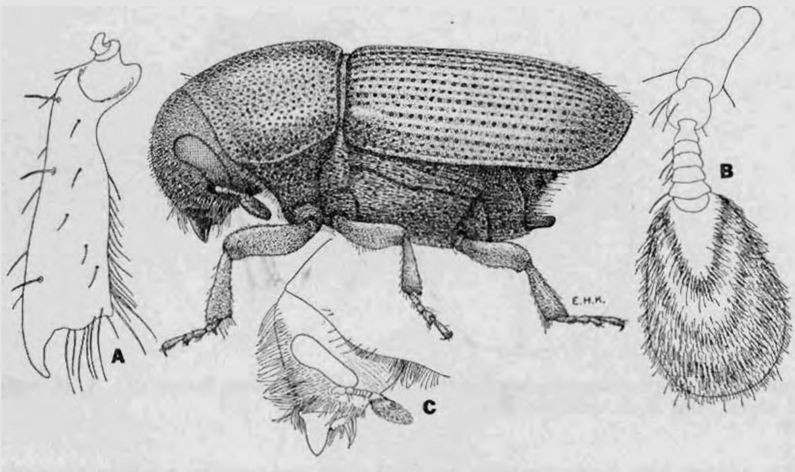

Figure 143. Lateral aspect of the lesser European elm bark beetle, *Scolytus multistriatus*, female. A, posterior aspect of left fore tibia. B, lateral aspect of left antenna. C, head of male. For comparison all enlarged to same scale as corresponding parts of Figure 142.

The larvae can be distinguished by the shape of the head capsule and the nature of the cutting edge of the mandible (Figure 144). Moreover, the head of the larva of *S. multistriatus* is more or less retracted within the thorax, while that of *H. rufipes* is usually entirely exposed.

In the field, the two species are often distinguished by the type of tunnels they make. The adult of *S. multistriatus* makes a vertical egg tunnel, the larval tunnels being horizontal. The adult of *H. rufipes* constructs an egg tunnel which is usually inclined but more nearly horizontal. There is much variation, however, and this will be considered in detail in a later paper on the life history.

DESCRIPTION OF STAGES

Adult

The original description of Eichhoff (1868) is as follows:

"Oblongus, brunneus, antennis pedibusque ferrugineis; capite nigro, convexo, rostro carinato, thorace antice coarctato, confertim punctato setosoque; elytris fortiter punctato-striatis, interstitiis seriatim granulatis setosisque. —Long. 1 1/3 lin. Patr.: Carolina."

Leconte's (1868) description is somewhat more detailed:

"Cylindrical, brownish-black, opake, thinly clothed with short stiff yellow hairs; antennae and feet ferruginous; head convex, thickly punctured; prothorax nearly as long as wide, narrowed in front, sides subsinuate near the tip; densely but not finely punctured, with a very narrow faint dorsal carina; elytra with striae composed of deep subquadrate punctures, intervals narrow, rough with transverse rugosities. Long. 2.5 mm. . . .

"The club of the antennae is subovate, nearly twice as long as wide, and more shining towards the base."

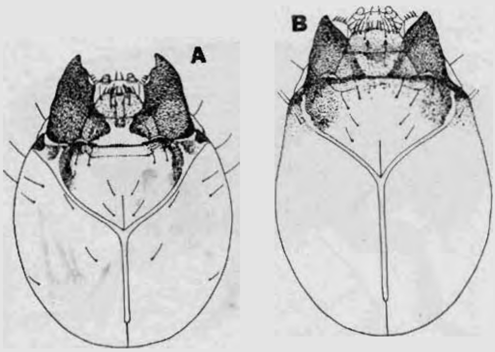

Figure 144. Anterodorsal aspect of the heads of fully grown larvae of: A, *H. rufipes*, × 33 about, and B, *S. multistriatus*, × 27 about.

The writer has been unable to find any externally visible secondary sexual character so that the following applies equally well to either sex. The color varies a little and is correlated somewhat with the age of the individual. Newly emerged adults are more evenly brown with the head alone darker than the rest of the body. Later, the head becomes practically black or a very dark brown. The prothorax becomes almost as dark except for a narrow region along the cephalic border which remains reddish. The elytra darken only slightly with here and there irregular splotches of black. The abdominal sternites and legs become reddish and never as dark as the elytra, while the antennae remain light.

The head is of the hypognathous type and only a small portion of it is visible from above (Figure 145). The prothorax widens towards its posterior end, and the sides of the elytra are subparallel. A part of the mesoprescutum and scutellum are exposed between the bases of the elytra, and just behind this level the body is widest.

Short, stiff, yellow bristles are found over most of the body, longer and thinner on the legs and antennae. They are sparse on the sides of the prothorax and appressed on the abdominal sternites. The elytral declivity is devoid of any conspicuous armature. The body is covered with punctures, the details of which will be given when the respective parts are considered.

The following figures will suffice to indicate the size of the beetles. They are based on measurements made on 62 males and 59 females preserved in alcohol.

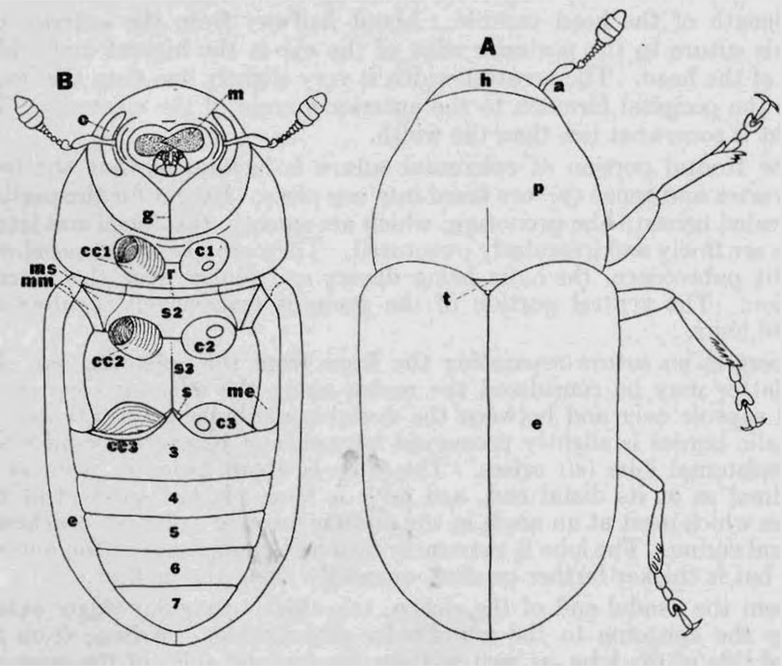

Figure 145. Adult of *H. rufipes* A, dorsal aspect. B, ventral aspect. a, antenna; c1, prothoracic coxa; c2, mesothoracic coxa; c3, metathoracic coxa; cc1, cc2, cc3, coxal cavities; e, elytron; g, gular suture; h, head; m, mandible; me, metepisternum; mm, mesepimeron; ms, mesepisternum; o, eye; p, pronotum; r, mesopresternum; s, metasternellar area; s2, mesosternum; s3, metasternum; t, mesotergum; 3 to 7, abdominal sternites.

TABLE 1. LENGTH OF BODY (VERTEX TO POSTERIOR BORDER OF ELYTRA).

	♂♂	♀♀
Mean	2.55 mm. ± .09 mm.	2.62 mm. ± .1 mm.
Maximum	2.9	2.87
Minimum	2.34	2.38
Coefficient of variation	4.45%	4.48%

Swaine (1918) gives the size limits for this species as between 3.25 and 3.75 mm., but the writer has never seen any that attain even the lower figure. The width at the broadest part is about 1.1 mm.

THE HEAD

The head (Figure 146) is normally more or less withdrawn into the prothorax so that the occipital region, half of the genae, and most of the vertex are not exposed. In the occiput (*oc*) and that portion of the vertex (*v*) concealed below the pronotum, the coronal portion of the epicranial suture (*es*) extends cephalad from the occipital foramen about one-fourth the length of the head capsule. About halfway from the anterior end of this suture to the posterior edge of the eye is the highest and widest part of the head. The greatest width is very slightly less than the length from the occipital foramen to the anterior margin of the epistoma. The height is somewhat less than the width.

The frontal portion of epicranial suture is lacking so that the frons (*f*), vertex and genae (*ge*) are fused into one piece. Except for the portions concealed beneath the pronotum, which are smooth, the dorsal and lateral areas are finely and irregularly punctured. They are likewise covered with a light pubescence, the hairs being denser and longer over the anterior portion. The ventral portion of the genae is transversely rugulose and free of hairs.

There is no suture separating the frons from the epistoma (*ep*), but the latter may be considered the region along the anterior edge of the head capsule over and between the dorsal mandibular articulations. Its cephalic border is slightly procurved laterad, and recurved mesad where the epistomal lobe (*el*) arises. This lobe is about twice as wide at its proximal as at its distal end, and as it is long. It is composed of two halves which meet at an angle in the midline forming a distinct, thickened, ventral carina. The lobe is extremely thin and emarginate at the anterior end, but is thicker farther caudad, especially along the midline.

From the caudal end of the carina, two thick triangular ridges extend under the epistoma to the mandibular articulations. Arising from the dorsal side of the lobe, as well as from the top and sides of the epistoma proper, are several tufts of long hairs. There is no epistomal process such as is present in *Dendroctonus*.

On the ventral side of the head is a distinct single gular suture (*g*) which forks at the anterior end. There is a rather poorly defined small pregular area (*pu*) anterior to this suture. Laterad of this area and extending dorsad to the epistoma is the pregena (*p*). Ventrally it does not appear to be separated from the hypostoma (*h*). The latter sclerite in Hopkins' sense forms the lateral and ventrolateral wall of the oral foramen. The more dorsal portion from the ventral articulation (postcoila) (*po*) to the dorsal articulation (precoila) (*pr*) of the mandible may be called the pleurostoma (*pl*). The hypostoma proper extends from the postcoila to the paracoila (maxillary articulation) (*pa*). Forming the floor of the buccal cavity and above the labium is a thickened membranous lobe-like hypopharynx. It is emarginate at its distal end and extends forward almost to the anterior end of the mentum. Laterally it is attached to the stipites of the maxillae.

The eyes (*o*) are subelliptical to elongate ovoid in shape and slightly wider at the top. The facets are small and closely set. There are no ocelli.

