SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 82, NUMBER 10

MORPHOLOGY OF THE BARK-BEETLES OF THE GENUS GNATHOTRICHUS EICHH.

BY
KARL E. SCHEDL

(PUBLICATION 3068)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
JANUARY 24, 1931

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 82, NUMBER 10

MORPHOLOGY OF THE BARK-BEETLES OF THE GENUS GNATHOTRICHUS EICHH.

BY
KARL E. SCHEDL

(PUBLICATION 3068)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
JANUARY 24, 1931

The Lord Baltimore Press
BALTIMORE, MD., U. S. A.

MORPHOLOGY OF THE BARK-BEETLES OF THE GENUS GNATHOTRICHUS EICHH.

By KARL E. SCHEDL

CONTENTS

INTRODUCTION

Since the early days of forest entomology, the superfamily of Scolytoidea has always fascinated the investigators working on forest insects. The destructive work of some of them, in spite of their relatively small size, and also their peculiar habits were undoubtedly the reasons for this extraordinary interest. However, with the cultivation of such crops as coffee, tea, and other subtropical crops these insects have become of greater interest to the economic entomologist in general.

The literature dealing with the nomenclature and the bionomics of species belonging to this superfamily is enormous. Several attempts have been made to construct a classification based on morphological characters. Other investigations were undertaken to homologize certain structures to act as a guide for the proper placing of the genera throughout the group. In this connection it is necessary to mention only a few authors, such as Lindemann, Eichhoff, Verhoeff, Hagedorn, Nuesslin, Fuchs, and Hopkins. However, up to the present there is comparatively little known in regard to the morphological, histological, and physiological details. There has been practically nothing published concerning the muscle structure, the respiratory system (with the exception of the number and position of the spiracles in the adults and in a few cases in the larvae), the circulatory system, the sensory organs, the blood, the nervous system, the metamorphosis, the histology, etc.

Concerning the control of the more important primary forest pests, hundreds of recommendations have been made by different authorities. However, all that have been made up to the present have failed to give satisfactory control under all conditions. The recent ideas of Seitner (53), used and enlarged by the Russian investigators Golovjanko (55) and Iljinsky (60), seem, in conjunction with more careful forest management, to represent the most hopeful direction for future work. Undoubtedly even these modern outlooks will require enormous further work to throw light upon the laws by which bark-beetle outbreaks are governed. After solving these problems the time will probably come when preventive measures will replace the expensive and often useless control methods of our day.

The following investigations are a tentative endeavor leading to a more intensive monograph of the genus *Gnathotrichus* Eichhoff. They have been carried out as a private study.

This first paper covers the chitinous skeleton of the adult, pupa and larva, the structure of the digestive system and the reproductive organs of the adult and larva. It is hoped later to publish two more

papers, one on the sensory and secretory organs, the muscle structure, the respiratory, circulatory, and nervous systems of the larva and imago; the other on the metamorphosis and histological investigations. Whether or not a biological study will complete the work depends upon the time at the author's disposal.

The study comprises only the North-American species *Gnathotrichus materiarius* Fitch, *sulcatus* Lec. and *retusus* Lec. The necessary material, dried and mounted adults of the two western species *Gn. sulcatus* Lec. and *retusus* Lec., was kindly provided the Dominion Entomological Branch from the Canadian National Collection in Ottawa. For the adults, pupae and larvae of *Gnathotrichus materiarius* Fitch, I have to thank Mr. L. J. Simpson, of the Dominion Entomological Laboratory, in Fredericton, N. B. All the necessary slides were prepared by the author. The specimens were dissected under water and the mounts imbedded in euporal. The drawings are all by the author, and were done with the aid of the camera lucida using transmitted light.

Attempts to obtain larvae and pupae of the western species were unsuccessful and therefore the discussion of the larval and pupal characters are based on material of *Gn. materiarius* Fitch only. A supplement on this account will be published in another paper.

Abstracts of the Literature up to Date

A. THE GENUS

1868. Eichhoff, W.(3).

Original description of the genus:

Tarsorum articulis tribus primis simplicibus. Antennarum funicolo 5-articulato, capitulo distincte triannulato. Ligula parte fulcrali angustior. Palpi labiales articulis primo et secundo subeaqualibus, simplicibus, tertio minimo. Maxillarum mala apice rotundata, setis falcatis densissimis ciliata, palporum articulo primo majore obconico, secundo minore subquadrato, tertio cylindrico elongato.

With respect to the position of the genus *Gnathotrichus* in the family *Scolytidae,* Eichhoff states:

Die Gattung lehnt sich durch die Form der Arten und dichte Bewimmerung der Maxillarlappen auf der einen Seite an die Gattung *Xyleborus,* auf der anderen an *Corthylus* und *Pterocyclon* an.

1876. Leconte, J. L., and Horn, H. G. (9).

Leconte, knowing of the new genus *Gnathotrichus* Eichh., still places the species of this genus under *Pityophthorus* Eichh. However, he subdivided the genus into subgroups, the first of which comprised the species of the present genus *Gnathotrichus* described at his time.

1878. Eichhoff, W.(11).

In the *Tomicini,* Eichhoff placed the Genus *Gnathotrichus* in his Section II, *Xylophagi,* subfamily *Xyleboridae.* The revised description of the genus as it was given on page 405 is:

Mentum oblongum, versus basin fortiter angustatum, post medium lateribus profunde sinuatum, et iterum versus apicem subdilatatum, apice rotundato; ligula linearis longa post medium menti inserta, versus apicem subdilatata, apice emarginata, angulis utrinque pilis longis munita. Palpi labiales valde elongati, articulis 1 et 2 longis, aequalibus, 3° parvo. Maxillae mala lata rotundata, pilis subtilibus longis intus ciliata, apice toto setis densissimis coactis cincta. Palpi maxillares articulis magnitudine gradatim decrescentibus, ultimo striis longitudinalibus obscuris notata. Antennae funiculo 5-articulato, articulo hujus 1° crassiusculo, bulbiformi, sequentibus multo minoribus, transversis, crassitie crescentibus; capitulo subgloboso, toto corneo, 3-articulato. Prosternum processu vix ullo. Episterna metathoracis a margine sinuato elytorum plane obtecta. Tibia lineares, extus remote denticulatae, apice truncatae. Tarsi haud recepti, articulis 1, 2, 3 aequalibus.

1883. Leconte, J. L., and Horn, H. G.(13).

The authors placed *Gnathotrichus* Eichhoff in their key to the genera in the subfamily *Scolytinae,* the Tribe *Tomicini* and Group *Corthyli.* In the group it was separated from *Corthylus* and *Monarthrum* by its five-jointed antennal funicle and from *Pityophthorus* and *Hypothenemus* by the fringed antennal club and the "outer part of the funicle very short" respectively.

1895. Blandford, W. F. H.(24).

Blandford placed *Gnathotrichus* in his subgroup V *Pityophthori* which comprises the genera *Styphlosoma* Blandford, *Dendroterus* Blandford, *Pityophthorus* Eichh. and *Gnathotrichus* Eichh. He regarded *Gnathotrichus* as standing midway between *Pityophthorus* and the *Corthyli.*

The author felt himself that the first two genera of this subgroup have very little in common with the latter two; they were included in this subgroup more on account of the difficulty of placing them elsewhere.

1909. Swaine, J. M.(40).

Only references to literature.

1910. Hagedorn, M.(42).

References only.

1910. Hagedorn, M.(41).

Based on the characters of the mouthparts, Hagedorn placed the genus *Gnathotrichus* in his subfamily *Saetidentatae.* His description is as follows:

Kaukante des Mittelkiefers mit Borsten besetzt.

Unfortunately he has, like other investigators, overlooked the long slender hairs of the lacinia. Therefore he misplaced the genus, which would, according to his interpretation of the characters used, fall in the subfamily *Mixtodentatae*.

1915. Hopkins, A. D.(48).

The author placed *Gnathotrichus* in his subfamily *Corthylinae*. No details.

1918. Swaine, J. M.(49).

The author placed the genus *Gnathotrichus* in his subfamily *Ipinae* in one group with *Conophthorus* Hopk., *Pseudopityophthorus* Sw. and *Pityophthorus* Eichh. The latter is separated from the rest of the *Ipinae* by the following characters:

Eyes not divided, antennal funicle 5-segmented, fore tibia more strongly widened, body nearly glabrous, pronotum with numerous asperities in front, the pronotum margined on the caudal border, and the metaepisternum largely covered by the elytra.

Gnathotrichus was distinguished from the other genera of this group by:

The mouthparts as seen from below rather sparsely clothed with slender hairs, the maxillary lobe pilose, body slender, very smooth, punctures and pubescens nearly obsolete except on the declivity; the pronotum closely but freely asperate in front, with an acute, arcuate, transverse, short carina at the summit, which is before the middle.

No generic description given.

1922. Blackman, M. W.(50).

Characters used by earlier authors were applied in placing the genus. The arrangement is similar to that of Swaine (49); but the author did not use Swaine's character "mouthparts densely covered with hairs."

1928. Blackman, M. W.(59).

The author uses the same characters as Swaine in separating the genus *Gnathotrichus* Eichh. from the rest of the *Pityophthorinae*. He regards the genera *Conophthorus* Hopkins, *Myeloborus* Blackman, *Pityophthorus* Eichhoff, *Pityoborus* Blackman, *Pityophilus* Blackman, *Pseudopityophthorus* Swaine and *Gnathotricus* Eichhoff as a compact division of the *Ipinae*.

B. GNATHOTRICHUS MATERIARIUS FITCH

1859. Fitch, Asa(1).

Original description:

Pine Timber-Beetle. *Tomicus materiarius,* new species. In the interior of the sap wood, mining slender straight cylindrical burrows in a transverse direction, parallel with the outer surface, from which very short straight lateral galleries branch off at right angles above and below; a rather slender cylindrical black shining bark-beetle, 0.15 long, with pale dull yellow legs and antennae, the fore part of its thorax and of its wing covers tinged with reddish yellow; the thorax equalling two-thirds the length of the wing covers, with a small elevated tubercle in the middle, forward of which it is rough from minute elevated points; the wing covers with rows of minute punctures, their tips rounded, the upper part of the declivity with a shallow longitudinal depression or groove along the suture, forming a slight notch.

The insects belonging to the genus *Tomicus* and kindred genera of the same family by their habits divide themselves into two distinct groups. The larger portion of them reside in or immediately beneath the bark of different trees and are currently termed bark-beetles. But this designation is inappropriate for another portion of them which dwell in the interior of the wood, and there excavate their galleries. The name timber-beetles appears to be the most appropriate for these. Another point in which, from the observations of M. Perris, these two groups appear to differ in a remarkable manner, is the relative numbers of the two sexes. With the bark-beetles there are commonly several males in company with but one female, and the former appear to perform the chief part of the labor in the excavation of their galleries. With the timber-beetles, on the other hand, the females are the most numerous, and probably mine their galleries without any assistance from the other sex. M. Perris states of one of the species, that upwards of fifty females were met with in the burrows they had excavated, without a single male being found there.

It is the habit of these timber-beetles to penetrate the tree in a straight line, passing inwards through the bark and into the sap wood to a depth of from half an inch to two inches, and then abruptly turning they extend their burrow in another straight line parallel with the outer surface and at right angles with the fibres of the wood, for the length of two to six inches. The only instance in which the burrow of the species now under consideration has come under my notice, was recently, in a billet of stove wood, which unfortunately did not contain the extreme end of the gallery. The annexed cut is an exact representation of this burrow, in which a live and dead beetle were found, both of them females, and the only specimens of this species which have come under my observation. The transverse burrow was excavated in the sap wood at a depth of half an inch from its outer surface. Near its middle it was crossed by another perforation extending from the outside directly towards the heart of the tree, which is indicated by a black dot in the figure; and at this point the burrow curved slightly outwards toward the exterior surface, as represented in the section above the principal figure in the cut; and at its end on the left where it passed out of the billet of wood, it commenced curving inwards towards the heart of the tree. Twelve lateral burrows

of the same diameter as the transverse one extended upwards and two downwards, as shown in the figure, all of the same length, each one having been excavated probably by a single larva. The gallery of our insect thus differs widely from that of the European species (*T. eurygaster* Erichson) which mines in the interior of the pine, which has no lateral burrows branching off from it.

The presence of these timber beetles in the wood can be distinguished from those which mine under the bark, by the little piles of sawdust which they throw out at the mouth of their burrows, this dust being so much more white and clean, and not composed in part of the brown or rust-colored particles of gnawed bark which are intermixed with the dust produced by the bark-beetles.

In addition to the short description of this beetle which is given above, it may be observed that the head is finely punctured, the punctures on the face giving out small pale yellowish hairs, whilst those on the vertex or crown are destitute of hairs, and there is a slight transverse elevation of the surface between the face and the vertex, from which an elevated smooth line extends backwards along the middle of the vertex. Thorax, when viewed from above, with its base transverse and rectilinear, its basal angles rectangular, its opposite sides parallel for a distance equalling the length of the base, and from thence rounded in a semicircle at its anterior end; its surface anteriorly with minute asperities, which, viewed vertically, appear like fine transverse wrinkles; its basal half with very minute punctures, and in its center a small transverse tubercle. Wing covers with fine shallow punctures in rows; the upper part of the apical declivity moderately depressed in the middle, producing a slight concavity in its outline when viewed from above anteriorly, the suture not elevated in this depression, but showing a slightly impressed line along each side; the hind end bearded with hairs similar to those upon the front. Under side black, the legs and antennae pale dull yellow.

1868. ZIMMERMAN, C.(4).

In the "Synopsis of the *Scolytidae* of America North of Mexico" the author placed *materiarius* Fitch in *Crypturgus* Erich. Distribution: North Carolina, and from Maine to Canada.

1868. EICHHOFF, W.(3).

Gnathotrichus corthyloides[1]: Valde elongatus, cylindricus, subopacus piceus, elytris basi dilutioribus, antennis pedibusque ferrugineis, thorace elongato cylindrico, antice asperato, disco subnodoso, postice omnium subtilissime vage punctulato, elytris subtiliter transversim aciculatis, subtilissime seriatim punctatis, declivitate postica convexiuscula, utrinque nodulo longitudinali a sutura remoto ornata. Long. 1⅓ Lin. Patria: America borealis, Carolina.

[1] "Ich vermuthe, dass *Gn. corthyloides* m. identisch ist mit *Crypturgus materiarius* = *Tomicus materiarius* Fitch (Noxious Ins. New York II. No. 24, 246), in der soeben von Mr. Leconte zum Geschenk erhaltenen 'Synopsis of the *Scolytidae* of America North of Mexico.'"

1869. Packard, A. S.(5).

P. 493:

A species, probably the *Cryphalus materiarius* of Fitch, has been found by Mr. Huntington, of Kelly's Island, to bore into empty wine casks and spoil them for use.

1876. Leconte, J. L., and Horn, H. G.(9).

Pityophthorus materiarius Fitch: Canada to Texas. Synonyms: *Tomicus materiarius* Fitch, *Crypturgus materiarius* Fitch (Zimmerman), *Gnathotrichus corthyloides* Eichh.

1877. Provancher, L'Abbe L.(10).

The author placed *Gn. materiarius* in *Gryphalus* Er. Found in red pine (le pin rouge). Rare.

1878. Eichhoff, W.(11).

The description of *materiarius* Fitch given by Eichhoff in his Ratio Tomicinorum is by far the most correct although it was published 50 years ago. Therefore it seems to be necessary to quote it here:

Linearis, cylindricus, nigro-piceus, subopacus, parce pilosellus, thorace elongato, anterius subtiliter rugoso-exasperato, posterius laevi, elytris basi dilutioribus, vix conspicue seriatim aciculato-punctulatis, apice rotundato, integro. Long. 3-3.2 mm.

Staturem fere et habitum coleopterorum ex genere *Pterocyclon* (*Corthylus fasciatus* Er.) exhibens, sed antennis aliter constructis. Caput deflexum, nigrum, subnitidum, fronte depressa, parce subtiliter punctata, linea media subelevata, laevi; pilis parcis, longioribus, adspersa, in margine antico non ciliato, ore inde denudato. Oculi oblongi, antice sinuati. Antennae ferugineo-testaceae, capitulo suborbiculari, compresso, subinfuscato, nitido, utraque pagina suturis duabus arcuatis notato, articulis subeaqualibus. Prothorax latitudine amplius, dimidio longior, cylindricus, basi truncatus, lateribus rectis, parallelis, apice obtuse rotundatus, angulis posticis (desuper intuenti) acute rectis; supra valde cylindrice convexus, piceus, dorso ante medium lineola transversa, elevata, notatus, anterius dilutior, subrufescens, rugis imbricatis subtiliter exasperatus, tenuissime pubescens, posterior glaber, subnitidus, laevis, imo vero oculo arcute armato, omnium subtilissime parce punctulatus. Scutellum piceum, sat magnum, triangulare, nitidum laeve. Elytra cylindrica, latitudine thoraxis et illo fere tertia parte longiora, basi truncata, humeris vix elevatis subrotundatis, lateribus rectis, a basi ad medium et ultra, post medium ad apicem fortiter rotundata; supra cylindrice convexa, nigro-picea vel brunneo-testacea, basi dilutiora, subnitida, versus apicem pilis paucis, seriatis adspersa, laevia, imo vero subtilissime lineato-punctato, interstitiis latissimis, transversim subtilissime aciculata strigulata, absque stria suturali; declivitas apicalis convexe rotundata, declivis, in singulo elytro tuberculo obsoleto, parum elevato, a sutura remoto, notata; margo apicalis communiter obtuse rotundatus. Corpus subtus nigro-piceum, cerebre subtiliter punctulatum, glabrum. Pedes ferrugineo-testacei, tibiis angustis, parum compressis, antrorsum vix dilatatis, tarsis testaceis.

Patria: America borealis (Carolina, Canada).

1881. PACKARD, A. S.(12).

The author does not bring out new facts but repeats the statements made by Fitch (1) and Perris. Also he mentions again the fact given in his "Guide to the Study of Insects." Nomenclature: *Pityophthorus materiarius* Fitch.

1886. SCHWARZ, E. A.(14).

Remarks on North American *Scolytids*:

Dr. Packard in his guide, p. 493 (see also Bull. 7, U. S. Ent. Comm., p. 174) states that "a species, probably the *Cryphalus materiarius* of Fitch, has been found . . . to bore into empty wine casks and spoil them for use." This is undoubtedly a confusion of species, as *C. materiarius* lives in pine trees. The species in question was probably *Xyleborus fuscatus,* which, in my experience, bores in several kinds of deciduous trees.

1890. SCHWARZ, E. A.(16).

Mr. Schwarz also stated that upon examination of about one hundred and fifty specimens of the common *Tomicus materiarius* Fitch (now *Gnathotrichus materiarius*) he had failed to find any males among them. In fact, the male sex appears to be never described. He alluded to the rarity of, and difficulty in finding, the males of most species of those *Scolytid* beetles which bore into the solid wood, because the males never leave the burrows.

Mr. Schwarz found *Pinus inops* as a host tree of *Gnathotrichus materiarius* Fitch.

1890. PACKARD, A. S.(15).

The author repeats nearly literally the statements of Fitch (1). No new facts.

1893. HOPKINS, A. D.(17).

Gnathotrichus materiarius Fitch. Timber-beetle. Enters green sap-wood at base stumps of dying trees. Causes "pin holes," "bluing," hastens decay. Infests pine.

Adults, May 8, July 13, October 15, May 3, November 7. Wood, Hampshire, Marion, Monongalia counties, West Virginia.

Enemies: *Hister parallelus* Say.

1894. HOPKINS, A. D.(20).

Gnathotrichus materiarius Fitch. Male = description of female. Female new. Antennae with long hairs and bristles as in *retusus*. Head smooth and sparsely punctured. Additional. Male head with elongated longitudinal elevation in front, ending in an acute point just above base of mandibles.

1895. BLANDFORD, W. F. H.(24).

Only references to literature.

1895. HAMILTON, J.(23).

Gnathotrichus materiarius, not rare, pine.

1897. Hubbard, H. G.(26).

Hubbard, like the first author, states that *Gnathotrichus materiarius* is an ambrosia beetle; that means that its main food consists of fungus mycelium. The latter is always abundant in the tunnels.

1899. Hopkins, A. D.(27).

Gnathotrichus materiarius Fitch. Very common in sap-wood of dead and dying pine and spruce trees, logs, and stumps; widely distributed.

Hister parallelus Say was found with *Gn. materiarius* in scrub pine wood. Kanawka Station.

1901. Felt, E. P.(28).

Taken from white and pitch pine, common.

1904. Hopkins, A. D.(31).

The eastern pine wood stainer. *Gnathotrichus materiarius* Fitch. Excavates several branching galleries from a single entrance burrow, the broods living in short side chambers in sap-wood and heart-wood of injured, dying, and recently felled pine and spruce. Eastern United States and Canada. Very common and injurious.

1905. Hopkins, A. D.(34).

The author describes a new species of *Gnathotrichus,* namely *nitidifrons* from Mexico. In a remark he mentions the near relationship to *materiarius* Fitch. and gives the range of the latter in pines as from Maine to Florida and Texas and in Picea from Maine to the higher mountains of North Carolina.

1905. Garman, H.(33).

Garman, in describing damages caused by *Monarthrum fasciatum* and *mali,* comes to the conclusion that those injuries mentioned by Packard (5) to wine casks are most probably the same.

1905. Currie, R. P.(32).

Copy of Hopkins, A. D.(17).

1906. Felt, E. P.(35).

No new data. Eastern pine wood stainer.

1907. Fall, H. C., and Cockerell, T. D. A.(36).

Gnathotrichus materiarius Fitch. Cloudcroft (Viereck).

1909. Swaine, J. M.(40).

References to literature only.

1910. Hagedorn, M.(41).

References only.

1918. Swaine, J. M.(49).

Host trees: Eastern pines, spruces, and eastern larch.

1922. Blackman, M. W.(50).

Author found it in only one locality in the Mississippi region (Agricultural College, loblolly pine). Otherwise it was found associated with *Platypus flavicornis* Fabr., *Ips calligraphus* Germ., and the clerid *Thaninisimus dubius* Fabr. Distribution: Eastern Canada, eastern United States, as far south as Texas and Florida.

Host trees: Pines, spruce and larch. In Mississippi, in loblolly pine.

C. GNATHOTRICHUS RETUSUS LEC.

1868. Leconte, J. L.(2).

Original description:

Cryphalus retusus. Cylindrical, slender, blackish-brown; base of elytra paler; antennae and feet yellowish; head prominent, convex, subcarinated, shining, sparsely punctured; prothorax nearly one-half longer than wide, sides slightly converging from the base and feebly rounded, tip strongly rounded, surface rough and sparsely hairy before the middle, granules tolerably coarse near the tip, behind the middle sparsely punctulate; elytra very finely rugose and distantly punctulate in rows, and with a few long hairs behind the middle, posterior declivity with a deep depression along the suture, limited each side by a longitudinal obtuse elevation, bearing on its highest portion a few very fine denticulations; suture not elevated. Long. 3.5 mm.

Collected in the coast region of California and Oregon by Doctor Horn. This species has the same form and sculpture as *C. materiarius,* but is larger and readily distinguished by the different sculpture of the posterior declivity of the elytra.

1876. Leconte, J. L., and Horn, H. G.(9).

Pityophthorus retusus Lec.: California, Oregon, Vancouver Island. Leconte doubted his formerly described *sulcatus* Lec. and is of the opinion that this is really the male of *retusus*.

1878. Eichhoff, W.(11).

Quotes Leconte's description.

1893. Hopkins, A. D.(17).

Gnathotrichus retusus Lec. Timber-beetles. Enters sap-wood. Causes pin holes and bluing. Infests white pine, also other pines. Adults from Virginia near West Virginia line, October 21. Adults dead in white pine wood, August 29. Monongalia county and Virginia. The only record of *retusus* in the eastern United States.

1894. Hopkins, A. D.(20).

In Leconte and Horn "*Rynchophora* of North America," the description of male is that of female; female description is of male. Additional: Male club of antennae with a few short, stiff hairs. No long bristles. Head with a longitudinal elevation

in front. Female antennae with a long bristle rising from the anterior edge of each joint of the funiculus, and the first and second joint of the club; also with a few long hairs, all curving upwards.

1906. Felt, E. P.(35).
Only reference to Hopkins (17).

1907. Fall, H. C., and Cockerell, T. D. A.(36).
Gnathotrichus retusus Lec. Gallinas Cañon (Doctor Snow).

1909. Swaine, J. M.(40).
References to literature only.

1910. Hagedorn, M.(42).
References only.

1914. Swaine, J. M.(47).
Swaine brings a short discussion of the habits of *Gn. retusus* Lec. and *sulcatus* Lec. In general it can be concluded that these habits are very similar to those of *Gn. materiarius* Fitch described by earlier authors. The author says:

The adult beetles excavate cylindric tunnels, about the diameter of a small pencil lead, from four to about six inches into the wood. The entrance tunnel, entering usually in the depth of a bark-fissure, passes directly through the bark and into the wood for from one to two inches; there branching takes place in a somewhat irregular fashion, though all parts of the set of tunnels extend in the same horizontal plane. Usually one long side-tunnel is cut shortly within the bark, parallel to the wood surface. The meal-like boring-dust and excrement are extruded through the entrance hole. Along the inner tunnels above and below, the females cut cup-like niches and deposit an elongate egg in each. The larva which hatches from the egg lengthens the niche in which it finds itself into a short tunnel or larval-cradle, slightly more than its own length when full grown, and transforms therein to the pupal stage, with its head toward the egg-tunnel. The pupa transforms to the adult in the cradle. The chief food of the larva, and an important food of the adult, is a peculiar fungus called Ambrosia, which grows in a dense glistening layer upon the walls of the tunnels and cradles. It penetrates the cut wood-cells and grows for a considerable distance along the vessels, but is entirely saprophytic in its relation to the wood. The walls of the tunnels are stained black for a millimeter or more in thickness. These, small, black, round, branching tunnels in the wood are characteristic of the Timber-beetles or Ambrosia-beetles.