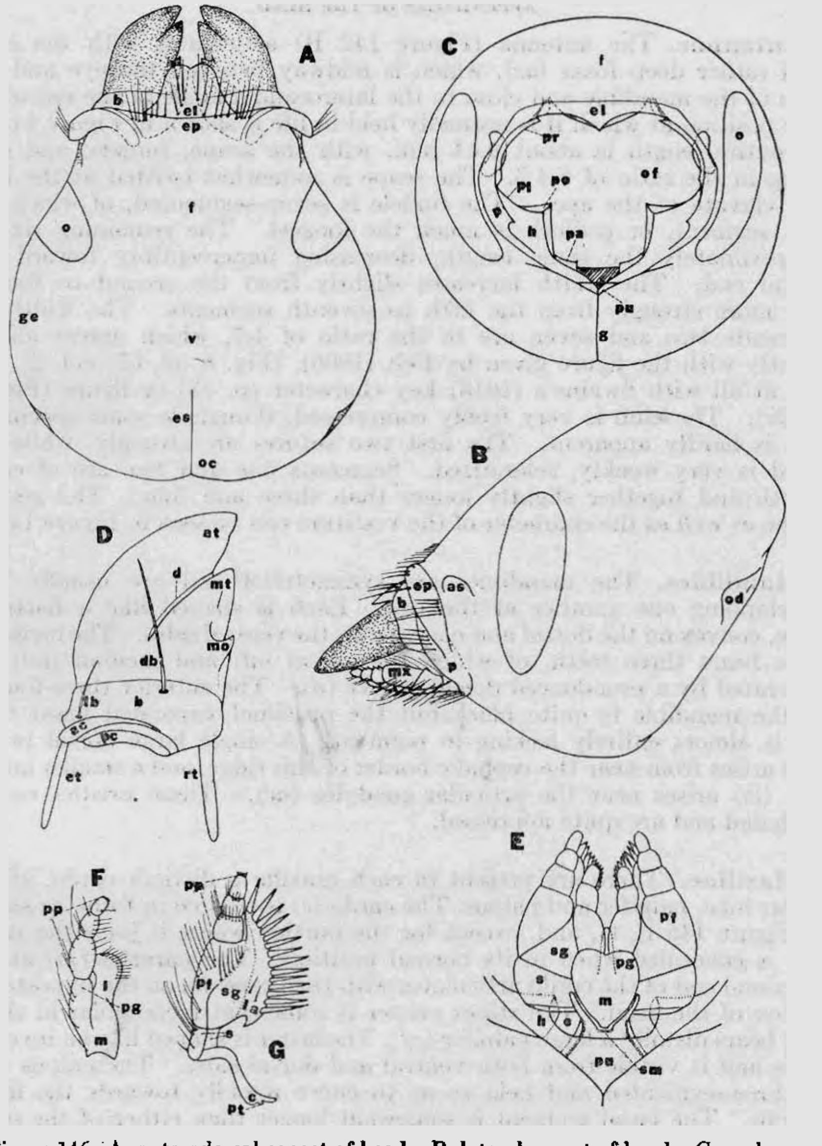

Figure 146. A, anterodorsal aspect of head. B, lateral aspect of head. C, oral aspect of head with mouthparts removed. D, dorsal aspect of left mandible. E, ventral aspect of labium and maxillae in situ. F, lateral aspect of labium. G, dorsolateral aspect of left maxilla. ac, anterior articulating condyle; as, antennal fossa; at, apical tooth; b, basal ridge of mandible; c, cardo; d, dorsal groove; db, dorsal bristle; el, epistomal lobe; ep, epistoma; es, epicranial suture; et, extensor tendon; f, frons; g, gular suture; ge, gena; h, hypostoma; l, ligula; la, lacinia; lb, lateral bristle; m, mentum; mo, molar tooth; mt, median tooth; mx, maxilla; o, eye; oc, occiput; od, occipital depression; of, oral foramen; p, pregena; pa, paracoila; pc, posterior articulating condyle; pf, palpifer; pg, palpigeral area; pl, pleurostoma; po, postcoila; pp, palpus; pr, precoila; pt, parartis; pu, pregular area; rt, retractor tendon; s, stipes; sg, subgalea; sm, submentum; v, vertex.

APPENDAGES OF THE HEAD

Antennae. The antenna (Figure 142 B) articulates with the head in a rather deep fossa (*as*), which is midway between the eye and the base of the mandible and close to the laterocaudal angle of the epistoma. The position at which it is normally held in life is shown in Figure 145 A. Its entire length is about 0.64 mm. with the scape, funicle, and club being in the ratio of 6:4:5. The scape is somewhat twisted at the base and clavate at the apex. The funicle is seven-segmented, of which the first segment, or pedicel, is much the longest. The remaining six are approximately the same length, decreasing imperceptibly toward the apical end. The width increases slightly from the second to fourth, and more strongly from the fifth to seventh segments. The widths of segments two and seven are in the ratio of 4:7, which agrees almost exactly with the figure given by Felt (1906), (Fig. 6, pl. 67, vol. 2), but not at all with Swaine's (1918) key character (p. 43) or figure (Fig. 1, pl. X). The club is very feebly compressed, though in some specimens this is hardly apparent. The first two sutures are strongly, while the third is very weakly, sclerotized. Segments one and two are of equal length and together slightly longer than three and four. The general shape as well as the character of the vestiture can be seen in Figure 142 B.

Mandibles. The mandibles are symmetrical and are usually held overlapping one another at the tips. Each is shaped like a flattened cone, convex on the dorsal and concave on the ventral sides. The incisorial edge bears three teeth, of which the apical (*at*) and median (*mt*) are separated by a pronounced dorsal groove (*d*). The anterior three-fourths of the mandible is quite black but the proximal expanded basal ridge (*b*) is almost entirely lacking in pigment. A single large dorsal bristle (*db*) arises from near the cephalic border of this ridge, and a smaller lateral one (*lb*) arises near the articular condyles (*ac*). These bristles extend cephalad and are quite appressed.

Maxillae. There are present in each maxilla a distinct cardo, stipes, malar lobe, palpifer and palpus. The cardo (*c*) is twisted in form, as shown in Figure 146 E, G, and, except for the portion where it joins the stipes (*s*), is concealed when in its normal position. The parartis (*pt*) at the proximal end of the cardo articulates with the paracoila on the hypostomal region of the head. The stipes proper is somewhat rectangular in shape and bears distally a large palpifer (*pf*). The latter is shaped like an inverted cone and is visible from both ventral and dorsal sides. The palpus (*pp*) is three-segmented and held so as to curve mesally towards the labial palpus. The basal segment is somewhat longer than either of the other two, which are about the same length. At the tip of the third segment are minute papillae. The subgalea (*sg*), which forms the base of the malar lobe, is in contact with the palpifer and stipes. The lacinia (*la*), which forms the upper part of the malar lobe, is almost entirely concealed from below when the maxilla is in its normal position. A row of setae indicates the line of separation between palpifer and malar lobe. According to Hopkins (1909) the galea is represented by the narrow margin next to the palpus and palpifer. There are 13 to 15 lacinial teeth projecting into the oral cavity, those nearer the proximal end being slightly longer and thinner. The lacinia bears at its mesocaudal angle a curved hook-like process which lies in contact with the hypopharynx. The arrangement of setae on the maxilla can be seen from the figure.

Labium. The labium (Figure 146 E, F) is composed of a fixed basal postlabium, or postmentum (Snodgrass), and a movable apical prelabium. The postlabium has a proximal plate, the submentum (*sm*), just in front of the pregular area. The submentum has a markedly recurved and thickened anterior border and is supported on each side by a strong brace extending out from the pregular area. The distal plate, or mentum (*m*), has a heart-shaped ventral portion with the laterocephalic wings representing the palpigeral area (*pg*). Seen from the side there is a thickened dorsal portion with the ligula arising from its distal end. The prelabium is much reduced, consisting of a pair of three-segmented excurved palpi, and a small ligula (*l*). The basal segments of the palpi are held quite close together, diverging only at the distal end. The other two segments are about equal in length, and combined are slightly longer than the first. Located at the tip of the third segment are minute papillae. The ligula is a membranous lobe separated from the mentum by a fold rather than a distinct suture. From the ventral aspect it is almost entirely concealed by the basal segments of the palpi. On the dorsal side it is furnished with a brush of short bristles. The arrangement of setae on the labium can be seen from the figure.

The characters of the mouthparts are such as to place *Hylurgopinus* in group 1, of Nüsslin's system (1911, p. 80).

THE THORAX

The thorax is clearly divided into the usual three parts, of which the first, or prothorax, is quite different in structure from the meso- and metathorax. The latter two are more similar in structure and together present a unit, the pterothorax (Snodgrass). Almost all of the tergal as well as part of the pleural areas of the pterothorax are normally concealed beneath the elytra. The anterior portion of the mesothorax is overlapped by the posterior portion of the prothorax. The pronotum is about as long as both the meso- and metaterga together. Of the sternal areas, that of the metathorax is the longest, being not quite twice that of the mesothorax, which in turn is slightly longer than that of the prothorax.

Prothorax. The length on the dorsal side is about four times that on the ventral. The tergal, pleural, and sternal areas are fused so that only a single suture remains, that lying transversely between the coxae (Figure 147 A). The pronotum is procurved at its anterior edge, and at its posterior bisinuate, where a strip is folded vertically. In the third quarter of its length there is a very faint carina on the middorsal line (Figure 145 A). The tergal region curves evenly over to the pleural in the cephalic half but caudad these two areas meet at an angle, most marked at the posterior end. There is no lateral carina, however.

The coxal cavities (*cc*) are separated by about half the long diameter of one. In the intercoxal area is a transverse suture (not present in

Dendroctonus or *Gnathotricus*) dividing the sternal (*sa*) and sternellar (*la*) areas. Anterior to the sternal area is a vertical ridge which can be considered the presternal area (*ua*). There is also a faint indication of a poststernellar area (*ea*) extending along the caudal edge of the segment. These ventral plates as well as a small exocoxal area (*xa*) on either side are free of punctures, while the remainder of the prothorax is minutely and evenly punctate.

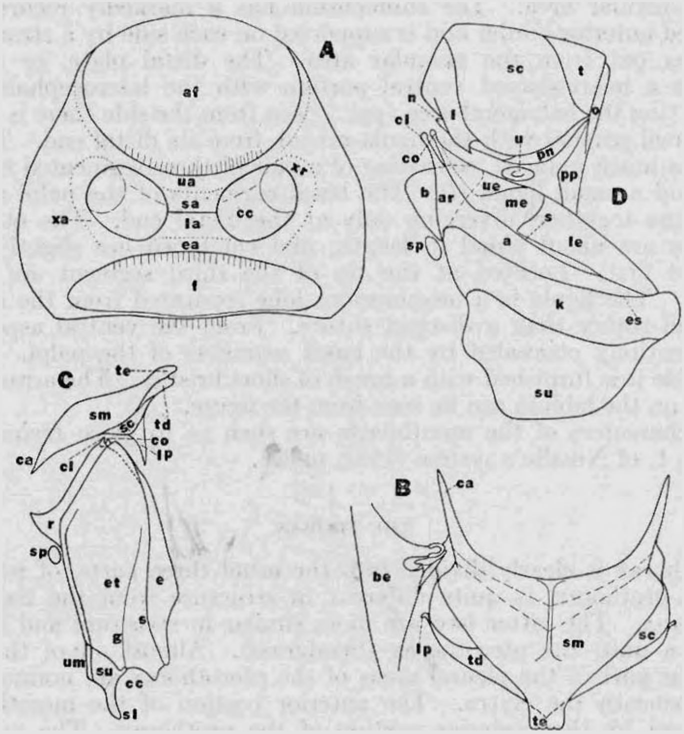

Figure 147. A, ventral aspect of prothorax. B, dorsal aspect of mesotergum. C, lateral aspect of mesothorax. D, lateral aspect of metathorax. a, anepisternum; af, anterior foramen; ar, preepisternal area; b, basalare; be, basal area of elytron; ca, clavicola; cc, coxal cavity; cl, clavicle process; co, coracoid process; e, epimeron; ea, poststernellar area; es, episternal suture; et, episternum; f, posterior foramen; g, transverse ridge; k, katepisternum; l, lateral prescutal lobe; la, sternellar area; le, lower area of epimeron; lp, lateral arm of postphragma; me, middle area of epimeron; n, anterior notal wing process; o, postscutellum; pn, posterior notal wing process; pp, postphragma; r, preepisternum; s, pleural suture; sa, sternal area; sc, scutum; sl, sternellum; sm, prescutum; sp, spiracle; su, sternum; t, scutellum; td, depressed part of scutellum; te, elevated part of scutellum; u, subalare; ua, presternal area; ue, upper area of epimeron; um, presternum; xa, exocoxal area; xr, exocoxal ridge.

It is not possible to delimit epimeral or episternal areas as in *Dendroctonus* and *Gnathotricus*.

Mesothorax. This is the shortest of the three thoracic segments. Moreover, much of it is concealed when in its normal position.