The winter is passed by parent adults in the tunnels and cradles, and pupae and larvae of various sizes in the cradles. Apparently work is continued in these tunnels in the spring; and new tunnels are started by the young adults. A second brood appears and starts fresh tunnels early in August.

A considerable amount of injury is caused by these pine hole borers, and they are likely to become more numerous in the future, as cutting becomes more extensive. They breed in all dying trunks, and recently cut logs and stumps; never in dead and dry wood, and seldom, perhaps never, in perfectly healthy trees. The timber-beetles are particularly injurious in the west to fire injured timber. As a control measure it is suggested to pile the logs in a way that they may dry out quickly or when possible to place them in water.

1918. SWAINE, J. M.(49).

No new data concerning the description and biology. Host trees: Western hemlock, Douglas fir, western yellow pine. Distribution: Generally distributed through southern British Columbia and southward.

1922. HOPPING, R.(51).

Hopping gives for *Gn. retusus* Lec. the following Host trees: *Pinus ponderosa* Laws, *Pinus lambertiana* Dougl., *Pinus jeffreyi* Oreg. Com., *Pinus contorta* London, *Pseudotsuga taxifolia* Britt., and *Tsuga mertensiana* Bong.

D. GNATHOTRICHUS SULCATUS LEC.

1868. LECONTE, L. J.(2).

Original description:

Cryphalus sulcatus. Form, size and sculpture precisely the same as in *C. retusus,* except that the front is divergently aciculate, and the occiput is sparsely punctured; the elytra are similarly punctulate in rows, but the general surface is more distinctly and densely rugose; the retuse elevation of the posterior declivity of the elytra is but slightly prominent, and not denticulate; the hairs behind the middle of the elytra are less numerous. Long. 3.5 mm.

One specimen from the coast region of middle California was given me by Doctor Horn. The color is paler than that of the three specimens of *C. retusus* now before me, being yellowish-brown, with the base of the thorax and the sides and tip of the elytra darker. Probably more mature specimens would be darker; it is perhaps the female of the preceding, but having failed to find any sexual characters in *C. materiarius,* I am not warranted at present in so regarding it.

1876. LECONTE, J. L., and HORN, H. G.(9).

Pityophthorus sulcatus Lec. See under *retusus* Lec.

1878. EICHHOFF, W.(11).

Quotes Leconte's description.

1904. HOPKINS, A. D.(31).

Western hemlock wood stainer. *Gnathotrichus sulcatus* Lec. Excavates numerous branching galleries from a central burrow, the broods living in closely joined side chambers; in the sap-wood and heart-wood of western hemlock, Douglas spruce, giant arbor vitae, and fir. California to northern Washington; common in hemlock.

1905. Hopkins, A. D.(34).
The author examined one specimen from Chaleo and another from Michocan, Mexico, and suggested that Blandford's *Gnathotrichus consentaneus* is identical with *sulcatus* Lec.

1905. Currie, R. P.(32).
Copy of Hopkins, A. D. Fir is replaced by lowland fir.

1907. Fall, H. C., and Cockerell, T. D. A.(36).
Gnathotrichus sulcatus (Hopkins MS.). —— Beulah (Skinner).

1909. Swaine, T. M.(40).
References to literature only.

1910. Hagedorn, M.(42).
References only.

1914. Swaine, J. M.(47).
See *retusus* Lec.

1918. Swaine, J. M.(49).
No new data concerning the description and the biology. Host trees: Grand fir, western hemlock, Douglas fir, western white pine. Distribution: Generally distributed throughout southern British Columbia, extending southwards. In sap-wood and heart-wood of dying and recently killed trees, and more rarely in those apparently sound.

1922. Hopping, R.(51).
According to the author *Gn. sulcatus* breeds in the following host trees: *Pinus monticola* Dougl., *Abies concolor* Parry, *Abies magnifica* Murr., *Abies grandis* Lindl., *Pseudotsuga taxifolia* Britt., and *Tsuga heterophylla* Raf.

Synonyma

A. Gnathotrichus materiarius Fitch

Tomicus materiarius Fitch (Fitch, Schwartz, 1890, Packard, 1890).
Crypturgus materiarius Fitch (Zimmerman, Packard, 1869).
Gnathotrichus corthyloides Eichh.
Pityophthorus materiarius Fitch (Leconte, Packard, 1881).
Cryphalus materiarius Fitch (Provancher).

B. Gnathotrichus retusus Lec.

Cryphalus retusus Leconte, 1868.
Pityophthorus retusus Lec. (Leconte, 1876).

C. Gnathotrichus sulcatus Lec.

Cryphalus sulcatus Leconte, 1868.
Pityophthorus sulcatus Leconte, 1876.

Common Names

A. Gn. materiarius Fitch.
Pine timber-beetle (Fitch).
Timber-beetle (Hopkins, 1893).
Eastern pine wood stainer (Hopkins, 1904, Felt, 1906).

B. Gn. retusus Lec.
Timber-beetle (Hopkins, 1893, Swaine, 1914).
Pine hole borer (Swaine, 1914).

C. Gn. sulcatus Lec.
Western hemlock wood stainer (Hopkins, 1904).

The Chitinous Skeleton of the Adult

General Appearance, Vestiture, Color, and Size

The general form of all three species is slender in both sexes, cylindrical, with the head concealed from above by the pronotum. The pronotum is longer than wide with the sides parallel on more than the caudal half and broadly rounded in front. The elytra are slightly narrower or as wide as the pronotum, subparallel as far as the origin of the declivity, sometimes slightly tapering posteriorly; moderately broadly rounded behind.

Length and relative proportions. (Dorsal aspect).—
Gnathotrichus materiarius Fitch.
Length of the body (elytra and pronotum; head concealed from above), 3.06 mm.
The body is 3.11 times as long as the width of the pronotum.
Width of pronotum, 0.98 mm.
The elytra are 1.46 times as long as the pronotum.
Examined specimens, 12.

Gnathotrichus retusus Lec.
Length, 3.72 mm.
The body is 3.23 times as long as the width of the pronotum.
Width of the pronotum, 1.15 mm.
The elytra are 1.54 times as long as the pronotum.
Examined specimens, 10.

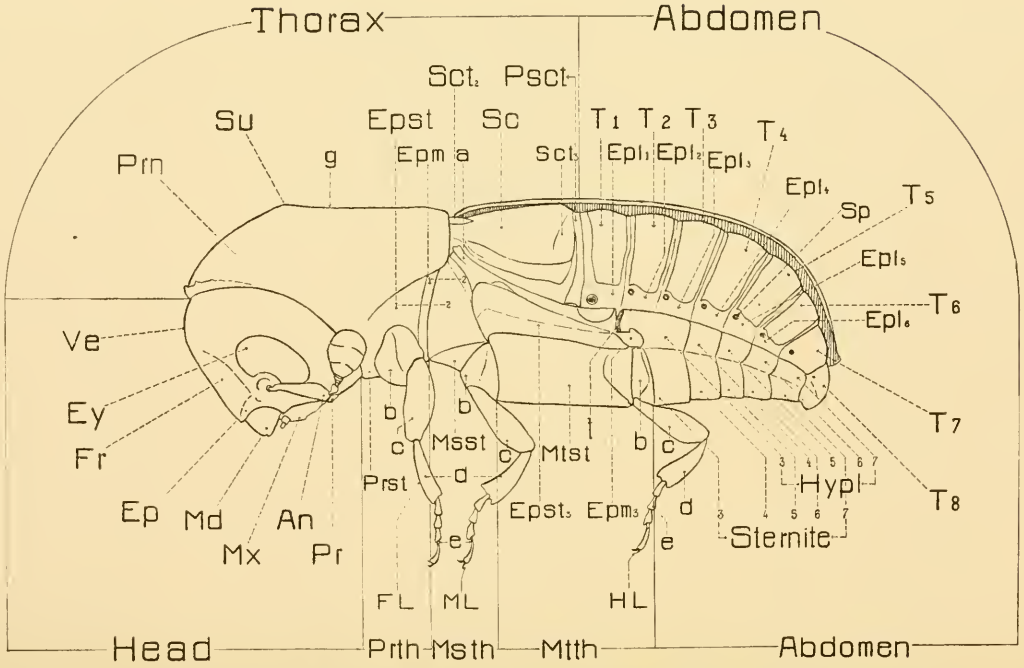

FIG. 1.—*Gnathotrichus materiarius* Fitch, adult male, lateral aspect.

An, antenna; *Ep*, epistoma; *Epl*, epipleurite; *Epm*, epimeron; *Epst*, episternum; *Ey*, compound eye; *HL*, hind legs; *Hypl*, hypopleurite; *FL*, forelegs; *Fr*, front; *Md*, mandible; *ML*, middle legs; *Msst*, mesosternum; *Msth*, mesothorax; *Mtst*, metasternum; *Mtth*, metathorax; *Mx*, maxilla; *Pr*, pregula; *Prn*, pronotum; *Prst*, prosternum; *Prth*, prothorax; *Prct*, prescutum; *Sc*, scutum; *Sct*, scutellum; *Sp*, spiracle; *Su*, summit; *T*, tergite; *Ve*, vertex; *a*, coracoid and clavicle process; *b*, coxa; *c*, femur; *d*, tibia; *e*, tarsus; *f*, lateral wing lock; *g*, transverse impression of pronotum.

Gnathotrichus sulcatus Lec.

Length, 3.59 mm.

The body is 3.38 times as long as the width of the pronotum.

Width of the pronotum, 1.07 mm.

The elytra are 1.60 times as long as the pronotum.

Examined specimens, 10.

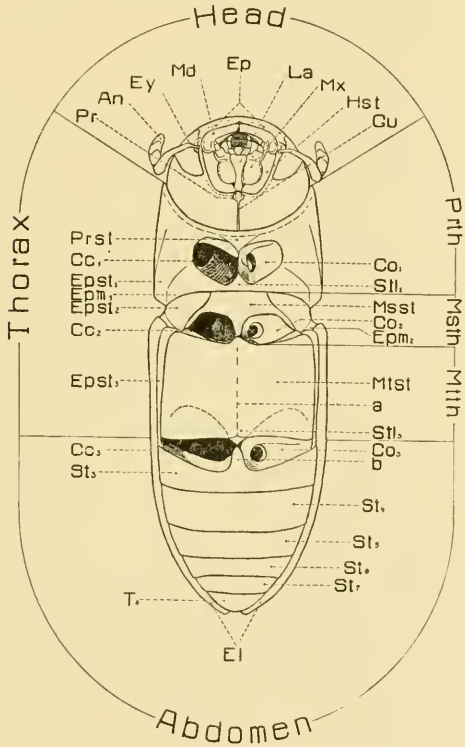

FIG. 2.—*Gnathotrichus materiarius* Fitch, adult male, ventral aspect.

An, antenna; *Cc*, coxal cavity; *Co*, coxa; *Ep*, epistoma; *Epm*, epimeron; *Epst*, episternum; *Ey*, compound eye; *Gu*, gular area; *Hst*, hypostoma; *La*, labium; *Msst*, mesosternum; *Msth*, mesothorax; *Md*, mandible; *Mtst*, metasternum; *Mtth*, metathorax; *Mx*, maxilla; *Pr*, pregula; *Prst*, prosternum; *Prth*, prothorax; *st*, sternite; *Stl*, sternellar area; *a*, median line.

Color.—The color ranges from a reddish-brown to nearly black in mature specimens; it is of no importance in this genus.

Vestiture.—In general it can be said that all three species are without extraordinary hair characters; few large bristles occur on the declivity. However, by careful examination under the microscope it was found that all external parts are more or less covered with fine hairs.

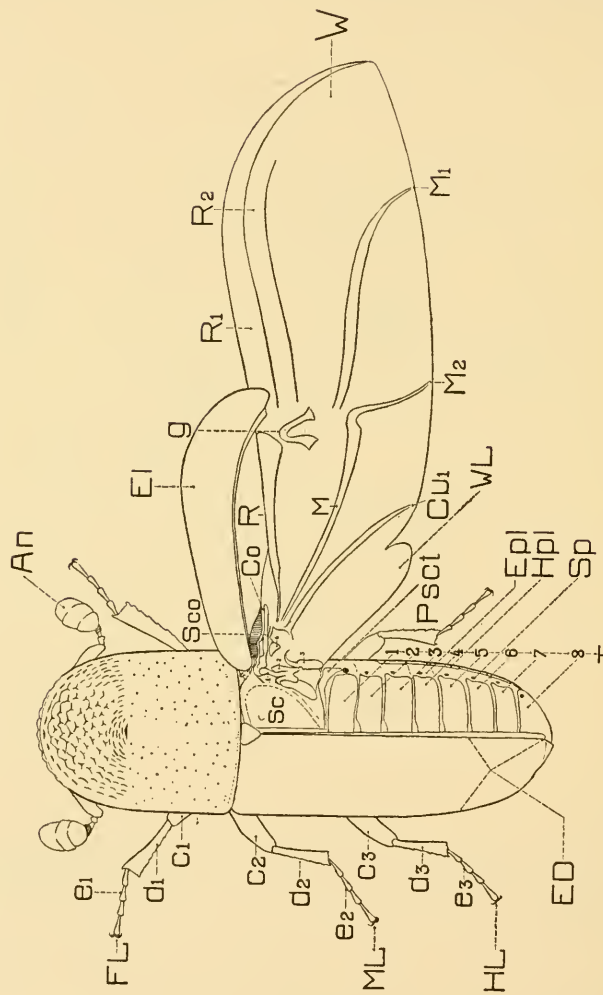

FIG. 3.—*Gnathotrichus materiarius* Fitch, adult male, dorsal aspect.