The most conspicuous part of the mesonotum (Figure 147 B) is the large subtriangular prescutum (*sm*). Extending anterolaterad are two long, thin, acute processes which together with the underlying lateral arm of the prephragma form the clavicola (*ca*), The middle portion of the prephragma extends as a ridge under the prescutum, becoming widest at the midline. Posterior to the prescutum is a conspicuous subquadrate, somewhat elevated plate, the scutellum (*te*). This is indistinctly three- to five-lobed on its posterior edge, and together with the posterior two-thirds of the prescutum is not concealed by the elytra. A depressed area of the scutellum (*td*) extends anterolaterad with the lateral arm of the postphragma, or pleural hook (*lp*), farther distad. The scutum (*sc*) is represented by an oval area below the prescutum and anterior to the depressed part of the scutellum. Only the transverse area in the middle third of the prescutum is punctured. A postscutellum is not present as a distinct sclerite.

The largest sclerite of the pleural area (Figure 147 C) is the episternum (*et*). It is broad at its ventral edge where it borders the coxal cavity (*cc*) and sternum (*su*). Its anterior and posterior edges are subparallel for somewhat over half the distance up the side, where it widens slightly. It then becomes triangular as the two edges converge dorsad. Extending from the anterior border of the coxal cavity is a transverse ridge (*g*). A thin strip forming the anterior part of the episternum is the pre-episternum. This is smooth as contrasted with the irregularly punctured episternum. The preepisternum sends a large, triangular, hooked process (*r*) cephalad for the attachment of muscles holding the mesothorax to the prothorax. At the dorsal angle of the preepisternum is the clavicle process (*cl*), the anterior of the two wing processes, or pleuralifera, for articulation with the elytron. The posterior, or coracoid, process (*co*) is born at the dorsal angle of the epimeron, of which the dorsal portion is a thin strip lying concealed by the episternum. The body of the epimeron (*e*) lies posterior to the pleural suture (*s*), and is subtriangular in shape with the rounded apex of the low triangle projecting caudad. Above the apex it is normally concealed by the elytra and is not punctured, while below this it is irregularly punctured.

The mesosternum is composed largely of the subquadrangular sternal area lying anterior to the coxal cavities, with an exocoxal piece laterad of each of these cavities. There is no suture between the sternum and the sternellar areas, but the latter is represented by a markedly elevated area (*sl*) between the coxae. Both the sternum and sternellum are sparsely punctured and the latter is also pubescent. The intercoxal distance is about two-thirds the long diameter of one of the coxal cavities. Lying between the sternum and the anterior border of the mesothorax is a narrow non-punctured presternum (*um*). There is no poststernellum.

The spiracle (*sp*) lies in the conjunctiva between the preepisternum and preepisternal process, all of which are normally concealed under the posterolateral angles of the pronotum.

Metathorax. The tergum of the metathorax (Figure 148 A) is quite complicated in appearance and it is difficult to homologize some of the highly developed structures with those of other insects.

The alinotum is made up of a large scutum divided into two lobes (*sl*), a large scutellum (*t*), and a prescutum, with its prephragma. The postnotum is relatively short and consists of the postscutellum with its postphragma.

The prescutum comprises the anterior region of the notum. It is sclerotized along the anterodorsal zone (*d*), but membranous in its posterior portion (*ma*) cephalad of the prescutal suture (and anterior apodeme). Laterally it is folded on itself so that there is a ventral portion (*al*) giving rise to the anterior notal wing process (*n*), and a dorsal portion, the prescutal lobe (*l*).

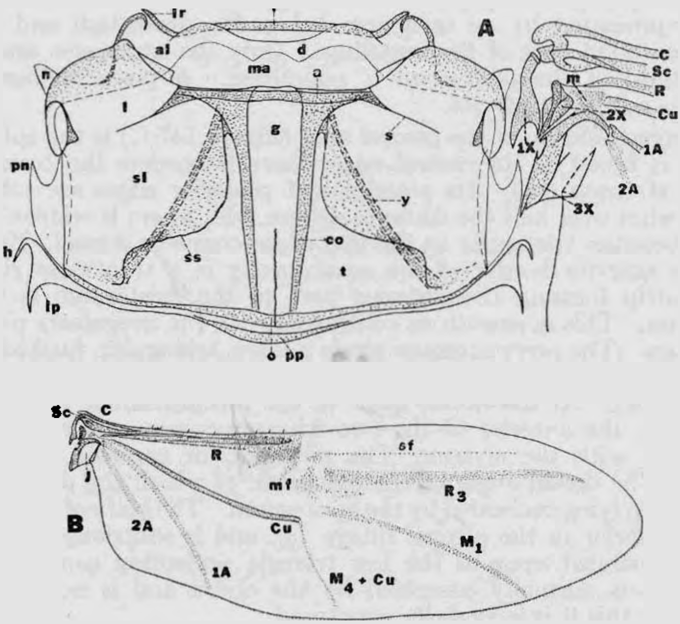

Figure 148. A, dorsal aspect of metatergum, and articulation of wing. The second axillary has been represented somewhat laterad of its normal position partly obscuring the first. B, right wing. The veins are labeled according to the usual system. a, anterior apodeme; al, anterior prescutal lobe; co, costae; d, dorsal band of prescutum; g, scutellar groove; h, pleural hook; j, wing lobe; l, lateral prescutal lobe; lp, lateral arm of postphragma; lr, lateral arm of prephragma; m, medial plate; ma, membranous area of prescutum; mf, median wing fold; n, anterior notal wing process; o, postscutellum; pn, posterior notal wing process; pp, postphragma; r, prephragma; s, prescutal suture; sf, scutellar fold; sl, scutal lobe; ss, scutoscutellar suture; t, scutellum; 1x, 1st axillary; 2x, 2nd axillary; 3x, 3rd axillary; y, y-shaped ridge.

Between the prescutal (*s*) and the scutoscutellar (*ss*) sutures lie the scutal lobes (*sl*). Each of these sutures is represented on the ental surface by a very pronounced apodeme, the anterior (*a*), and median (Y-shape ridge) (*y*), respectively, which are clearly visible from above. The scutoscutellar suture is sinuate and extends anteromesad from the posterolateral angle of the alinotum to the transverse prescutal suture. The ridge extends ventrolaterad instead of directly ventrad, so that from above there appears to be a deeply pigmented sclerite present where the integument is double. The anterior apodeme has a lateral extension which gradually fades out before reaching the lateral edge of the notum. Nevertheless it is clear that Hopkins was justified in considering the area anterior to this as prescutal, and not scutal as Schedl believes it should be called. Extending back from the anterior suture on either side of the midline is a pronounced ridge. These costae (*co*), or parapsidal ridges, converge slightly caudad and enclose a scutellar groove (*g*) which is apparently for the reception of the sutural margins of the elytra. Lateral to the scutal lobe is a semi-membranous posterior notal wing process (*pn*), which is presumably an anterolateral extension of the scutellum.

The postscutellum (*o*) is a narrow sclerite posterior to the scutellum. On its posterior edge is the postphragma (*pp*) which is expanded laterally into two processes.

The pleuron (Figure 147 D) is represented by the usual two major divisions, episternum and epimeron, separated by the pleural suture (*s*). Dividing the episternum transversely is the episternal suture (*es*). Below this suture is the long katepisternum (*k*) which is the only part of the pleuron not concealed when the elytra are closed. This is the sclerite termed "episternum" by the systematists. Above this suture is the anepisternum (*a*), which, though semi-membranous and less pigmented than the katepisternum, is, like the latter, coarsely punctured. This division does not seem to occur in *Dendroctonus* or *Gnathotricus*, though in the former there is a preepisternum which is clearly homologous to the anterior portion of the anepisternum (*ar*). At the produced anterodorsal angle of the anepisternum is the clavicle (*cl*) or anterior wing process.

The epimeron is entirely membranous and divided into three areas. The anterodorsal area (*ue*) is triangular and is produced to form the coracoid (*co*), or posterior wing process. It is thickened along the pleural suture, but is very thin and practically transparent elsewhere. The median area (*me*) is somewhat oval and is darkly pigmented. The posterior area (*le*) is larger than the other two combined, triangular, and only very faintly pigmented.

There are two epipleurites or paraptera. The anterior or episternal parapteron (*b*) is large and triangular. It is attached ventrally to the anterior angle of the katepisternum and dorsally by a ridge joining the pleural suture. It has been called the clavicle disc (Hopkins), pronator disc (Schedl) and basalare (Snodgrass). The posterior or epimeral parapteron, (subalare Snodgrass), is small and oval (*u*). It lies free in the conjunctiva between the posterior notal wing process and the pigmented middle area of the epimeron. It is homologous to the postepimeron in *Dendroctonus*.

The spiracle (*sp*) lies in the conjunctiva just cephalad of the basal angle of the basalare. It is normally concealed by the mesepimeron.

The sternum (*su*) is a broad subrectangular plate about twice as wide as long. There is a median line (Figure 145 B) pigmented along its caudal three-fourths, but indistinct cephalad. The entire area is coarsely punctured and pubescent. At the posterior end of the midline the sternum is emarginate, exposing a small triangular sternellar area (Figure 145 B, *s*). Most of this is normally concealed by the intercoxal portion of the first visible abdominal sternite. The presternum and poststernellum are not represented by external parts.

THE LEGS

The three pairs of legs are quite similar in size and structure, varying only in a few details. The coxa (*c*) of the prothoracic leg (Figure 149 A) is subglobose, punctate and sparsely setose with a few long hairs extending from its ventral area. The fossa for the articulation of the trochanter is on the posterior aspect. The mesocoxa (Figure 149 B) is oval to cylindrical, and the metacoxa (Figure 149 D) elongate transversely. Both the meso- and the metacoxae are similar in vestiture to the precoxa. They differ from it in having the trochanteral fossa on the anterior aspect. Especially prominent on the pro- and mesocoxae are the basicostal suture (*s*), and basicoxite (*b*) proximad of it. A faint indication of a coxal suture (*cs*), as well as clearly distinct artes, or articulation condyles (*st* and *co*), are visible only on the metacoxa.

The trochanter (*t*) is the smallest leg segment. It has the shape of a flattened, truncated cone and is immovably joined along its distal wide edge to the femur. It bears no punctures, but a few setae, with an especially long one extending ventrad.

The femur (*f*) is the strongest and largest segment of each leg and is about one and one-third times as long as the tibia, which is next longest. It is suboval in outline, and bears at its distal end a rather deep groove for the reception of the articular condyles of the tibia. While all the femora are somewhat compressed the metafemur is more so than the other two. They are all minutely punctured and setose with some of the setae plumose.

The tibiae (*ti*) of all the legs are about the same size and shape. However, the prothoracic tibia has a long, tarsal groove (*g*) on the anterior aspect, while on the meso- and metatibiae (Figure 149 C) there is a groove on the posterior aspect, much shorter and more shallow than the former. There is a distinct subapical ridge (*r*), longer on the protibia, produced to form an apical tooth (*a*). Along the distal edge of this ridge are six to eight spinelike setae. Extending along the distal and lateral edges of the tibia are a number of marginal teeth (*m*) set in sockets. These teeth vary in number, size and spacing, there being no apparent correlation with sex or size of individual. On the protibia they number five to seven with the majority five; on the mesotibia, six to nine with the majority seven; and on the metatibia, seven to eleven with the majority eight. The tibia is densely covered with setae, many of which are plumose.

The tarsus (Figure 149 E) is composed of five segments which together are about as long as the tibia. It is capable of being bent back over the tibia fitting into the tarsal groove of the latter. The first and second segments are similar, cylindrical in shape, slightly expanded distad, with the first longer than the second. The third is about as long as the first, and bilobed. The fourth is small and visible only from the dorsal aspect. It is oval and fits into the emargination of the third. The fifth segment is the longest, being about as long as the first and second combined. It is slightly longer on the meso- and metatarsi than on the protarsus. It arises from the dorsal surface of the fourth segment and has the shape of a long narrow cone, curved slightly so that it is convex dorsad. At its distal end it bears a pretarsus with a minute arolium (*ar*) and two smooth claws (*cl*). The arrangement of the setae is shown in the figures.

MESOTHORACIC WINGS OR ELYTRA

The form and general appearance of the elytra can be seen from Figures 142 and 145. Viewed from above when closed, the sides are subparallel for about two-thirds the length, then gradually converge in a gentle

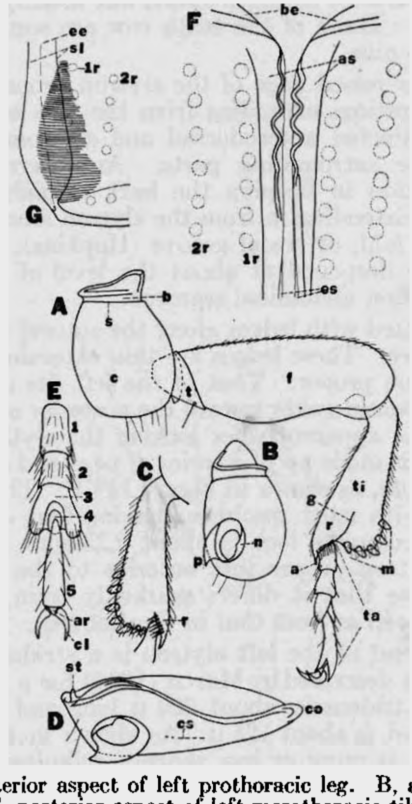

Figure 149. A, anterior aspect of left prothoracic leg. B, anterior aspect of right mesothoracic coxa. C, posterior aspect of left mesothoracic tibia. D, anterior aspect of left metathoracic coxa. E, dorsal aspect of prothoracic tarsus. F, ventral aspect of elytra along their sutural margins to show locking device. G, ventral aspect of posterior end of left elytron to show stridulating area. a, apical tooth; ar, arolium; as, anterior shelf; b, basicoxite; be, basal area; c, coxa; cl, claws; co, coxartis; cs, coxal suture; ee, edge of elytron proper seen through ledge; es, anterior end of sutural ledge; f, femur; g, tarsal groove; m, marginal teeth; n, anterior coxotrochanteral articulation; p, posterior coxotrochanteral articulation; r, subapical ridge; s, basicostal suture; sl, sutural ledge; st, sternartis; t, trochanter; ta, tarsus; ti, tibia; 1 to 5, 1st to 5th segments; 1r, 1st row of punctures; 2r, 2nd row of punctures.

curve at the posterior end. From the side it can be seen that this curving takes place where the declivity begins. Thus, the declivity is shaped like the surface of one-fourth of a sphere. Each elytron is produced cephalad to form a triangular basal area with articulating elements

(Figure 147 B). The sutural margin is perfectly straight, but the costal presents a slight double sinuous curve when seen from the side.

There are on each elytron a total of ten rows of punctures, or striae, of which the first (next the sutural margin) is the longest, and the tenth (along the costal margin), the shortest. The interspaces are somewhat wider than the striae, are raised, (more so toward the caudal end), and bear short, thick, yellow setae. On the declivity the interspaces are provided with minute, coarse, darkly pigmented asperities. The punctures of the striae are a variable distance apart, but usually slightly more than their own diameter. Those of the tenth row are somewhat smaller than those of rows one to nine.

Along the anterior raised edge of the elytron proper is a row of about 14 small, coarse serrations extending from the first to the seventh interspace. They are directed anterodorsad and are somewhat more darkly pigmented than the surrounding parts. An interesting discussion of their possible function in keeping the bark tunnels clean is given by Trägårdh (1930). Extending in from the elytron along the costal margin is a distinct lateral fold, or costal groove (Hopkins), as in *Dendroctonus*. The groove is much deepened at about the level of the suture between metepisternum and first abdominal segment.

Both elytra are fitted with ledges along the sutural margin for articulation with one another. These ledges are thin extensions from the ventral surface of the elytron proper. That of the left fits on top of the right, the latter widening considerably toward the posterior end. At the anterior end there is a device apparently for locking the elytra in position when they are closed. It is made up of a series of pegs and sockets so arranged that they interdigitate, as shown in Figure 149 F. These vary in number from three to six, with most specimens having four or five each of pegs and sockets. The complete lock is about 0.25 mm. long, and lies on a shelf under the elytron proper just anterior to the sutural ledges. It is interesting to note that it differs markedly from the device present in *Dendroctonus*, as well as from that in *Gnathotricus*.

At the posterior end of the left elytron is a stridulatory area (Figure 149 G) similar to that described by Marcu (1930) for a number of Hylesine species. The pars stridens is about 280 μ long and the greatest width, near the posterior end, is about 125 μ. As shown in the figure, the transversely sulcate area is more or less sharply delimited on its mesal edge but rather irregular on its lateral. This is due to the fact that the striae extend unequal distances laterad. These striae are so fine and so closely set that they are not visible when viewed with even the highest powers of a binocular dissecting microscope, the lenses of which do not have the requisite resolving power. With the aid of a compound microscope they can be seen. They are closer together at the anterior end, where there are 10 in a space of 18 μ, while a similar number fill a 42 μ space at the posterior end. Only a few are two-branched. Though the mesal ends of all the striae are on the ledge (*sl*), which is quite wide at this region, the lateral ends are on the elytron proper, between the first and second rows of punctures.

Nothing is said by Marcu as to the "scraper" or other device against which the pars stridens is rubbed in order to produce a sound. In *Gnathotrichus* this device is on the right elytron. In *Dendroctonus*, Hopkins calls attention to a median bifid process on the posterior edge of the seventh abdominal tergite of the male. He considers this the stridulating scraper. A similar process is present in the males of *Hylurgopinus* (Figure 150 C) though it must be admitted that it does not seem particularly well adapted for scraping against the pars stridens. Moreover, there is no such process, nor any other, on the tergites of the females, yet the organ on the elytron is the same in both sexes.

METATHORACIC OR HIND WINGS

The wing (Figure 148 B) is oval in shape and about three times as long as wide. The veins are much reduced in number and are named according to Forbes (1922) and Snodgrass.

In the axillary region, or articular area of the wing (Figure 148 A), are the pteralia. Of these the humeral plate is lacking, but there are three characteristically shaped axillaries and a rather poorly defined triangular medial plate. The axillaries are numbered according to Snodgrass, the first being equivalent to the scapular plate of Hopkins, the second to his subscapular, and the third to his flexor plate. What Schedl calls a fourth axillary is really the medial plate. The shapes of these axillaries are very similar in the three genera *Hylurgopinus, Dendroctonus*, and *Gnathotricus*.

The first vein, or costa (*C*), appears to articulate directly with the clavicle, or anterior wing process of the metanepisternum. It continues as a distinct vein, along the costal margin of the wing, for only a short distance. For most of its length it is practically fused with the subcosta, which two in turn join the radius distally. The subcosta (*Sc*) presents a twisted head which articulates with the head of the first axillary. As stated above, it fuses with the costa and later joins the radius. The radius (*R*) arises from the second axillary by a very thin, inconspicuous strand. It becomes wider, more heavily pigmented, and thicker as it proceeds, and distally is contiguous with the costa-subcosta. These three veins extend about one-third the length of the wing, and at their termination the wing is strengthened by an irregular sclerotization. An unconnected branch of the radius, R_3, arises from the median fold (*mf*) and continues almost to the apex of the wing, parallel with the scutellar fold (*sf*). The cubitus (*Cu*) arises from the indefinite medial plate and extends to the region of the median fold of the wing. Here it becomes deflected toward the anal margin and is fused with medius 4. The medius is not represented proximally. Of its two distal branches, M_1 has no basal connection and M_4 is fused with the distal portion of the cubitus. There are two anal veins which arise from the third axillary. The first is quite distinct and extends almost to the anal border. The second is very faint and about half the length of the first.

The wing of *Hylesinus fraxini*, according to the figure given by Nüsslin (1911, p. 274), is practically identical in appearance with that of *Hylurgopinus*, and both fall into his "Type 2" (*op. cit.*, p. 305). In Table 2 is given a comparison of the nomenclature of Hopkins, Nüsslin, and Schedl with that employed by the author.

TABLE 2. COMPARISON OF WING VEIN NOMENCLATURE.

System here used	Hopkins *Dendroctonus valens*	Schedl *Gnathotricus spp.*	Nüsslin *Hylesinus fraxini*
C	C	C	?
Sc	Sc	Sc	?
R	R	R	?
R_3	R_2	R_2	I
M_1	M_1	M_1	II
Cu	M	M	III
M_4+Cu	M_2	M_2	
1st A	Cu_1	Cu_1	IV^1
2nd A	Cu_2	lacking	IV^2
[3rd A] lacking	A	lacking	lacking

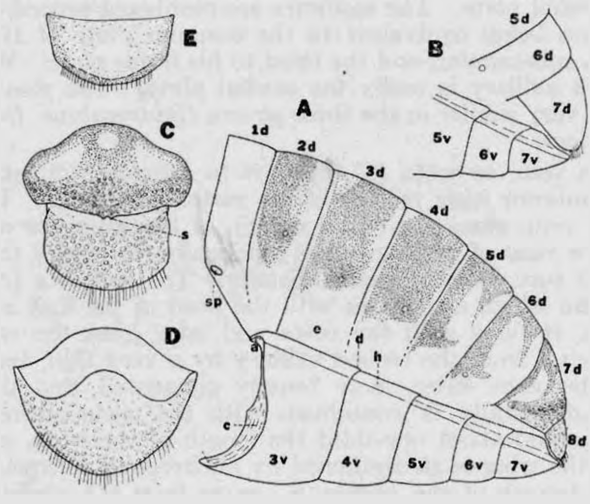

Figure 150. A, lateral aspect of abdomen of male. B, same of female, posterior segments. C, posterior aspect of male tergites 7 and 8. D, posterior aspect of female tergite 7. E, posterior aspect of female tergite 8. a, articular socket; c, cavity of metacoxa; d, dorsopleural line; e, epipleural area; h, hypopleural area; p, processus ventralis; s, stridulating scraper (?); sp, spiracle; 1d to 8d, first to 8th tergites; 3v to 7v, 3rd to 7th sternites.

There is a very small wing lobe (*J*) distal to the third axillary. A few small setae arise from the proximal half of the costal margin, and the entire anal margin is set with very fine setulae.

THE ABDOMEN

The structural details are shown in Figures 145 B and 150. Only the sternites are visible externally when the elytra are closed. These are five in number, representing segments three to seven. They are punctured and covered with scattered short setae. According to Hopkins, sternites 1 and 2 are represented by the thick wall of the metacoxal cavity on sternite 3. The latter sternite is the first visible one and sends a median triangular process (*p*), the processus ventralis of Verhoeff (1896), cephalad between the metathoracic coxae. Laterad the sternite is furnished with an articular socket (*a*) for the reception of the posterodorsal angle of the metakatepisternum. Sternites 8 and 9 are completely concealed. Since they are intimately connected with the genitalia they will be discussed with the latter.

Though not separated from the sternites by sutures, the hypopleural areas (*h*) are clearly defined in segments 3 to 7. Those from 5 to 7 become increasingly wider caudad, but at the very end the seventh is abruptly shortened (more so in the male than female) for the reception of the last visible tergite.