An, antenna; *Co*, coxa; *Cu*, cubitus; *ED*, elytra declivity; *El*, elytra; *Epl*, epipleurite; *FL*, fore legs; *HL*, hind legs; *Hpl*, hypopleurite; *M*, median veins; *ML*, middle legs; *Psct*, postnotum or postscutellum; *R*, radius; *Sc*, scutum of metathorax; *Sco*, subcostal vein; *Sp*, spiracle; *T*, tergite; *W*, metathoracic wing; *WL*, wing lobe; *c*, femur; *d*, tibia; *e*, tarsus; *g*, median folding hinge of wing; 1, 2, 3, 4, the four axillaries.

Sculpture.—The front and the elytral declivity are the only bearers of specific modifications. The sculpture of the pronotum and the elytra, which is very useful in distinguishing the species in many other genera of the *Scolytidae*, does not vary to any extent in this genus.

Secondary sexual characters.—Secondary sexual characters were found in the development of the hairs on the antennae, the number of fully developed tergites and in the number of spiracles mainly.

THE HEAD

The head capsula or cranium (figs. 4-7) is dorsally divided by the epicranial suture. The sutura fronto verticale Berlese or coronal suture (figs. 5, 6, Cos) is distinct in all three species examined. In *Gnathotrichus retusus* Lec., and less pronounced in *Gn. materiarius* Fitch, this suture and a short piece of the sutura metopica da Miall and Denny or frontal suture become elevated near the junction, forming a Y-like ridge. The slightly raised line (figs. 4, 5, a) which originates at the upper margin of the antennal groove (figs. 4, 6, b, 7, c) and which is directed toward this junction may be considered a remnant of the frontal suture. These anterior remnants of the frontal suture are never connected with the posterior portion.

Front.—The area between the frontal sutures is largely occupied by the frons (figs. 4, 5, 7, Fr). The shape of the front is plano-convex; the median line is slightly raised, and there is a shallow depression on each side of the latter. The front is sculptured by scratches which radiate from the center of the anterior margin, and which extend over the entire sclerite, becoming less distinct and less dense towards the outer margin. These scratches look as though they had been made with a needle point, and therefore have been called acciculation by several authors. Scattered over the acciculate area are small but deep, sparse punctures. Bristles varying from short to moderately long occur over the entire front; most of these originate in punctures. They are more numerous in the antero-lateral corners.

Specific modifications:—

A—Acciculation strongly developed, close; front with punctures near the outer margin and antero-lateral region only, with bristles very sparse in the acciculate area (fig. 5, Ac).

Gn. sulcatus Lec.

AA—Acciculation weakly developed or obsolescent, more or less restricted to the median anterior area; front elsewhere punctulate, bristles more numerous.

Gn. retusus Lec. and *materiarius* Fitch.

Labrum, clypeus and epistoma.—The labrum and clypeus are not evident as separate sclerites. The epistoma (figs. 4, 5, 7, ep), probably also containing elements of the labrum and clypeus, is not separated from the front by a distinct suture or line. It is present as a ridge and forms the anterior margin of the front. This region is widened laterally, and is connected with an elevation which surrounds the antennal

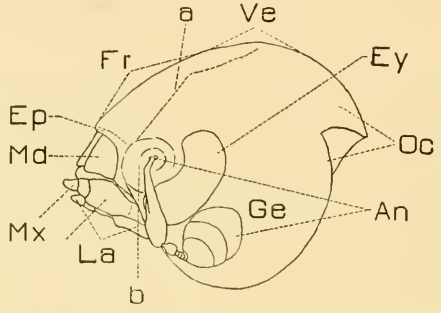

FIG. 4.—*Gnathotrichus sulcatus* Lec.: Head, lateral aspect.

An, antenna; *Ep*, epistoma; *Ey*, compound eye; *Fr*, frons; *Ge*, gena; *La*, labium; *Md*, mandible; *Mx*, maxilla; *Oc*, occipital area; *Ve*, vertex; *a*, frontal suture; *b*, antennal groove.

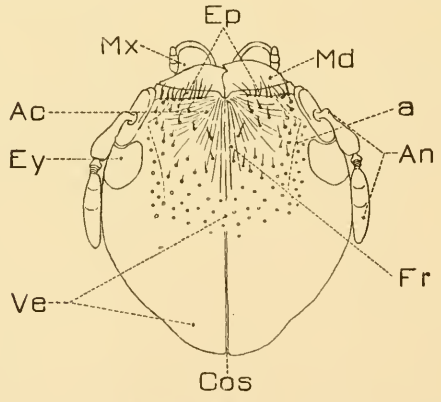

FIG. 5.—*Gnathotrichus sulcatus* Lec.: Head, dorsal aspect.

Ac, acciculation; *An*, antenna; *Ep*, epistoma; *Ey*, compound eye; *Fr*, frons; *Md*, mandible; *Mx*, maxilla; *Cos*, coronal suture; *Ve*, vertex; *a*, frontal suture.

scrobe. In the middle of the anterior margin, an evenly rounded emargination is visible which may be called serratus epistomalus (fig. 7, SE) and which corresponds to Hopkin's median impression. From the serratus epistomalus the acciculation of the front radiates. The epistoma is without sculpture and bears a row of bristles on its posterior margin. The mandibles articulate with the underside of the epistoma.

Gula.—The gula is bounded by the two very closely placed gular-sutures (figs. 6, 7, Gus) and widens anteriorly to form the pregula.

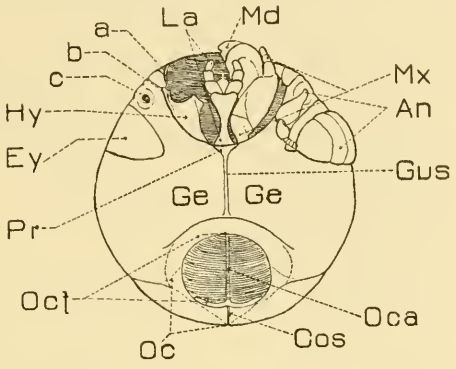

FIG. 6.—*Gnathotrichus sulcatus* Lec.: Head, ventral aspect.

An, antenna; *Cos*, coronal suture; *Ey*, compound eye; *Ge*, gena; *Gus*, gular sutures; *Hy*, hypostoma; *La*, labium; *Md*, mandible; *Mx*, maxilla; *Oc*, occipital area; *Oca*, occipital apodeme; *Oct*, occipital foramen; *Pr*, pregula; *a*, dorsal articulation of the mandible; *b*, ventral articulation of the mandible; *c*, antennal groove.

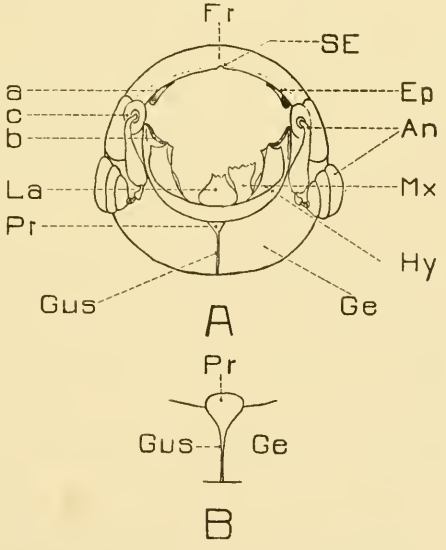

FIG. 7.—A, *Gnathotrichus sulcatus* Lec.: Head, oral aspect. B, *Gnathotrichus retusus* Lec.: Pregula.

An, antenna; *Ep*, epistoma; *Ge*, gena; *Gus*, gular sutures; *Fr*, frons; *Hy*, hypostoma; *La*, labium; *Mx*, maxilla; *Pr*, pregula; *SE*, serratus epistomalus; *a*, dorsal articulation of mandibles; *b*, ventral articulation of mandibles; *c*, antennal groove.

These two distinct sutures appear to be exceptional in this family. Hopkins apparently did not find any double sutures in his investigations.

In *Gnathotrichus*, the pregula (figs. 6, 7, Pr) is always without sculpture or hairs. The very distinct specific modifications are described in the following key:

A—Pregula flat, triangular, not produced anteriorly, its anterior margin continuous with those of the gena.

Gn. sulcatus Lec.

AA—Pregula convex, produced anteriorly, its anterior not continuous with those of the gena.

B—Pregula very convex, extending far beyond the genal margin.

Gn. retusus Lec.

BB—Pregula feebly convex, extending slightly beyond the genal margin.

Gn. materiarius Fitch.

Epicranium.—The remaining lobes of the cranium situated between the epicranial suture, the gula, and the foramen bear the compound eyes (figs. 4-6, Ey), the antennae and the articulations of the mouthparts. For merely descriptive purposes these lateral areas of the cranium have been divided into several regions. The occipital area (figs. 4, 6, Oc) surrounding the occipital foramen is not limited anteriorly in *Gnathotrichus*. However, there occur obscure lines which may be regarded as homologous with the occipital suture. The epicranium or parietals (Crampton), the gena, and the vertex do not show any sculpture which exhibits specific differences. The hypostoma (Hopkins) (figs. 6, 7, Hy), an area corresponding to the epistoma, which like the former belongs morphologically to the epicranium, is well developed.[1] It is in the form of a semicircular band and bears at its extremities the ventral articulations (figs. 6, 7 b) of the mandibles. From the oral aspect it is visible; from the ventral, it is hidden by the pregula and the gena.

Other regions, such as the pregena (Hopkins), etc., are not at all distinct or limited and are therefore of no interest in this discussion.

THE APPENDAGES OF THE HEAD

THE ANTENNAE

The antennae present good generic characters; the species modifications are less important. The sexual differences are distinct also. All the longer setae of the antennae are feathered.

[1] The hypostoma, as the term is used here, or the ventral angles of the postgena, is the bearer of the maxillare and not the labium. A submentum, as this term was used by Hopkins in *Dendroctonus*, is not defined by sutures.

The scape (fig. 8, A, S) is slender and clavate toward the apex. Hairs and punctures are rather sparse. The scape is about as long as the funicle and the club together. The funicle (fig. 8, A, F) is

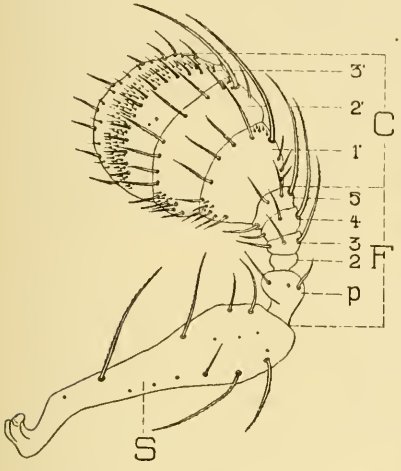

FIG. 8, A.—*Gnathotrichus retusus* Lec., adult female: Antenna, internolateral aspect.

C, antennal club; *F*, funicle; *S*, scape; *p*, pedicle; 2, 3, 4, 5, joint of the funicle; 1′, 2′, 3′, joints of the club.

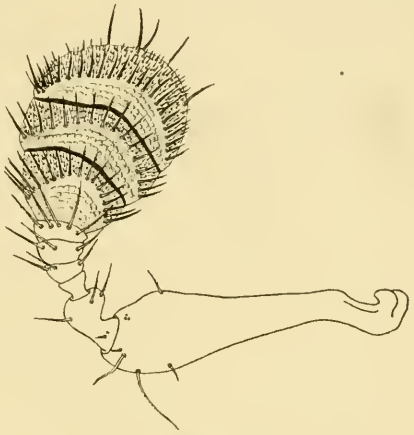

FIG. 8, B.—*Gnathotrichus retusus* Lec., adult female: Antenna, externolateral aspect.

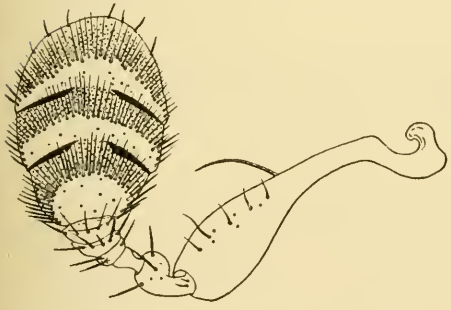

FIG. 8, C.—*Gnathotrichus sulcatus* Lec., adult male: Antenna, externolateral aspect.