There are eight tergites, all normally covered by the elytra. Upon removing the elytra all eight are visible in the male, but in the female tergite 8 is completely covered by 7. The appearance of these caudal tergites is quite different in the two sexes (Figure 150 C, D), providing a means of distinguishing them without dissection. The first six tergites are entirely membranous, and rather indefinitely set off from the epipleural areas (*e*). Tergite 1 is entirely unpigmented. Tergite 2 to 6 have gray pigment in variable patterns, as shown in the figure. In the male, tergite 8 and the posterior third of 7 are both sclerotized and densly punctured. The caudal edge of 7 is thickened and produced to form a bifid process (*s*), similar to what in *Dendroctonus*, according to Hopkins, carries the stridulating scraper. Extending from the caudal edge of 8 is a brush of setae. Tergite 7 of the female is larger than that of the male and quite different in shape. Its anterior portion is membranous, but the posterior two-thirds is sclerotized and punctured. Tergite 8 lies concealed beneath the posterior portion of 7, being protruded presumably only during oviposition. It is slightly smaller than and almost the same shape as 8 in the male. It has a central membranous portion, semisclerotized lateral areas, and a thickened sclerotized caudal edge. This caudal area is minutely punctured, and like the caudal area of tergite 7 is provided with setae. The relation of tergites 7 and 8 in both sexes corresponds very closely to that given by Verhoeff (1896) for *Hylesinus fraxini* and *Hylurgus piniperda* in which 8 in the male is called a "covered pygidium" and 7 in the female a "covered pseudopygidium".

There are six pairs of spiracles in the female and seven pairs in the male. The first (*sp*) is large, oval, has a thickened peritreme, and lies in the epipleural area of segment 1, close to the anterior border. The rest are small, circular, and without evident peritremes. The second to fifth lie well up on the tergites, while the sixth (and seventh in the male) lie close to the anterolateral corners of the tergites. The seventh on the male is quite rudimentary.

MALE REPRODUCTIVE SYSTEM

There is a pair of testes (*t*), each with about five lobes. Two short efferent ducts from each testis join to form a vas deferens (*vd*), and each vas deferens is provided with a seminal vesicle (*sv*). Emptying into the vas deferens just proximal of the vesicle is a pair of long, accessory, or mucous glands (*mg*). These are thinner than the vas deferens, are much coiled, and the members of a pair are not always the same length. They have been considered ectodermal in origin by Verhoeff, and hence were given the name ectadenia proposed by Escherich (1894). The seminal vesicle itself Verhoeff called mesodenia. But Nüsslin (1911, p. 372 *et seq.*) has shown that the vesicula seminalis is a composite of three structures. The tube formed by the junction of the paired mucous glands with the vas deferens he called the "Zunge". This and the proximal portion, or "Mantel", of the vesicle are mesodermal. Only the distal cup-shaped "Becher" is ectodermal. Hence, he called the mucous glands mesadenia.

A short distance beyond the vesicle the paired vasa deferentia join to form the ejaculatory duct (*ed*). This duct is thicker than the vasa and

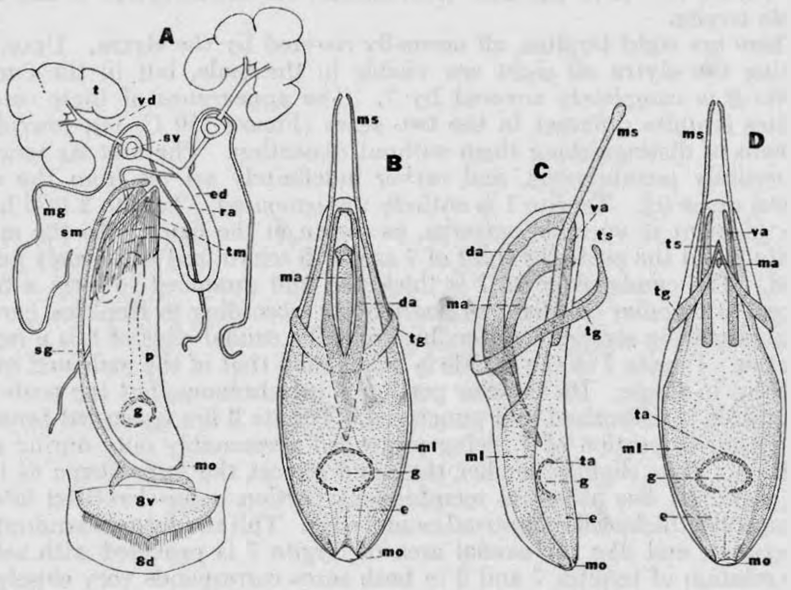

Figure 151. A, dissection of male genitalia from the ventral aspect. B, dorsal aspect; C, lateral aspect; and D, ventral aspect of phallic structures. da, dorsal arm of pars ancora; e, internal sac; ed, ejaculatory duct; g, gonopore; ma, median arm of pars ancora; mg, mucous gland; ml, median lobe; mo, median orifice; ms, median struts; p, phallus; ra, retractor muscle of pars ancora; sg, spiculum gastrale; sm, spicular muscle; sv, seminal vesicle; t, testis; ta, transfer apparatus; tg, tegmen; tm, tegminal muscle; ts, tegminal strut; va, ventral arm of pars ancora; vd, vas deferens; 8d, 8th tergite; 8v, 8th sternite.

quite long. It is bent in the form of a "U" before entering the phallus, in which it is still further bent as shown in Figure 151 A.

The parts of the reproductive system extruded during the act of copulation are enclosed in a long oval structure, the phallus (*p*), about 0.6 mm. in length. Lying along the right side of this is a long sclerotized rod which is curved transversely at the posterior end. This is the spiculum gastrale (*sg*), which, according to Verhoeff, and Hopkins, is homologous with the ninth sternite. At its anterior end it is compressed and serves for the attachment of the spicular muscle, and posteriorly it is produced to form a prong at each end of the transverse portion. These prongs are attached by thin muscle strands to the eighth sternite (*8v*). This sternite is subtriangular and membranous, except for a very weakly sclerotized posterior edge, along which is borne a row of setae.

The phallus is a bilaterally symmetrical structure but since it lies somewhat on its left side its plane of symmetry does not coincide with that of the body of the bettle. Its parts are very complicated and difficult to homologize entirely with those of other insects. This difficulty is heightened by the already existing conflicting terminology in the literature. Where possible the terminology of Sharp and Muir (1912) and Sharp (1918) has been followed.

The outermost or tegminal layer of the phallus is represented by a proximal annular sclerite, the tegmen (*tg*). Sharp considers the spiculum gastrale to be a part of this layer, but the lateral lobes, or parameres, are lacking. The tegmen is incompletely sclerotized, the dorsal part being membranous. On its ventral side it is produced to form a hooked tegminal strut (*ts*).

The middle layer of the phallus is the median lobe (*ml*). It is this which Snodgrass considers the aedeagus, though the latter term has been used by Sharp and Muir to include the tegmen and median lobe together. The median lobe is somewhat sclerotized on each side but semi-membranous over most of its extent. Extending cephalad from the lateral sclerotized areas is a pair of long, thin processes, the median struts (*ms*). They are slightly expanded at their tips where they almost touch each other. At the posterior end of the median lobe is an opening, the median orifice (*mo*).

The ejaculatory duct can be seen only faintly, extending almost to the posterior end of the median lobe. It ends in an expanded gonopore (*g*) which is furnished with a darkly pigmented rim. This thickened rim corresponds to what is called the transfer apparatus (*ta*), present in some Rhynchophora. From the gonopore to the median orifice is the internal sac (*e*). It is evident then that the internal sac is an endophallus and the median orifice is a phallotreme. Surrounding and supporting the ductus ejaculatorius anterior to the gonopore is a complicated arrangement of sclerotic rods. This complex is apparently peculiar to some Scolytids and was first described by Lindemann (1875), who called it the "Ankergestell" from its resemblance to a ship's anchor. It was not mentioned by Sharp and Muir (1912), and Sharp (1918) passes it by with a reference to Lindemann's paper. The pars ancora is composed of a pair of long dorsal arms (*da*), a pair of shorter ventral arms (*va*), and an unpaired median arm (*ma*). The dorsal arms are joined by a thin bridge at their anterior ends and fuse near the posterior end to form a single acute curved rod ending just anterior to the gonopore. The ventral arms are really continuations of the dorsal and do not extend so far caudad. The median arm extends from the ventral side just posterior to the tip of the tegminal strut, around to the dorsal side where it becomes fused caudad to the dorsal arms. That the pars ancora functions as a support for the membranous internal sac when it is everted in copulation was demonstrated to the writer by the fortunate circumstance of finding a pair of beetles killed in copula. The internal sac was everted and a terminal vesica could be seen.

TABLE 3. COMPARISON OF TERMS, MALE GENITALIA

Lindemann 1875	Verhoeff 1896	Nüsslin 1911	Fuchs 1911	Sharp and Muir 1912, and Sharp 1918	Hopkins 1915	Schedl 1931	Snodgrass 1935
Körper	Penis	Penisrohre	innere Hülle	median lobe	body	inner covers	aedeagus
Gabel	Gabel Paramerenreste	Gabel	äussere Hülle	tegmen	tegmen	parameren	phallobase
Stengel	spiculum gastrale	spiculum gastrale	Stengel	spiculum gastrale	spicule	spiculum ventrale*	
	Praeputialsac			internal sac			endophallus
Füsschen	femora	Füsschen	peduculi	median struts "temones"	body apodemes	femora penis peduculi	aedeagal apodeme
			metula	median orifice			phallotreme
Ankergestell	Ankergestell			tegminal strut	apodemal process	metula	
					preputial sac		phallus

*The term spiculum ventrale, which is used for a structure present in the female, was probably used by Schedl in error for spiculum gastrale. He has, unfortunately, likewise confused seminal vesicle in the male with receptaculum seminis in the female.

Extending from the lateral areas of the tegmen to the tip of the spiculum gastrale is a large spicular muscle (*sm*), which is a retractor. From the ventral area of the tegmen to the tips of the median struts are the fibers of the tegminal muscle (*tm*), a protractor. Dorsal to the tegminal and mostly covered by the spicular muscle is the retractor of the pars ancora (*ra*). Its fibers are attached cephalad to the tips of the median struts.

For purposes of comparison the various names of the parts of the male genitalia used by different authors are brought together in Table 3.

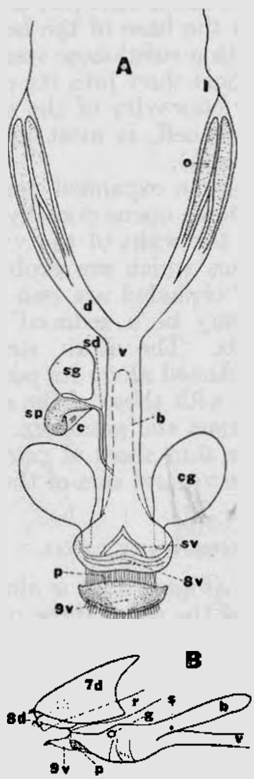

Figure 152. A, dissection of female genitalia from the ventral aspect. B, lateral aspect of posterior portion to show relation of genitalia to tergites and rectum. b, bursa copulatrix; c, compressor muscle; cg, colleterial gland; d, oviduct; g, opening of colleterial gland; l, suspensory ligament; o, ovarioles of ovary; p, protractor muscle; r, rectum; s, opening of seminal duct; sd, seminal duct; sg, spermathecal gland; sp, spermatheca; sv, spiculum ventrale; v, vagina; 7d and 8d, 7th and 8th tergites; 8v and 9v, 8th and 9th sternites.

FEMALE REPRODUCTIVE SYSTEM

The genital system in the female (Figure 152) is very much simpler than that of the male and little difficulty is encountered in its study. There are two ovaries, each of which in turn has two ovarioles (*o*). In the resting stage (or in young individuals) the ovarioles are thin and long, as shown in Figure 152, but during the maturation of the ova they are much dilated. The ovaries lead into a pair of short, thick oviducts (*d*) which join to form the vagina (*v*). This is a thickened muscular organ extending to the posterior end of the body. It is much dilated near its distal end, then abruptly depressed dorsoventrally at the gonopore. Arising from the dorsal side of the vagina is a muscular bursa copulatrix (*l*). It is somewhat narrower than, and almost as long as the vagina.