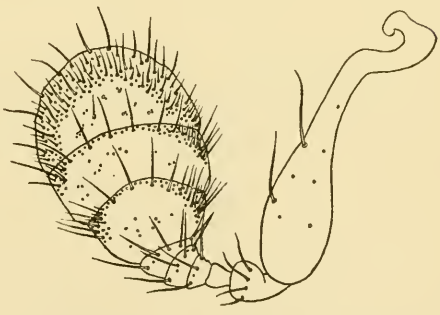

FIG. 8, D.—*Gnathotrichus sulcatus* Lec., adult male: Antenna, internolateral aspect.

five-jointed and distinctly shorter than the club. The pedicle (fig. 8, A. p) the first and longest of all joints, is as long as joint two and three together. The setae and punctures are more concentrated on the apical half of the pedicle, only two small bristles occurring near the basal articulation (fig. 8, B). The other joints decrease in

length but increase in width towards the club. All the joints bear numerous punctures and hairs except the second which has neither. The club (fig. 8, A, C) is from 1.21 to 1.35 times as long as wide, egg-shaped in outline, widest near the apex and strongly compressed. Two nearly continuous septate sutures divide the club into three joints. The first and third joints are nearly equal in length; the second is distinctly shorter. The septae are arcuate and distinctly visible from the externo-lateral aspect (fig. 8, B, C). On the interno-lateral side (fig. 8, A, D) they are indicated by single sutures. Each of the joints is covered by numerous hairs and punctures. Externo-laterally these are closely placed and arranged in arcuate rows; interno-laterally, they are sparse, and the punctures are more numerous.

The females (fig. 8, A) bear, moreover, on the interno-anterior margin of the club a few very long hairs. The anterior setae of the third, fourth, and fifth joints of the funicle are longer in this sex. These are the only external characters by which the sexes may be distinguished when the elytra are kept in the closed position.

Specific modifications:—

A—Septae in the form of continuous bands of equal width throughout, slightly less pronounced medially; externo-lateral side of the club with minute, transverse wrinkles and small punctures producing a slightly roughened surface (fig. 8, A, B).

Gn. retusus Lec.

AA—Septae wider laterally, indistinct and narrow medially; externo-lateral side of the club smooth or with very minute, sparse wrinkles; club stouter.

B—Externo-lateral side of the club smooth, interno-lateral side with numerous hairs and punctures (fig. 8, C).

Gn. sulcatus Lec.

BB—Externo-lateral side of the club with minute wrinkles, interno-lateral side with very few hairs and few punctures; club very stout.

Gn. materiarius Fitch.

THE MOUTHPARTS

The mouthparts present generic as well as specific characters. They include the mandibles, the first maxilla and the second maxillae or labium.

Mandibles.—The mandibles (fig. 9) are very much alike in all three species, so much so that it is not possible to distinguish them by mandibular characters. The shape is stout and triangular as in most Scolytidae. The apical tooth (fig. 9, a) and the subapical tooth (fig. 9, b) are well developed and separated by a deep emargination. In contrast to other genera, two median teeth (fig. 9, c) occur. The latter are rather feebly developed and the separating emargination is shallow. The molar tooth (fig. 9, d) is evenly rounded. There are one lateral and two dorsal setae (fig. 9, f, g). Other details are illustrated in figure 9. No specific differences have been found in these.

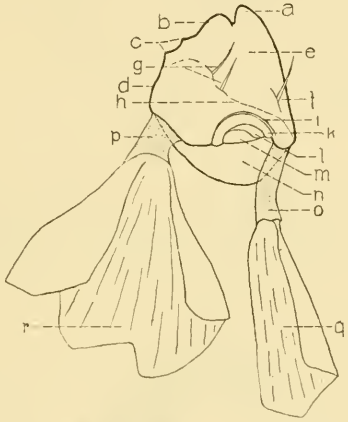

FIG. 9.—*Gnathotrichus materiarius* Fitch: Mandible, dorsal aspect.

a, apical tooth; *b*, subapical tooth; *c*, median teeth; *d*, molar tooth; *e*, dorsal area; *f*, lateral bristle; *g*, dorsal bristles; *h*, transverse ridge; *i*, anterior fossa; *k*, condyle; *l*, posterior fossa; *m*, posterior impression; *n*, condyle of ventral articulation; *o*, extensor tendon; *p*, retractor tendon; *q*, extensor disk; *r*, retractor disk.

The Maxilla.—The maxillae (figs. 2, 6) are exposed on each side of the labium. Each is held in such a way that the cardo is parallel with the long axis of the head; the stipes, lacinia, and galea are at right angles to the cardo; the second and third palpial joints are slightly curved outwards. The galea and lacinia are represented by two lobes which are fused except at the apex where they are separated by a moderately deep notch. The stipes is separated from these fused lobes by a very fine, feeble suture on the outer side; on the inner side, no suture is evident. Another paper will deal with the generic differences in the maxilla of *Gnathotrichus* Eichh. and related genera. Nevertheless, it should be noted that, as far as known at present, the labium and the maxillae in the genus *Pityophtorus* Eichh. always bear at least a few feathered bristles; in *Gnathotrichus*

Eichh. these bristles are simple. This is important, as it has been seen that the character "maxilla spinose" in *Pityophthorus* Eichh. and "maxilla pilose" in *Gnathotrichus* Eichh., as used by several

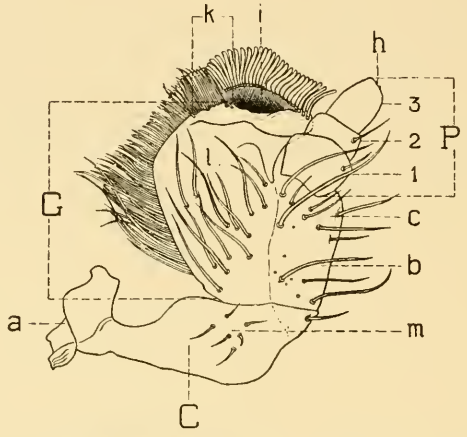

FIG. 10.—*Gnathotrichus sulcatus* Lec.: Maxilla, outer aspect.

C, cardo; *G*, galea; *P*, palpus; 1, 2, 3, first, second and third joint of the palpus; *a*, articulation of the maxilla; *b*, stipes; *c*, palpiferal area; *i*, anterior emargination separating galea and lacinia; *k*, dorsal setae of the galea; *l*, median setae of the galea; *m*, cardol setae.

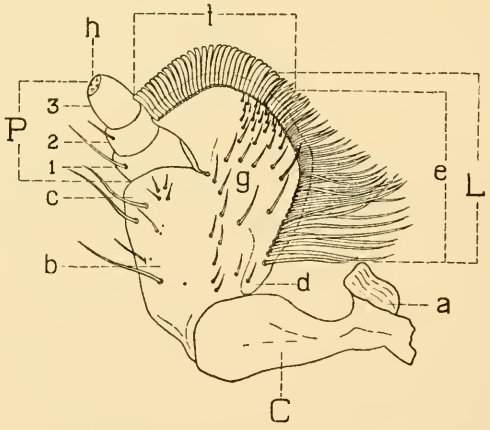

FIG. 11.—*Gnathotrichus sulcatus* Lec.: Maxilla, inner aspect.

C, cardo; *L*, lacinia; *P*, palpus; 1, 2, 3, first, second and third joint of the palpus; *a*, articulation of the maxilla; *b*, stipes; *c*, palpiferal area; *d*, subgaleal area; *e*, posterior setae of the lacinia; *f*, dorsal setae of the lacinia; *g*, median setae of the lacinia; *h*, papilla.

authors to separate *Gnathotrichus* Eichh. from the rest of the *Pityophthorinae* does not hold, as will be shown in the discussion of the lacinia and galea. The maxillae exhibit no specific differences of importance in *Gnathotrichus*. The maxillae are illustrated in figures 10 and 11.

Cardo.—The cardo (C) is similar in shape in all three species and is articulated with the ventral angles of the postgena in such a way that the maxilla can be moved laterally as well as in a dorsal-ventral plane. The longitudinal axis of the cardo and that of the stipes (b) enclose an angle of about ninety degrees or even a little less. The articulation of the stipes and the cardo is similar to that of other genera of the family. There is also an articulation between the subgalea and the cardo. In figure 12, which illustrates this fact, the cardo and the rest of the maxilla are stretched to show the connection. The inner side of the cardo is smooth; the outer side shows from five to seven hairs which may be called the cardol setae (m).

Stipes.—On the outer side the stipes is defined as an elongate, subparallel sclerite; on the inner side it is fused with the lacinia. The

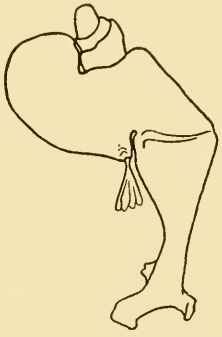

FIG. 12.—*Gnathotrichus materiarius* Fitch.: Maxilla, stretched, the subgalea showing.

setae are not very numerous, about six to eight being present. These are more concentrated anteriorly near the base and near the apex. The latter, situated on the apical area of the stipes, may correspond to the palpiferal setae of some authors. The palpifer (c) being a topographical area of the stipes only, is not limited by lines or sutures.

Lacinia and galea.—The lobus internus or the lacinia and the lobus externus or the galea are largely fused to form a single large lobe. Apically they are distinctly separated by a moderately deep emargination (i) or notch. The inner free lobe is distinctly larger than the outer one. Posteriorly they are fused. It will need much further investigation to decide the exact areas of these two lobes. In the meantime it is proposed to call the inner lobe and the inner surface of the combined lobes the lacinia and the outer free lobe and the outer surface of the fused part the galea.

The lacinia bears on the anterior portion of the free dorsal margin short, stout, blunt setae (f) which are slightly incurved at their tips.

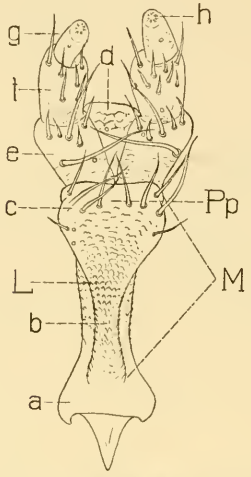

FIG. 13, A.—*Gnathotrichus retusus* Lec.: Labium, ventral aspect.

L, ligula; *M*, mentum; *Pp*, palpifer; *a*, base of ligula; *b*, neck of mentum; *c*, ventral setae of the palpifer; *d*, anterior part of ligula; *e*, first joint of palpus; *f*, second joint of palpus; *g*, third joint of palpus.

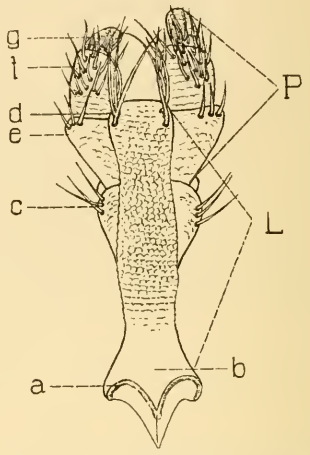

FIG. 13, B.—*Gnathotrichus retusus* Lec.: Labium, dorsal aspect.

P, palpus; *L*, ligula; *a*, articulation of the labium; *b*, base of ligula; *c*, dorso-lateral setae of the palpifer; *d*, dorso-anterior setae of the ligula; *e*, *f*, *g*, first, second, and third joint of the palpus.

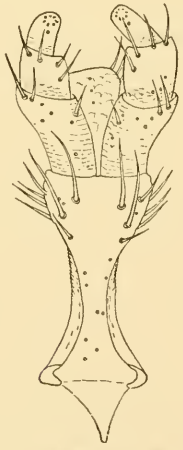

FIG. 13, C.—*Gnathotrichus sulcatus* Lec.: Labium, ventral aspect.

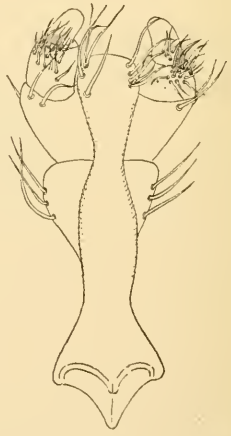

FIG. 13, D.—*Gnathotrichus sulcatus* Lec.: Labium, dorsal aspect.

These setae gradually become longer, more slender, and pointed posteriorly (e). Near the subgaleal area (fig. 11, d) they are about three times as long as on the dorsal margin. Besides these setae on the outer

margin of the lacinia numerous bristles (g) are scattered over the entire lobe; the surface is slightly reticulate. Basally, the united lacinia and galea end in a lobe, the subgaleal area (d), which is distinctly defined on the inner side by an impressed line. The galea bears a short row of slender setae (k) on its free dorsal margin; the surface is armed with rather sparse, long hairs (e).

Adopting the terms of other authors, it may be said the lacinia is pilose on its dorsal margin and spinose on its posterior and that the galea is spinose.

Palpi.—The palpi (P) are three-jointed. The first joint is the longest, the second and the third are subequal in length. Anteriorly joints one and two bear setae, joint three punctures only. There occur slight differences in the size and the shape of the joints in the species, but they are not distinct enough to be of importance.

Labium.—The labium (fig. 13), consisting of the mentum, the ligula, and the palpi mainly, presents the most important generic and specific characters of the mouthparts.

The shape of the mentum (fig. 13, M) is similar in all three species. It is flask shaped, the palpifera always being wider than the neck (fig. 13, b) and the base of the mentum and the latter always narrower than the ligula (fig. 13, L). The basal portion of the mentum is feebly widened in *Gn. retusus* Lec. (fig. 13, A) and strongly widened in *Gn. materiarius* and *sulcatus* (fig. 13, C). In *Gn. sulcatus* and *materiarius,* the mentum and the ligula are separated by deep sutures throughout, even at the extreme base of the ligula; in *retusus* they are similarly distinct except at the extreme base before which they completely disappear. The sculpture of the mentum on the ventral side (fig. 13, C), except for a few distinct punctures, is smooth in *Gn. sulcatus. Gn. materiarius* is very similar but it shows slight evidences of transverse wrinkles also. In *Gn. retusus* the punctures are obsolete; the wrinkles are strongly developed and become on the neck of the mentum and the basal half of the palpifer more or less toothlike (fig. 13, A). All the setae are simple bristles (c), and there are eight to ten of these bristles on each half of the ventro-lateral side of the apical third of the palpifer. In *Gn. retusus* and *materiarius* there are ten of these bristles; in *sulcatus* eight is the usual number.

Ligula.—In this genus, the ligula (L) is much larger and more prominent than is usual; it is wider than the mentum in its basal half and is distinctly limited by sutures at the extreme base of the labium except in *retusus.* The ligula (fig. 13, L) extends in all three species a little farther anteriorly than the first joint of the palpus. Its

shape is elongate; it is subparallel with two more or less distinct contractions when viewed from the dorsal aspect. The basal portion is semicircular in cross-section, while the anterior, unfused part is strongly compressed. In *Gn. retusus* Lec., the ligula is more parallel and the contractions less distinct than in the other species.

The anterior margin is very feebly, shallowly emarginate or evenly rounded; however, this does not seem to be constant in individuals of the same species. On the ventral aspect, there is on each side near the anterior margin a row of setae (d). No specific differences have been found either in the shape or in the number of these setae which vary in number from three to seven in each row. The sculpture of the ligula on the ventral aspect in all three species is very much alike, being nearly smooth or feebly transversely wrinkled. Dorsally *Gn. retusus* shows similar transverse, toothlike wrinkles on the mentum; the basal portion only is smooth. *Gn. materiarius* and *sulcatus* have the corresponding area smooth with slight indications of transverse wrinkles on the sides.

Palpi.—The palpi are directed ventrad. Each is composed of three segments, decreasing in size toward the apex. Segments two and three bear dorsally a plush-like arrangement of hairs, while the first joint has a few scattered hairs only. Ventrally, the setae are more sparse and are intermixed with punctures on segments one and two; segment three has no setae but a few punctures.

Summary of the specific characters:—

A—Base of the mentum scarcely widened basally, fused with the ligula before the basal margin of the latter; mentum and ligula when seen from above with strongly developed, toothlike, transverse wrinkles; ligula subparallel. *Gn. retusus* Lec.

AA—Base of the mentum distinctly widened basally, extending to the basal margin of the labium; mentum and ligula when seen from below smooth or with slight indications of transverse wrinkles; contractions of the ligula well developed.

B—Ventral side of the mentum smooth, with few punctures. *Gn. sulcatus* Lec.

BB—Ventral side of the mentum with transverse wrinkles. *Gn. materiarius* Fitch.

THE THORAX

The three segments of the thorax, pro-, meso-, and metathorax (figs. 1, 2 and 3) are clearly defined in this genus as is usual in this family. Each of these segments has as a basis three primitive ele-

ments, the dorsal plate, or tergum, the ventral plate, or sternum, and the lateral area, or pleuron. The thoracic segments and their elements vary considerably in shape and size. The protergum, or pronotum, is nearly twice as long as the tergum of the metathorax. The mesotergum, still shorter than the latter, is represented by a short triangular area only. The prosternum is about half as long as the metasternum and about one-third the length of the pronotum, giving the pleural area of the prothorax the shape of a trapezium. The mesosternum is present as a plate nearly equal in size to the mesotergum; the mesopleura are also developed in proportion, giving the mesothorax the shape of a short tube. The metathorax, more complicated in structure, represents the segment in which all three primitive elements are well developed and defined.

THE PROTHORAX

In the prothorax the tergal, pleural and sternal areas (fig. 14) are fused, forming a continuous chitinous tube. However, corresponding elements to other thoracic segments are visible due to the different kinds of sculpture. Taxonomically the prothorax bears generic characters but none of specific importance. The two openings of the tube-like prothorax, the anterior and posterior foramina, are bordered by a fringe of closely placed hairs which arise from the inner margin.

Pronotum.—The pronotum (figs. 1, 2, 3 and 14) is one solid plate by which the head is concealed. The dimensions are as follows:

Gn. materiarius Fitch.,	length, 1.23 mm.,	width, 0.98 mm.
Gn. retusus Lec.,	length, 1.44 mm.,	width, 1.15 mm.
Gn. sulcatus Lec,	length, 1.35 mm.,	width, 1.07 mm.

The measurements are the average of 10 specimens from each species.

Seen from above, the sides of the pronotum are subparallel on the posterior margin, while the anterior margin is broadly rounded. The anterior margin bears 10 to 16 low serrations which are only slightly longer toward the median line and sometimes fused at their base. On the anterior area, that is, the area in front of the summit which consists of a short slightly curved ridge and is placed a short distance before the middle of the pronotum, occur many comparatively small and low serrations arranged in concentric rows and decreasing in size towards the summit. Behind the summit the surface of the pronotum is covered with punctures. There are two kinds of punctures; the one comparatively coarse in contrast to the other but fine compared to those in other nearly related genera; the other, minute and only

visible under higher magnification. The coarser punctures are sparse, deep and distinct, the minute ones closely placed giving this part of the pronotum a more opaque appearance. The posterior margin is slightly arcuate. Immediately anterior to the posterior margin there is an impressed line giving the intermediate space the appearance of a low ridge. This raised margin served as one of the main characters in placing this genus near *Pityophthorus* and allied genera. The pronotum is covered with inconspicuous hairs which are longer and

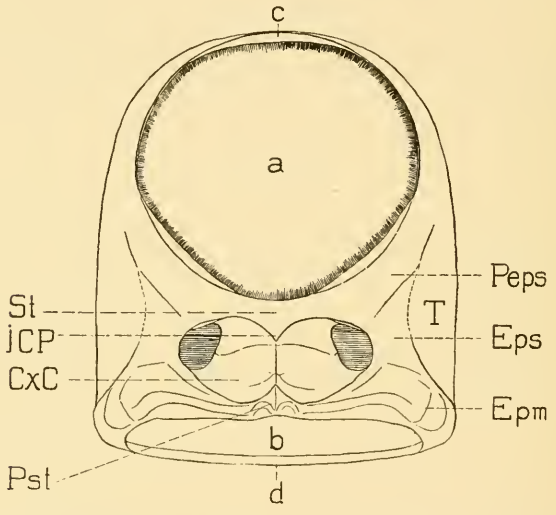

FIG. 14.—*Gnathotrichus sulcatus* Lec.: Prothorax, ventral aspect.

a, anterior foramen; *b*, posterior foramen; *c*, anterior margin of pronotum; *d*, posterior margin of pronotum; *CxC*, coxal cavities; *Epm*, epimeral area; *Eps*, episternal area; *ICP*, intercoxal process; *Peps*, preepisternal area; *Pst*, poststernal area; *St*, sternal area; *T*, tergum or pronotum.

coarser anteriorly. Posterior to the summit occurs a shallow transverse impression. The lateral limitations of the pronotum are not clearly defined but near the postero-lateral angle is a longitudinal ridge which may be considered as a remainder of the pleuro-notal suture.

Pleural area.—The propleural area (fig. 14) is represented as one continuous plate in the shape of a trapezium of which the base is formed by the remainders of the pleuro-notal suture. Ventrally the pleural area is completely fused with the prosternum (St). Externally no sufficiently distinct lines are present to justify the distinction of subdivisional plates as episternum, epimeron, etc. Nevertheless there can be distinguished three parts of different structure which one may call the preepisternal (Peps), the episternal (Eps) and the epimeral

area (Epm). The preepisternal area is flattened, slightly depressed with a surface smooth except for a few minute wrinkles parallel to the longer axis. The episternal area is entirely covered by continuations of the serrations which occur on the anterior half of the pronotum. A narrow strip along the posterior margin of the propleuron, quite distinctly limited to the surrounding plates by its transverse wrinkles, may be called the epimeral area.

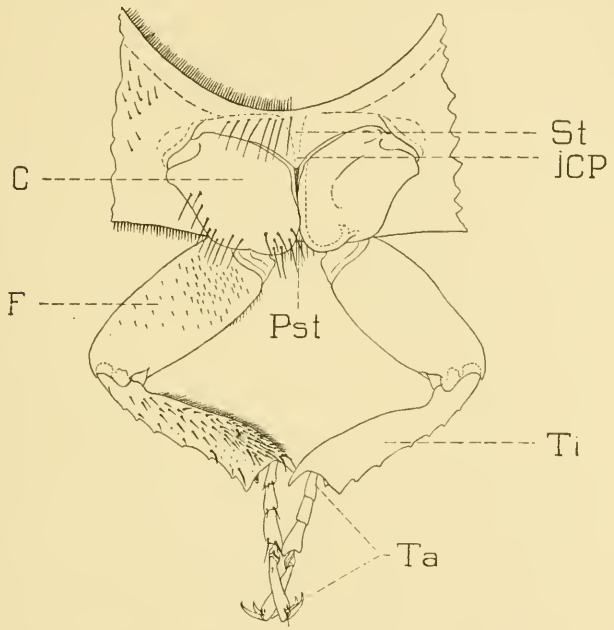

FIG. 15.—*Gnathotrichus retusus* Lec.: Prosternum and fore legs.
C, coxa; *F*, femur; *ICP*, intercostal process; *Pst*, poststernal area; *St*, sternal area; *Ta*, tarsus; *Ti*, tibia.

Sternal area.—The lateral ill-defined sternal area is largely occupied by the coxal cavities (CxC). The intercoxal process (ICP) belonging to the intercoxal or sternellar plate is clearly defined and very short so that the coxae touch each other. The sternum proper and the presternal area are again not limited by sutures but by differences in sculpture.

Prothorax.—The distinguishing characters of the prothorax are:

1. The pronotum of *Gn. materiarius* Fitch is a little more slender than that of *Gn. retusus* Lec. and *sulcatus* Lec.
2. The punctures of the posterior half of the pronotum of *Gn. retusus* Lec. are somewhat coarser than in the case of the others.

THE MESOTHORAX

The mesothorax is the shortest of the three thoracic segments. The form is that of a ring with the anterior diameter smaller than the posterior one. The meso- and metathorax are very closely connected, giving the appearance of one single unit. Seen from above (dorsal) the scutellum only is visible, while in the lateral and ventral aspect the mesopleura and the mesosterna can be distinguished. The two

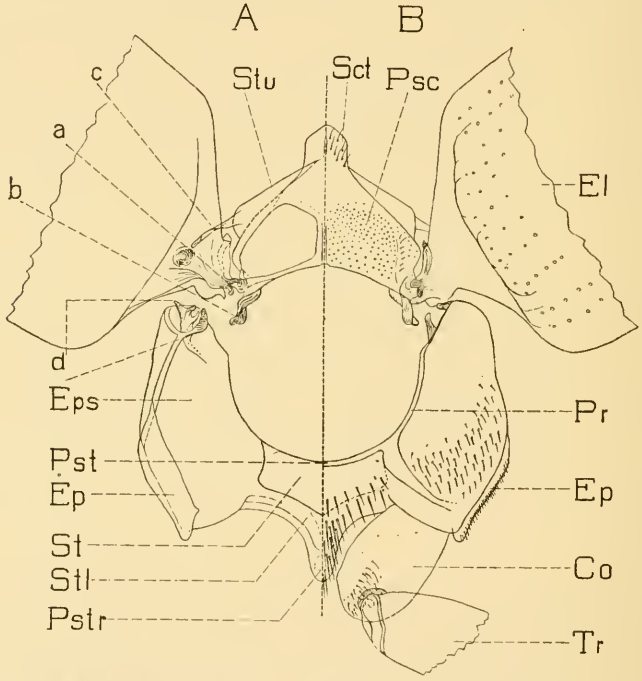

FIG. 16.—*Gnathotrichus retusus* Lec.: Mesothorax, view from anterior foramen. The parts are disconnected by stretching under the coverglass.