A large spermatheca (*sp*), or receptaculum seminis, is present on the right side of the vagina. It has the shape characteristic for Scolytids, and is heavily sclerotized. The seminal duct (*sd*) is as long as the spermatheca and runs from the latter to the base of the bursa copulatrix. The spermatheca is also provided with a subglobose spermathecal gland (*sg*) which empties by an extremely short duct into its cephalic wall. The muscle (*c*) present on the posterior concavity of the spermatheca, though called an expansion muscle by Verhoeff, is most probably, from its apparent function, a compressor (Nüsslin).

Situated on either side of the expanded part of the vagina is a large oval colleterial gland (*cg*). Each opens dorsally into the vagina by a short, thick duct. In this region the walls of the vagina are strengthened by thin, plate-like sclerotizations which are probably homologous with the eighth sternite. Extending cephalad are two thin pieces in the form of an inverted "V", which may be a reduced spiculum ventrale (*sv*) as exhibited by other Scolytids. The ninth sternite is present as a thin semimembranous plate, thickened along its posterior edge and sides. Its lateral angles are connected with those of the eighth tergite so that these two sclerites surround the anus and gonopore. A row of setae is present on the posterior edge and a thin sheet of protractor muscle (*p*) extends from its anterior edge to the ventral side of the vagina.

ALIMENTARY CANAL

The entire digestive tract (Figure 153) is almost three times as long as the body. It is composed of the usual three major divisions, fore-, mid-, and hind-gut.

Fore-gut. The esophagus (*e*) is a simple tube leading from the pharynx and mouth cavity. It is widened slightly to form a conical crop (*cr*) and the latter in turn leads to the barrel-shaped proventriculus (*pv*) which is about 0.4 mm. long. Starting in the posterior portion of the crop, but most marked in the proventriculus itself, the sclerotic intima is highly modified to form a complicated system of ridges and teeth.

Since the proventricular armature is of importance in the taxonomy of the Scolytidae, details of its structure are here given. This armature is located on eight plates arranged so that a transverse section is a regular octagon. The anterior limit of each plate is rather indefinite, the armature extending irregularly into the crop. The posterior end is sharply delimited, and beyond this the proventriculus is abruptly narrowed.

Following Lindemann, and Nüsslin, we may distinguish on each plate an anterior portion, the "Plattenteil", and a posterior "Ladenteil". The anterior portion (*a*) is unpaired, shorter than the posterior (*p*), and, as already mentioned, is not definitely set off from the crop. The posterior portion is composed of a pair of longitudinal plates which meet at an angle projecting into the lumen (Figure 153 B). The line of junction has been called the "Mediane" by Nüsslin, or median suture (*me*), and the boundary separating the entire posterior plate from its neighboring plate on each side, the "Intermediane", or marginal suture (*ma*). Along each posterior plate is a series of closely set bristles (*d*), the declivity teeth (Nüsslin), or masticatory teeth (Schedl), extending from the marginal suture but not reaching the median suture. They each bear three or four serrations which are larger and more conspicuous on the teeth of the anterior third of the plate. The medial halves of these teeth are broken

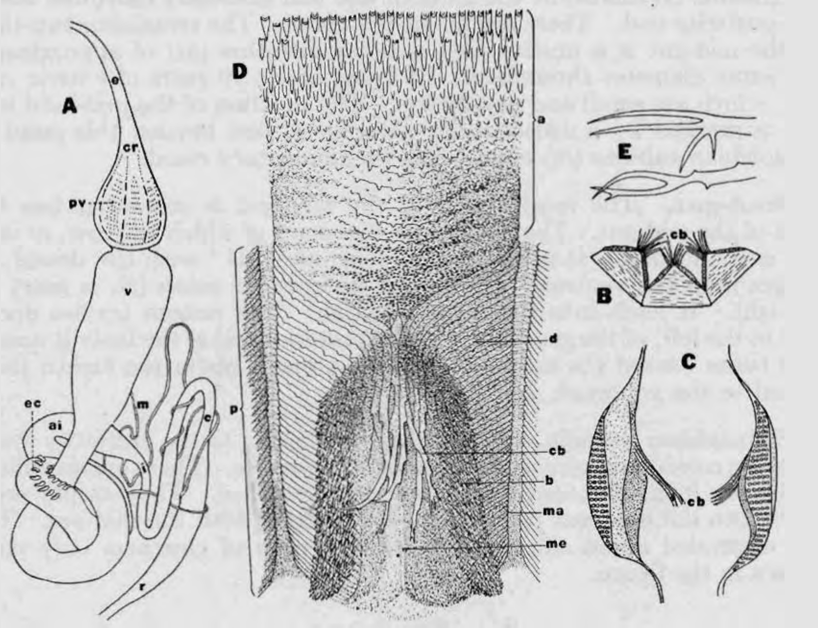

Figure 153. **A, dissection of the alimentary canal from the lateral aspect. For clearness the parts of the hind-gut have been separated somewhat, and only one Malpighian tubule is shown.** B, transverse section through anterior part of the proventriculus showing three of the eight plates. C, longitudinal section of proventriculus passing through the center of plate on left, and to the side of plate on right. D, single **proventricular plate. E, distal ends of closing bristles. a, anterior plate; ai, anterior** intestine; b, masticatory brushes; c, colon; cb, closing bristles; cr, crop; d, declivity teeth; e, esophagus; ec, enteric caeca; i, ileum or posterior intestine; m, Malpighian tubule; ma, marginal suture; me, median suture; p, posterior or masticatory plate; pv, proventriculus; r, rectum; v, ventriculus.

up in a peculiar manner into a large number of fine serrulations so that all together they have the appearance of a brush. These masticatory brushes (*b*) are deeply pigmented, and form the most conspicuous component of the proventricular apparatus.

Just anterior to the declivity teeth are a few long bristles (*cb*) whose basal portions are parallel to the former, and whose distal ends extend freely into the lumen (Figure 153 B, C. and D). They have been called closing bristles (Nüsslin), or straining bristles (Beal 1927), from their apparent function. The basal portion of each is serrated like the declivity teeth, while the free end is variously serrated and spinulated (Figure 153 E).

On the unpaired anterior plate there are several indefinite rows of minute asperities occupying the median third. Farther cephalad these intermingle with short, thick teeth which extend over the entire width of the plate. There are about seven rows of these short, thick teeth, which are supplanted farther cephalad by about four rows of long, thin teeth. Beyond this are the scattered teeth extending into the crop.

Mid-gut. The first part of the mid-gut or mesenteron is a thin-walled ventriculus (*v*) dilated at the anterior end and gradually narrowed toward the posterior end. There are no gastric caeca. The remaining two-thirds of the mid-gut is a much coiled anterior intestine (*ai*) of approximately the same diameter throughout. It bears about 10 pairs of enteric caeca (*ec*), which are small and papilliform. The junction of the mid- and hind-gut is marked by a constriction. Moreover, just beyond this point the Malpighian tubules (*m*) empty into the alimentary canal.

Hind-gut. The total length of the hind-gut is somewhat less than that of the mid-gut. There are three divisions, of which the first, or ileum (*i*), is the longest. It is bent in the form of a "U" with the dorsal arm longer than the ventral. The second division, or colon (*c*), is short and straight. It leads into the dilated rectum. The rectum (*r*) lies dorsad, and to the left, of the genitalia. At the posterior end of the body it narrows and turns toward the midline. The anus opens under the eighth tergite dorsal to the gonopore.

Malpighian vessels. Although these belong to the excretory system they are considered here as a matter of convenience. There are six tubules, each very long, thin, much coiled, and unbranched. They empty separately into the hind-gut just beyond its junction with the mid-gut. They are entangled about the gut, and for the sake of clearness only one is shown in the figure.

The Pupa

The accompanying drawings (Figure 154) show the general appearance and external anatomical details of the pupa. The total length, including caudal spines, is about 3.25 mm., and the greatest width, about 1.5 mm. The relative position of the head, and the lengths of the abdominal segments vary somewhat, depending upon the degree of contraction or expansion.

Over the body are a number of setae, a discussion of which will be reserved for a separate section. These setae are not any less distinct in older specimens, as was found by Hopkins in *Dendroctonus*, nor do they tend to disappear later, as found by Schedl in *Gnathotricus*. They are as pronounced at the end of the pupal period as at the beginning.

The head is not visible from above, being covered by the prothorax. None of the cephalic sutures are discernible, but the antennae and mouthparts are well set off. The antennae (*a*) are plainly geniculate and extend back beyond the prothorax. A faint indication of segmentation is present only on the club. The mandibles (*m*) are distinct and are pigmented even in the young pupae, but the maxillary lobes (*mx*) and labium (*l*) are rather indistinct. Somewhat overlapping the mandibles is a median labral-like lobe (*el*), the epistomal bristle pad (Hopkins), or epistomal lobe (Schedl). The eyes are not visible in young pupae but become so after they acquire pigment later on.

The shape and relative proportions of the pronotum (*p*) are very similar to those of the adult. On the mesothorax there is a large spiracle (*ms*) located in the triangle visible between the prothoracic femur, elytron and pronotum. The mesonotum is subrectangular and bears a rounded scutellar process (*sc*). The base of the elytron is fused to the tergal area. The metanotum (*t*3) exhibits a faint indication of a scutellar groove and a conspicuous posterior transverse band.

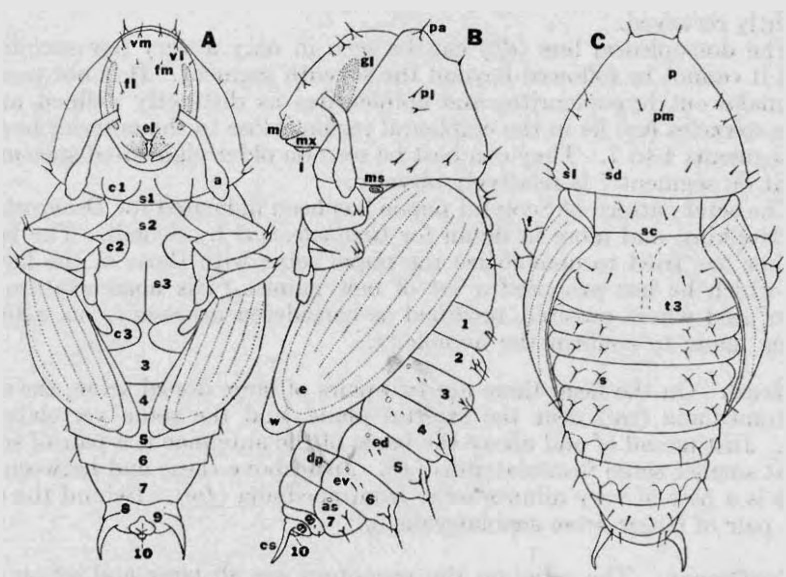

Figure 154. Pupa. A, ventral; B, lateral; and C, dorsal aspects. a, antenna; as, abdominal spiracle; cs, caudal spine; c1, prothoracic coxa; c2, mesothoracic coxa; c3, metathoracic coxa; dp, dorsopleural line; e, elytron; ed, setae epipleuricum dorsalis; el, epistomal lobe; ev, setae epipleuricum ventralis; f, setae femoralis; fl, setae frontolateralis; fm, setae frontomediana; gl, setae genolateralis; l, labium; m, mandible; ms, mesothoracic spiracle; mx, maxillary lobe; p, pronotum; pa, setae prescuti anterior; pl, setae prescuti lateralis; pm, setae prescuti medialis; s, setae scuti; sc, scutellar process; sd, setae scuti dorsalis; sl, setae scuti lateralis; s1, prosternum; s2, mesosternum; s3, metasternum; t3, metathoracic tergum; vl, setae vertolateralis; vm, setae vertomediana; w, metathoracic wing; 1 to 10, abdominal segments.

The prothoracic and mesothoracic legs are plainly visible for the most part, but of the metathoracic legs only the mesal portion of the coxae (*c*3) can be seen. The remainder of these legs is concealed by the elytra. Except for the distal end and part of the caudal border the metathoracic wings (*w*) are also concealed under the elytra (*e*).