A, external aspect; *B*, internal aspect; *Co*, coxa; *El*, elytra; *Ep*, epimeron; *Pr*, preepisternum; *Psc*, prescutum; *Eps*, episternum; *Pst*, presternum; *Pstr*, poststernellum; *Sct*, scutellum; *St*, sternum; *Stl*, sternellum; *Stu*, scutum; *Tr*, trochanter; *a*, articulation of elytra; *b*, clavicola; *c*, pleural hook of scutum; *d*, pleural clavicola.

pairs of appendages are implanted between the pleura and tergum and the pleura and sternum respectively.

Mesonotum.—From the mesonotum or tergum only the scutellum is exposed dorsally. The rest of the notum is covered by the elytra laterally and is hidden by the pronotum anteriorly.

The scutellum.—The scutellum (fig. 16, Sct) is a triangular plate, heavily chitinized, covered with short bristles, and externo-anteriorly fused with the prescutum. There occur slight differences in shape in the different species but they are of no importance.

Scutum.—The scutum (fig. 16, Stu) is represented as two slightly chitinized lobes which are anteriorly fused with the prescutum. The posterior ends are free and lie under the scutellum. A long slender pleural hook (c) originates near the extreme lateral angle.

Prescutum.—The largest area of the mesonotum is occupied by the triangular prescutum (fig. 16, Psc). Externally it forms with the scutellum a smooth continuous plate. The inner side consists of two large and shallow excavations which are surrounded by heavily chitinized ridges. The median ridge is anteriorly divided by two closely placed sutures. Obscure remainders of these sutures are also visible externally and on the scutellum. The extreme anterior corners of the prescutum are produced into two prominent hooks which may correspond to Hopkins' " Lateral arm of prephragma and prescutum " or Korschelt's " Zapenfortsatz des Mesonotums," or Berlese's " clavicola." The clavicola (b) is hinged in parts of the pleural claviculas. At a short distance behind the clavicola is a well developed prealar process which embraces the third axillary of the elytra. On the anterior two-thirds of the prescutum, numerous small punctures are visible externally and near the lateral margin occurs a single row of minute hairs.

The prephragma and the postscutellum are not represented by separate plates. Remainders of the former are probably the wide anterior ridge of the prescutum.

Mesopleura.—The mesopleura are distinctly defined from the tergum and sternum. The largest area of each is occupied by the episternum (Eps) which is a strongly chitinized plate, elongate, with the lateral dorsal area smooth and with a fine pubescence on the lateral ventral area. A narrow strip in front of the episternum, which is defined externally by a suture, and a continuation of it towards the ventral posterior angle of the episternum, may represent the preepisternum. Dorsally the preepisternum is produced into the clavicolar-disk. Under the ventral half of the episternum projects a narrow plate, the epimeron (Ep). Preepisternum and epimeron are structureless but the latter bears on its posterior margin a row of fine hairs.

Mesosternum: Presternum.—A narrow ridgelike plate which is fused with the preepisternum (fig. 16, Pr) of the pleura represents the presternum (Pst). The rest of the sternum is externally defined from this by a suture. Internally the suture is obsolate.

Sternum.—The sternum (St) is a rectangular plate with its posterior side produced into an angle, externally fused with the sternellar area or intercoxal process (Stl) but internally defined by a suture. The outer surface is smooth and bears a row of bristles and also a few punctures.

Sternellar area.—The sternellar area is strongly produced posteriorly and internally defined by a suture from the postero-sternellar piece.

Poststernellar area.—This piece (Pstr) is a narrow continuation from the sternellar area. Externally both are covered with long bristles.

THE METATHORAX

Metatergum.—The general appearance and structure is illustrated in figures 1, 2 and 3, which also show the two main parts, namely the notum and the postnotum, or pseudonotum, as the postnotum is often called. The latter is well developed and connected with the notum by a transparent membrane (a). The dorsal aspect of the metatergum is shown in figure 17; the inner in figure 19.

Metanotum.—The metanotum (figs. 17, 19) is typical in *Gnathotrichus* in so far as the prescutum (Psc) is only loosely connected with the scutum (Sct). The connection consists medially of a transparent membrane (b); laterally the extreme ends of the posterior prealar process (d) are fused with the lateral margin of the scutular lobes. In this connection it should be mentioned that Hopkins' prescutal lobe seems more likely to be a part of the scutum than of the prescutum. Other modifications are the overlapping of the scutum beyond the posterior prealar process and the development of the scutellum.

The metanotum is clearly defined into three transverse divisions which are the prescutum, the scutum and the scutellum.

Prescutum.—The prescutum (Psc) forms a well developed transverse band extending from pleuron to pleuron. Medially it is bent downwards, forming a ventral reflected lobe which may correspond to the prephragma in other insects. A precosta is not present as a plate defined by lines or sculpture. On the level of the interior origin of the anterior apodeme a suture extends interiorly separating the posterior prealar process from the prescutum proper. This process extends laterally, is covered by the scutular lobe and is fused with it at the extreme end. From the antero-lateral corners of the prescutum proper originate two prominent hooks, the anterior prealar processes (f). Laterally to the anterior prealar process are two disklike formations on each side (g, h) connected with the posterior prealar process. According to Hopkins, the posterior disk (prescutal disk) serves for the small muscles connecting it with the pleural clavicula. A rather intensive investigation would be necessary to determine the purpose of all these formations and homologize them with similar equivalent parts in other groups.

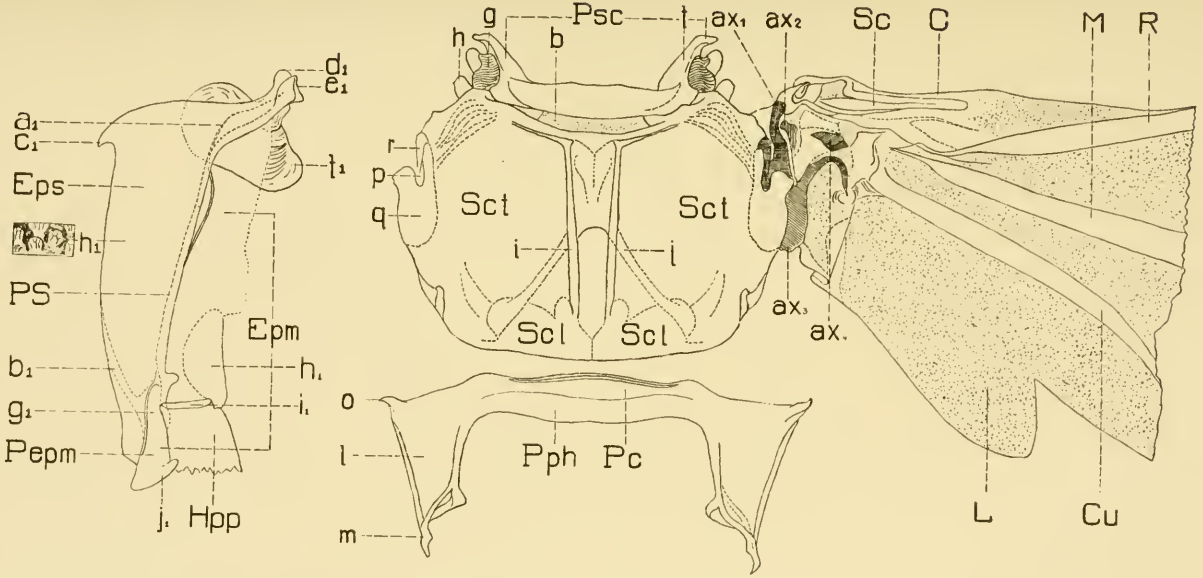

FIG. 17.—*Gnathotrichus retusus* Lec.: Metatergum and metapleuron, dorsal aspect and lateral aspect respectively.

C, costal vein; *Cu*, cubital vein; *Epm*, epimeron of metapleuron; *Eps*, episternum of metapleuron; *M*, median vein; *Pc*, precosta of postnotum; *Pepm*, postepimeron of metapleuron; *Pph*, postphragma of postnotum; *PS*, pleural suture; *Psc*, prescutum; *R*, radial view; *Sc*, subcostal vein; *Scl*, scutellum; *Sct*, scutum; *Hpp*, hypopleurite; *L*, posterior wing lobe; ax_{1-4}, axillaries of the wing base; *b*, anterior membrane; *g*, anterior prescutellar disk; *h*, posterior prescutellar disk; *i*, scuto-scutellar suture; *j*, median apodeme or endodorsum; *f*, anterior prealar process; *l*, prealar bridge of postnotum, or postscutellum; *m*, prealar hook of postnotum; *o*, pleural hook; *p*, lateral emargination; *q*, lateral impression; *r*, scapular hook; a_1, anterior branch of pleural suture; b_1, posterior branch of pleural suture; c_1, anterior ventral angle of episternum; d_1, clavicle process; e_1, caracoid process; f_1, pronator disk; g_1, epimeral suture; h_1, structure of episternum; i_1, lateral wing lock; j_1, postepimeral hook.

Scutum.—The largest plate of the metanotum is the scutum extending backward from the anterior membrane (b). The limitation between the scutum and the scutellum, the scuto-scutellar suture, is visible as a ventrally elevated ridge which becomes indistinct laterally. The anterior apodeme divides the scutum in two subdivisions, the scutum proper and the scutular lobes. The latter extend beyond the posterior prealar process of the prescutum as was stated above and cover the process dorsally. Externally the scutum is one continuous half spherical plate medially divided by the scutular groove. Internally projections of the scutellum extend far into the scutum. From the inner externo-lateral corners of the scutum proper arise two pairs of parapsidal ridges (k) which converge in a slightly curved line medially.

Scutellum.—The scutellum, which is posteriorly limited by a membrane (a), encloses the scutum in a half circle. The scuto-scutellar suture is produced anteriorly forming the lateral limitations of the scutellar groove. It extends to the anterior margin of the scutum. The space between the produced suture is strongly depressed externally forming a wide scutellar groove. The posterior end of the mesoscutellum rests in this groove. From the posterior lateral corners of the scutellum arise two armlike formations which converge anteriorly meeting at about the middle of the scutum. These formations correspond to the endodorsum (Amans), V-shaped ridge (Snodgrass), or median apodeme (Hopkins). Where they join they are connected with the scutellar groove. It is likely that the intensive study of the endodorsum of the Scolytidae will bring out many new features for the systematic arrangement of this group.

Postnotum.—The postnotum or pseudonotum is subdivided into three transverse divisions, the precosta (Pc), with the prominent prealar bridges (l) and the postphragma (Pph). The precosta is a simple band separated from the postphragma by the postnotal apodeme. Laterally it is produced into prominent prealar bridges. The inner margin is developed as a heavily chitinized ridge which is posteriorly divided, forming a ring and externally produced into a slender hook, the prealar hook (m).

The postphragma is a slightly ventrally bended band. The postnotum is visible externally, giving the appearance of a reduced tergum at the first abdominal segment.

Metapleura.—The pleuron of the metathorax (fig. 17) consists chiefly of two plates, the episternum (fig. 17, Eps) and the epimeron (Epm). The pleural suture (Ps) is externally represented as a distinct line, internally as a ridgelike structure. From the pleural suture

branch three other sutures or ridges. Anteriorly there is a short suture dividing the parapterum from the wing process; posteriodorsally another ridge separates the postepimeron (Pepm) from the rest of the epimeron. Ventrally another ridge indicates that part of the episternum which is covered by the sternum and the metacoxa.

Episternum.—The episternum is an externally continuous plate having the shape of a narrow triangle with the base facing forward. Ventro-anteriorly it is produced into a hooklike angle, the sternal hook (c_1) or anterior sternal hook of Hopkins. The sternal hook fits into an emargination of the sternum, the clavicula (fig. 18, d). Dorsally the extreme angle of the episternum with the pleural suture (probably also containing elements of the epimeron) is produced into the parapterum (e), or coracoid process, and the wing process, or clavicular process (d). From the underside of the parapterum originates a well-developed pronator, or muscle disk (fig. 17, t_1). The episternum is heavily chitinized and covered by numerous large punctures which are interlaced by a network of fine ridges. See also figure 17, h_1. When the elytra are kept in the closed position the metapleura are nearly completely hidden by them.

Epimeron.—Between the pleural suture and the lateral margin of the metanotum a more flexible, partly membranous sclerite is inserted. Posteriorly it is subdivided by a branch of the pleural suture separating the postepimeron from the epimeron proper. While the epimeron proper is more membranous and flexible, the postepimeron is more heavily chitinized. The postepimeron bears dorso-posteriorly a recurved hook, the postepimeral hook (j_1), which articulates with the clavicula of the sternum of the first abdominal segments. The hypopleurite (Hpp) extends forward up to a shallow emargination on the dorsal margin of the postepimeron. The anterior margin of the hypopleurite is double reflexed, fitting in a reflexed ridge of the inner layer of the elytra. The area between the anterior margin of the hypopleurite and the dorsal nob of the pleural suture is deeply impressed. Epipleurite 1 of the abdomen is situated in front of the hypopleurite closely attached to the scutellum of the postnotum.