In the abdomen there are 10 segments, of which the sternites of the first two are not exposed. Due to the ventral curvature of the abdomen, the ninth and tenth segments are not visible in a dorsal view. Segment nine is very small and is not clearly separated from eight ventrally. It bears from the laterocaudal angles two large processes, the caudal spines (*cs*). Segment ten is reduced to four minute lobes around the anus, the lateral ones perhaps representing epipleurites as in *Dendroctonus*, (Hopkins).

The sexes can be distinguished as in the adults. When looked at from the posterior end, not from above, it can be seen that tergite seven in the female is large, with an evenly rounded, markedly recurved, posterior border. A portion of tergite eight, about one-fifth to one-fourth as long as seven, is exposed. The lateral borders of this tergite converge caudad. In the male, tergite eight is almost as long as seven, the lateral edges are subparallel, and the posterior borders of tergites seven and eight are only slightly recurved.

The dorsopleural line (*dp*) can be seen in only a very few specimens, and it cannot be followed beyond the seventh segment. It is not possible to make out hypopleurites and epipleurites as distinctly defined areas. The spiracles (*as*) lie in the epipleural regions close to the anterior borders of segments 1 to 7. They can best be seen on older pigmented specimens. That on segment 7 is relatively obscure.

The setal pattern of Scolytid pupae has been indicated for *Dendroctonus* by Hopkins, and more in detail for *Gnathotrichus* by Schedl. The latter author has tried to homologize the pupal setae with those of the larvae, for which he has proposed a set of new names. His nomenclature has been used where possible, modified as considered necessary, no attempt being made to confirm the homology.

Head. On the head there are two pairs of large dorsal setae, the setae vertomediana (*vm*) near the sagittal plane, and the setae vertolateralis (*vl*). Just mesad of and above the bases of the antennae is a pair of somewhat smaller setae frontolateralis (*fl*). Just above these and between the eyes is a pair of very minute setae frontomediana (*fm*). Behind the eyes is a pair of larger setae genolateralis (*gl*).

Prothorax. The setae on the pronotum are all large and set on conspicuous cone-shaped elevations. There is a pair of setae prescuti anterior (*pa*) close to the cephalic border, a pair of setae prescuti medialis (*pm*) in the mid-dorsal region, and two pairs of setae prescuti lateralis (*pl*). Near the caudal border of the pronotum is a group of scutal setae arranged in almost a transverse row. These are one pair of setae scuti dorsalis (*sd*), and three pairs of setae scuti lateralis (*sl*).

Mesothorax and metathorax. The tergum of each of these segments carries two pairs of setae scuti, those on the metathorax lying farther laterad than those on the mesothorax.

Legs. At the distal end of each of the femora on both pro- and mesothoracic legs is a pair of setae femoralis (*f*), one apical in position and the other subapical. Schedl considers these remainders of the sternal setae of the larva. The metathoracic legs have no setae.

Abdomen. Two pairs of dorsal setae are borne on segments 1 to 8. These setae scuti (*s*) are increasingly larger from segments 1 to 6, as are likewise the conical elevations from which they arise. Those on segments 7 and 8 are usually much smaller than any on 1 to 6, sometimes being

Table 4. Variations in Setal Pattern in Pupae.

Location	Name of setae	Number of Individuals	Missing	Additional
Head	frontomediana	14	both	
	frontomediana	1		2 pairs
	frontomediana	1		1 pair
	genolateralis	8	both	
	genolateralis	2	right	
	genolateralis	1	left	
	frontolateralis	1	right	
	vertolateralis	1	right	
	vertomediana	1	right	
	frontolateralis	1	left	
Prothorax	prescuti medialis	2	right	
	prescuti medialis	2	left	
	prescuti lateralis	1	1 pair	
	scuti lateralis	1	1 pair	
	prescuti medialis	1		1 pair
Mesothorax	scuti	1	1 right	
	scuti	1	1 left	
Metathorax	scuti	2	1 right	
Abdomen 1	scuti	1	1 pair	
	scuti	1	1 right	
	epipleuricum	2		1 pair
Abdomen 2	scuti	2	1 left	
	epipleuricum	5		1 pair
	epipleuricum	2		2 pairs
Abdomen 3	epipleuricum	7	2 pairs	
	epipleuricum	8	1 pair	
Abdomen 4	scuti	1	1 right	
	scuti	1		1 left
	scuti	1		1 right
	epipleuricum	7	1 pair	
	epipleuricum	5	2 pairs	
Abdomen 5	scuti	1		1 left
	epipleuricum	7	1 pair	
	epipleuricum	3	2 pairs	
Abdomen 6	scuti	1		1 left
	scuti	2	1 right	
	scuti	2	1 left	
	epipleuricum	4	1 pair	
	epipleuricum	3	2 pairs	
Abdomen 7	scuti	3	1 pair	
	scuti	2	2 pairs	
	epipleuricum	1		1 pair
Abdomen 8	scuti	2	2 pairs	
Proleg	femoralis	4	1 pair	
	femoralis	2	1 right	
	femoralis	2	1 left	
Mesoleg	femoralis	2	1 pair	

minute. On segments 3 to 6 the epipleural region of each side bears a pair of setae epipleurica (*ev* and *ed*). They are very small, the dorsocephalic one (*ed*) being often minute and difficult to see. Occasionally segments 1 and 2 also may have setae epipleurica as indicated below.

Variations. On examining a number of pupae one cannot fail to notice the great variation in number, size and position of the setae. The preceding table indicates the extent of this variation among 28 individuals taken at random. This list does not include frequent instances of asymmetry of position, most common on the prothorax, nor of size, but accounts only for a difference in the number of setae, as compared with the arbitrary "standard" described above.

The Larva

The general appearance of the larva is shown in Figure 155 A. The following description is based upon the fully grown larva, but the earlier instars do not differ essentially from this. The larva is legless, wrinkled, subcylindrical, and curved so that the dorsum is convex. Except for the head capsule (*h*), which is yellow to brown and fairly hard, the body is creamy white and soft. It is capable of a considerable degree of contraction and expansion as well as of change of curvature. The fully grown larva is about 3.5 to 4 mm. long, and about 1.4 mm. wide at its widest part, the metathorax.

The head. The head capsule is about 0.8 to 0.9 mm. in width. This is about equal to the length from the posterior border of the occiput to the epistomal suture (*es*), or on the average about 7 per cent greater. If the clypeus and labrum are included, the length is about 1 mm. In the first instar larva, the head is much larger in proportion to the rest of the body (Figure 155 G). There are no ocelli, the antennae are quite rudimentary, and the mouthparts are fairly well developed. A discussion of the setae is given on page 646.

The epicranium is large and there are no sutures separating the parietal areas of it normally designated as occiput (*o*), vertex (*vx*), and gena (*ga*). There is a very distinct Y-shaped epicranial suture which is double-lined for most of its length. The median occipital apodeme (*oa*) is represented externally by a pigmented line continuing caudad of the coronal, or metopic suture (*rs*), and in like manner the frontal apodeme (*fa*) is represented cephalad on the frons.

The frons (*fr*) is a large triangular sclerite between the arms of the frontal part (*fs*) of the epicranial suture. It is deeply pigmented along its anterolateral angles where it is merged indistinctly with the epistoma

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prothorax; q, medial tooth; qm, setae palpo-maxillaris; qq, setae prescuti; r, precoila; ra, paracoila; rc, retractacuta; ro, postcoila; rs, coronal suture; rt, retractor tendon; sa, pleurostoma; sl, sternal lobe; sm, submental lobe; sp, spiracle; ss, setae sternalis; st, stipes; sx, mesothorax; tm, setae menti distalis; tx, metathorax; u, labrum; us, subgenal suture; v, postartis; vm, setae vertomediana; vs, setae vertolateralis; vv, vaginant membrane; vx, vertex; w, postgenal area; wa, pregenal area; ww, setae sternellaris; xe, epipharyngeal papillae; xf, maxillary foramen; xx, setae scuti; y, hypostoma; yb, entogular plate; yy, setae laterotergalis; z, apical tooth; zm, setae palpifera-maxillaris; zz, seta laterosternalis; 1 to 10, 1st to 10th abdominal segments.

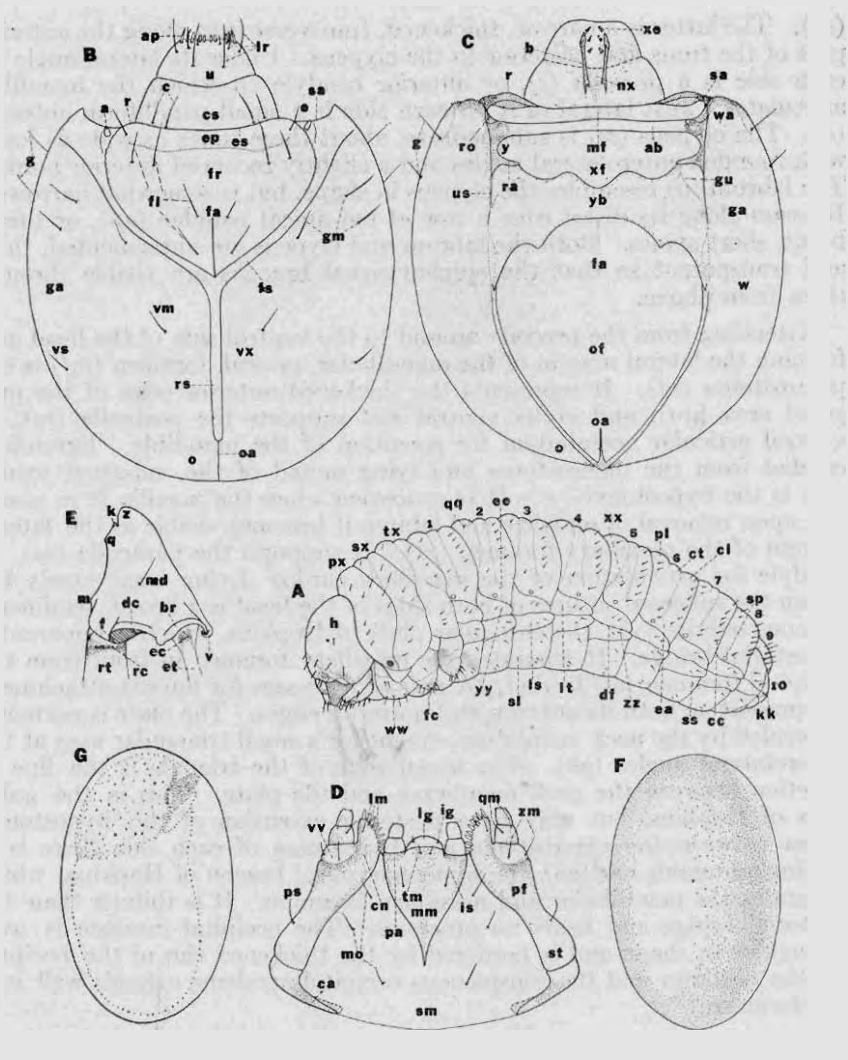

Figure 155. A, lateral aspect of fully grown larva. B, anterodorsal aspect of head. C, ventral aspect of head with mouthparts removed. D, ventral aspect of labium and maxillae. E, right mandible, dorsolateral aspect. F, egg. G, 1st instar larva ready to hatch from egg. a, antenna; ab, hypopharyngeal bracon; ap, apical papillae; b, epipharyngeal bracons; br, basal ridge; c, setae clypei; ca, cardo; cc, setae scutelli; cl, scutellar lobe; cn, lacinia; cs, clypeus; ct, scutal lobe; dc, preartis; df, dorsopleural fold; e, setae epistomalis; ea, epipleural area; ec, extensacuta; ee, seta epipleuricum; ep, epistoma; es, epistomal suture; et, extensor tendon; f, dorsal fossa; fa, frontal apodeme; fc, foot callus; fl, setae frontolateralis; fr, frons; fs, frontal suture; g, setae genolateralis; ga, genal area; gm, setae genomediana; gu, gular area; h, head; ig, setae ligulae; is, setae menti lateralis; k, subapical tooth; kk, setae analis; lg, ligula; lm, setae laciniomaxillaris; lr, setae labralis; ls, laterosternal lobe; lt, laterotergal lobe; m, molar tooth; md, seta mandibulae dorsalis; mf, mandibular foramen; mm, mentum; mo, setae submento-lateralis; nx, epipharynx; o, occiput; oa, occipital apodeme; of, occipital foramen; pa, palpigeral area; pf, palpifer; pl, prescutal lobe; ps, setae stipitis maxillaris; px,

(*ep*). The latter is a narrow, thickened, transverse area along the anterior part of the frons and posterior to the clypeus. Under its lateral angle on each side is a precoila (*r*), or anterior condyle on which the mandible articulates. Just lateral of it on each side is a small papilliform antenna (*a*). The clypeus (*cs*) is subquadrate, about three times as wide as long, with rounded anterolateral angles and a slightly recurved anterior border. The labrum (*u*) resembles the clypeus in shape, but is somewhat narrower. It bears along its distal edge a row of ten apical papillae (*ap*), or thick, blunt, short spines. Both the labrum and clypeus are unpigmented, thin, and transparent so that the epipharyngeal bracons are visible through them from above.

Extending from the precoila around to the ventral side of the head and forming the lateral margin of the mandibular, or oral, foramen (*mf*) is the pleurostoma (*sa*). It represents the thickened anterior edge of the pregenal area (*wa*), and at its ventral end supports the postcoila (*ro*), or ventral articular acetabulum for reception of the mandible. Extending caudad from the pleurostoma and lying mesad of the subgenal suture (*us*) is the hypostoma (*y*). It is concealed when the maxilla is in place, but upon removal of maxillae and labium it becomes visible as the lateral margin of the maxillary foramen (*xf*). It supports the paracoila (*ra*), or condyle for articulation of the maxillary cardo. Lying transversely between the subgenal sutures of both sides of the head is a broad, semimembranous sclerite (*yb*), the entogular plate of Hopkins, which is apparently a tentorial bridge. It separates the maxillary foramen in front from the occipital foramen (*of*) behind. A pair of processes for muscle attachment are present on both its anterior and posterior edges. The plate is normally concealed by the neck membrane, except for a small triangular area at the anterolateral angles (*gu*). The mesal edge of the triangle is the line of junction between the neck membrane and the plate. This is the gular area of Hopkins, but may be a posterior extension of the hypostoma. From between the pleurostoma and hypostoma of each side there is a semimembranous bar (*ab*), the hypopharyngeal bracon of Hopkins, which separates the mandibular and maxillary foramina. It is thinner than the tentorial bridge and bears no processes. The occipital foramen is ovo-triangular in shape and is bordered by the thickened rim of the occiput. At the posterior end the conspicuous occipital apodeme extends well into the foramen.

The epipharynx (*nx*) is a thickened lobe on the ventral side of the labrum and clypeus. It is furnished with two heavily sclerotized and pigmented rods, the bracons (*b*), which are thicker cephalad, and converge slightly caudad. Between the bracons on the anterior part of the epipharynx are three pairs of papillae (*xe*).

The mandible is short, stout, and heavily pigmented. It is slightly convex on the dorsal, and concave on the ventral surface where it comes in contact with the hypopharynx. The incisorial edge bears four teeth of which the proximal, or molar, is separated by a considerable diastema from the distal three. At the proximal edge of the lateral surface is a pronounced basal ridge (*br*). This ridge bears at its dorsal end the preartis for articulation to the precoila on the head, and at its ventral end the postartis (*v*) which articulates with the postcoila. From between these two articular condyles an extensor tendon (*et*) arises. This tendon is fairly well sclerotized to form an extensocuta (*ec*) near its base. A very broad retractor tendon (*rt*) is attached near the molar region. It contains a retractocuta (*rc*).

The labium is very large and conceals the greater part of the ventral side of the head. The submentum (*sm*) is a broad, semimembranous lobe, wider behind and lying between the maxillae. Its anterolateral angles extend forward to the labial palpi. The mentum (*mm*) is triangular, with its acuminate apex projecting caudad. It bears an indistinct palpigeral area (*pa*), and a pair of two-segmented palpi. The segments of the palpus are about equal in length, and the second is provided with several minute papillae at its apical end. The ligula (*lg*) is broad and supported between the palpi by the median part of the mentum.

The maxillae are relatively small and much less complicated in structure than those of the adult. The cardo (*ca*) is distinct with a transverse portion bearing the parartis which articulates with the paracoila on the head. **The anterolateral end of the cardo is expanded.** Extending forward from this is a long, narrow segment which is made up of a proximal stipes (*st*) indistinctly separated from a distal palpifer (*pf*) by a slight constriction. The anteromesal angle is produced into a lacinial lobe (*cn*) which is provided with nine teeth. There is a two-segmented palpus which is telescopic, the palpifer bearing at its distal end a large vaginant membrane (*vv*), which simulates a basal palpal segment. The second segment is slightly longer than the first and is provided with several apical papillae.

The hypopharynx lies on the dorsal side of the labium. It is approximately square on the face in contact with the labium and extends dorsad to fit against the ventral concave side of the mandibles.

Setal Pattern. As in the case of the pupae, the nomenclature proposed by Schedl is followed. He has modified the names as used by Russo (1926) for the larva of *Chaetoptelius vestitus* Fuchs. The head setae are all quite conspicuous and with a very few exceptions are large enough to be seen with the lower powers of the dissecting microscope. They are all shown in Figure 155. In Table 5 is given a list of the setae with the number occurring on each side of the head. This is taken from Schedl (who studied *Gnathotricus materiarius*), with the addition of figures for *H. rufipes* for comparison. In two places the names were modified slightly as was thought necessary. In the case of *Dendroctonus valens* the figures included in brackets were obtained from a comparison with Hopkins' illustrations and text, where such appear to differ from those given by Schedl.

When a fourth seta labralis is present, it is quite small and almost in line with the apical papillae, so that it is difficult to see. Two of the setae lacinio-maxillaris are in like manner obscured by the lacinial teeth. One of the setae palpo-maxillaris lies on the dorsal side of the palp and so is concealed from below. The seta on the mandible is difficult to see from above, but it can be seen by turning the mandible on its side.

TABLE 5. COMPARISON OF HEAD SETAL ARRANGEMENT*

Name of Setae	Abbreviation in Figure 155	H. rufipes	D. valens	C. vestitus	G. materiarius
frontolateralis	fl	4	4	4	6
epistomalis	e	1	1	1	1
clypei	c	2	1	2	1
labralis	lr	3 (or 4)	2	5	1
vertomediana	vm	1	? [1]	0	12
vertolateralis	vs	1	? [1]	0	2
genolateralis	g	2	? [2]	8	6
genomediana	gm	3	? [2]	4	5
epicrano-lateralis	—	0	? [0]	0	1
mandibulae-dorsalis	md	1	2	2	2
mandibulae-lateralis	—	0	1	1	1
stipitis maxillaris	ps	1	? [1]	1	1
palpiferae maxillaris	zm	2	? [2]	2	2
palpo-maxillaris	qm	2	0	1	1
lacinio-maxillaris	lm	3	0	1	3
submento-lateralis	mo	3	3	3	3
menti			0	0	1
lateralis	is	1	[1]		
distalis	tm	1	[1]		
labio-palpiferis	—	0	1 [0]	1	2
ligulae	ig	1	1		
distalis				1	1
mediana			0	0	1
basalis			0	1	1

*Figures are for one side of head.

THORAX

The three thoracic segments are about equal in size. The tergum of the prothorax (*px*) is undivided, but the meso- and metathoracic terga (*sx* and *tx*) each have two divisions, the anterior being the prescutal lobe, and the posterior, the scutellar. As pointed out by Hopkins, an indistinct lateral area may be considered the scutal lobe, for it extends dorsad slightly between the other two lobes. The ventral surface of each segment is divided into an anterior sternal lobe which is narrow at the sides but wide mesad and projects caudad over the posterior, or sternellar, area. Thus the sternellar area is represented externally by a pair of lateral lobes connected by a very narrow area which lies posterior to the sternal lobe. The sternellar lobe of each side has a circular foot callus (*fc*). These calli are beset with minute asperities. Pleural lobes are only faintly indicated, and the prothorax alone bears a spiracle. The setae will be discussed with those of the abdomen.

ABDOMEN

There are ten segments in the abdomen, the tenth being reduced to the anal lobes. The first to seventh segments are about the same size, but the eighth and ninth are smaller. Moreover, the tergites of the first seven are divided into three lobes, the prescutal (*pl*), scutal (*ct*), and scutellar (*cl*). The division between prescutal and scutal is less distinct on tergites six and seven, and the tergites of segments eight and nine are undivided transversely.

On the ventral surface of each segment is a single undivided sternal lobe (*sl*), but laterad of this is a small suboval lobe (*ls*) which was considered by Schedl to be the sternellar lobe. The fold (*df*) dorsal to this was taken for the pleural suture by Hopkins, who considered the lobe to be a hypopleuron. The lobe (*ll*) above this suture he considered the epipleuron, but Schedl called it the hypopleural plate, and reserved the term epipleural plate for the area above it (bearing the spiracle in segments 1 to 8). However, according to Snodgrass the groove between the two lateral lobes is undoubtedly the dorsopleural fold. The lobe dorsal to this fold he called the paratergal (1931) or laterotergal (1935). The lobe (sternellar of Schedl) ventral to this fold he called the abdominal pleuron (1931), but by analogy it is here termed the laterosternal. There is only one lateral lobe, the laterosternal, present on segment nine.

The abdominal spiracles are smaller than the one on the prothorax and much less conspicuous. That on segment one is often larger than the others. While there are no sclerotic plates or spines on the posterior segments as in *Dendroctonus*, the sternites of segments eight and nine are beset with minute asperities similar to those on the foot calli.

Setal pattern of thorax and abdomen. While the setae on the head are relatively large, thick, and easily visible, those on the thorax and abdomen are not so. With the exception of the setae surrounding the foot calli and those on the tergites of segments eight and nine, the setae are very fine and extremely difficult to see. Their thickness is necessarily exaggerated in the illustration.

In Table 6 is indicated the number of setae on the various body areas. As before, the names are from Schedl, modified where necessary. Segment nine has no spiracle or laterotergal lobe, but one seta is in a position corresponding to the epipleurica and two corresponging to the laterotergalis of preceding segments. The thoracic segments have no laterosternal lobes, but the setae lateral to the foot calli have been considered laterosternalis.

TABLE 6. BODY SETAL PATTERN*

Name of Setae	Abbreviation in Figure 155	Thorax			Abdomen					
		I	II	III	1-3	4-5	6-7	8	9	10
sternalis	ss	1	1	1	3	3	3	3	2	—
sternellaris	ww	7	7	6	—	—	—	—	—	—
laterotergalis	yy	—	—	—	2	2	2	2	2	—
laterosternalis	zz	2	1	1	2	2	2	1	—	—
scutelli	cc	3	4	4	5	6	6	6	5	—
scuti	xx	—	—	—	1	1	1	—	—	—
prescuti	qq	3	1	1	1	1	2	2	—	—
epipleurica	ee	3	3	3	1	1	1	1	1	—
analis	kk	—	—	—	—	—	—	—	—	1

* Figures are for one side of body

The Egg

As shown in Figure 155 F the egg is oblong-oval in shape. It is shining and pearly white. The average length of 113 eggs was 0.66 mm.; the average width, 0.38 mm.

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