Metasternum.—The metasternum is represented as a rectangular continuous plate divided by remainders of a median line. It is illustrated in figure 18. The anterior margin is medially produced into an angle which extends far between the mesocoxae. This angle and the thickened anterior margin may correspond to the presternum of other segments. The anterior lateral angles (a) are modified to receive the sternal hooks of the metaepisternae. Therefore these emarginations should be called the anterior claviculae of the metasternum. Posteriorly the sternum is infolded producing a narrow plate, the

sternellar area. Normally the sternellar area is hidden by the coxae except for the two prolongations between the coxae. These are bent dorsally, giving the support for and articulation of the furca. The

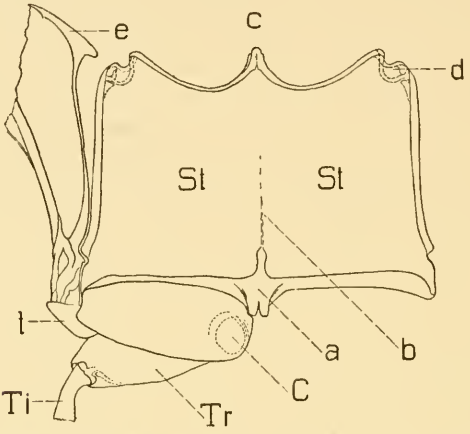

FIG. 18.—*Gnathotrichus materiarius* Fitch: Metasternum, inner aspect.

C, coxa; *St*, sternum; *Ti*, tibia; *Tr*, trochanter; *a*, sternellar area; *b*, median line; *c*, presternellar area; *d*, clavicula; *e*, sternal hook of metapleuron; *t*, head of postepimeron.

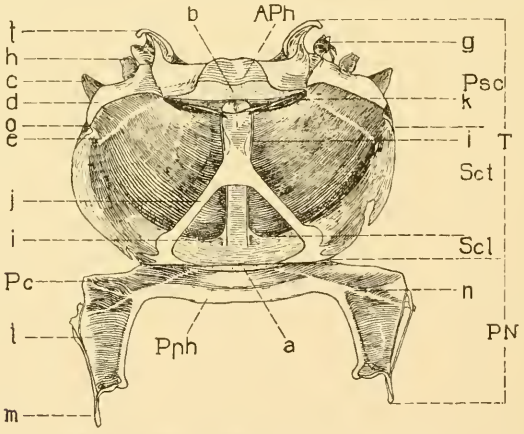

FIG. 19.—*Gnathotrichus materiarius* Fitch: Metatergum, inner aspect.

APh, prephragma; *Pc*, precosta of postnotum; *PN*, postnotum; *Pph*, postphragma; *Psc*, prescutum; *Sct*, scutum; *Scl*, scutellum; *a*, posterior membrane; *b*, anterior membrane; *c*, scutellar lobe; *d*, posterior prealar process; *e*, anterior apodeme; *f*, anterior prealar process; *g*, anterior prescutellar disk; *h*, posterior prescutellar disk; *i*, scuto-scutellar suture; *j*, median apodeme or endodorsum; *k*, parapsides; *l*, prealar bridge of postnotum, or postscutellum; *m*, prealar hook of postnotum; *n*, postnotal apodeme; *o*, scapular hook.

sculpture of the metasternum is minutely rectangulate. The punctures which occur are sparse, the hairs of medium length and more numerous laterally.

The metathorax shows little specific and no sexual modifications.

THE ABDOMEN

The chitinous skeleton of the abdomen shows little specific modification but it bears characters which are of importance in separating the higher groups. The differentiation is mainly in the number of dorsal plates or tergites and the development of the spiculum ventrale in the females. The structure and the relative proportions of the different sclerites are illustrated in figures 1, 2, 3, 20, 21, 22, 23, and 24.

Dorsal plates or tergites.—All the tergites are normally covered by the elytra. In the females seven and in the males eight tergites are well developed. The first six tergites are more or less membranous

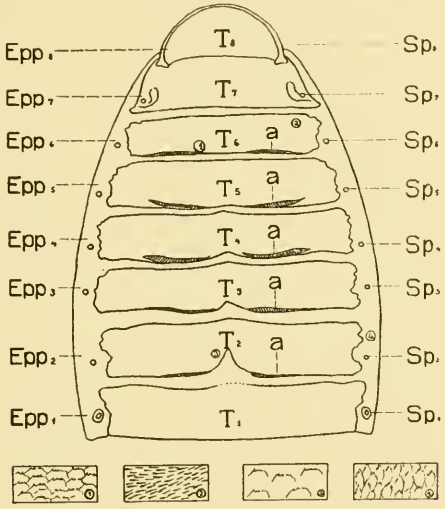

FIG. 20.—*Gnathotrichus materiarius* Fitch, male: Abdominal tergites, ventral aspect.

1, 2, 3, 4, enlarged sections showing details of structure on the dorsal side; *Epp*, epipleurites; *Epp* 7 and 8 fused with tergites; *Sp*, spiracles; *T*, tergites.

and flexible in both sexes, yellowish in color, and covered with spinous to toothlike armature on the external surface. The spinelike armature is more medial and posterior on the plates. Near the anterior margin the armature becomes more toothlike, forming broad plates armed with minute spines posteriorly (figs. 20, $T_{1, 2, 3, 4}$). These plates near the median line on the second, third and fourth tergites are stouter and not so densely placed. In the same tergites there is a reduction of the chitinization, forming a membranous emargination. Still another type of armature is found on the pleurites as illustrated in figures 20, 4. The purpose of these armatures is doubtful. The intersegmental membranes are colorless without any markings. Heavily chitinized bands are situated near the posterior margin of plates two

to six. These bands or ridges resemble the parapsides of the metathorax both in structure and in position. Punctures are numerous in all the plates and the lateral limitations are always irregular. The seventh and eighth tergites in the males and the seventh in the females are heavily chitinized and lack the above mentioned armature but have numerous hairs and punctures.

Lateral plates or pleurites.—The pleural suture seems to be the line which divides the heavily chitinized hypopleurites from the membranous epipleurites. The pleural suture is not visible in the seventh and eighth pleurites because the epipleurite is heavily chitinized here and completely fused with the tergite. The second hypopleurite which

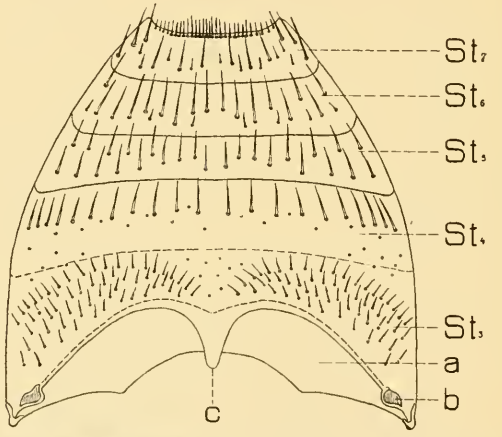

FIG. 21.—*Gnathotrichus materiarius* Fitch: Abdominal sternites, ventral aspect. *St*, sternites; *a*, coxal cavity; *b*, clavicula; *c*, intercoxal process.

extends beyond the postepimerum of the metathorax is ventrally defined by a suture while the others are fused ventrally with the sternites. The former corresponds to the second tergite. The hypopleurite belonging to the first tergite is not represented as a plate but fused with the epipleurite. The hypopleuritic areas are covered by the elytra when they are kept in the closed position, and form a vertical plane, while the sternites make an angle of about 120 degrees with them. As was mentioned before, the epipleurites are membranous except those which correspond to the last tergites. The hypopleurites corresponding to the last seventh and eighth tergites are present only as narrow membranes.

Ventral plates or sternites.—In both sexes only five ventral plates or sternites are distinctly defined by sutures as is illustrated in figure 21 and they represent the sternites three to seven. The sternites are

widest at the base, decreasing in width towards the apex. The first visible sternite is the longest and is separated from the second by a suture which is only visible under high magnification. It is very likely that the first visible sternite contains elements of more than one abdominal segment but they are not indicated by sutures or lines. Medially the first sternite is produced into a long process called the intercoxal process, which extends far between the metacoxae. From

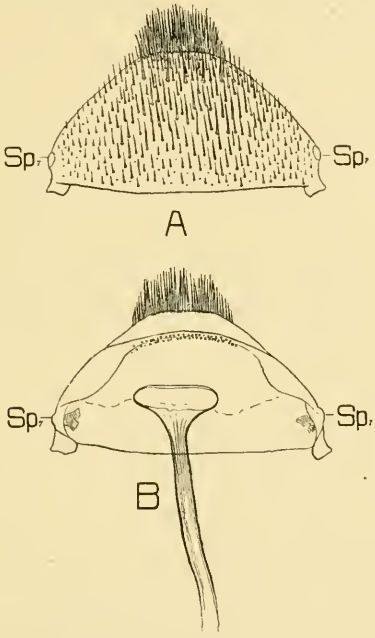

FIG. 22.—*Gnathotrichus retusus* Lec.: Seventh tergite of female. *A*, dorsal aspect; *B*, ventral aspect; *Sp*7, seventh spiracle.

the base of this process a ridge arises which extends laterally, separating the part of the sternite covered by the metacoxae from the remainder. At the antero-lateral corners this ridge is developed into a clavicula. In this clavicula (b) articulates the ventral part of the postepimeral hook. The surface of the uncovered part of the first sternite bears numerous hairs which are arranged in concentric rows encircling the metacoxae. Punctures are sparse. All the other sternites are separated from each other by deep septae and they have the shape of short rectangular plates of nearly equal length. They are all heavily chitinized and armed with long hairs arranged in a trans-

verse row. The last sternite is infolded on the apex. There occur no striking differences in either different species or in the two sexes.

Spiculum ventrale.—In the females of all three species the spiculum ventrale is well developed. By careful dissection it can be seen fastened to the Fortsatzlappen Verhoeff. Without any doubt we are dealing here with a true spiculum laterale clausum (Fuchs). The median line commissura, which gives by certain modifications the spiculum ventrale opportum, is especially well defined in *Gn. materi-*

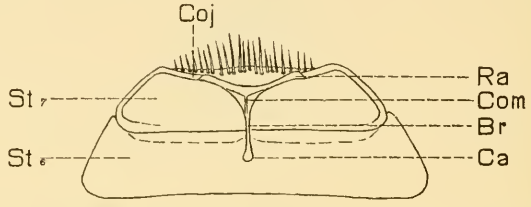

FIG. 23, A.—*Gnathotrichus retusus* Lec.: Sixth and seventh sternites of a female with the spiculum ventrale.

Ca, caput; *Coj,* conjunctus lateralis; *Com,* commissura; *Br,* brachium; *Ra,* radix; *st,* sternites.

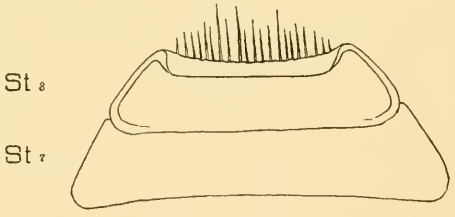

FIG. 23, B.—*Gnathotrichus retusus* Lec.: Seventh and eighth sternites of a male.

arius Fitch and *retusus* Lec. For further studies on this subject it is proposed to name the different parts of the spiculum. The part where the spiculum joins the seitlichen Ansatzlappen (Verhoeff), seitlichen Lappen (Fuchs), may be called radix spiculorum; the more or less chitinized, sometimes membranous bands extending anteriorly, brachium; and the apically thickened part, caput. The seitlichen Lappen (Fuchs), Fortsatzlappen (Verhoeff) should be called the conjunctus lateralis. The spiculum ventralis of *Gn. sulcatus* Lec. may be easily distinguished from the others by its slimmer brachiae. *Gn. retusus* Lec. and *Gn. materiarius* Fitch show no striking differences in this regard.

THE SPIRACLES

Corresponding to the number of the epipleurites, there are eight spiracles in the male and seven in the female. These are implanted in the membranous epipleurites and the apical epipleuro-tergite respectively. The eighth pair of spiracles in the male are always rudimentary. *Gn. materiarius* Fitch shows comparatively the best development in this regard. The seventh epipleurotergite of the female bears a pair of spiracles which are well developed and only very slightly smaller than the others. There also occurs one pair of spiracles on the prothorax. They lie under the produced caudad-lateral angles of the pronotum.

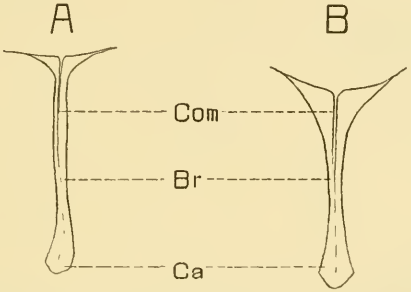

FIG. 24.—Spiculum ventrale in female: A, *Gnathotrichus sulcatus* Lec., B, *Gnathotrichus materiarius* Fitch.
Br, brachium; *Ca*, caput; *Com*, commisura.

THE LEGS

The three pairs of legs are illustrated in figures 25 and 26. They do not vary strikingly from species to species neither in form nor in sculpture. Therefore the drawings were made from *Gnathotrichus materiarius* only. The legs present all the typical segments common in Coleoptera, which are the coxa, the trochantin, the femur, the tibia, the tarsus and the pretarsus.

Coxa.—The coxa (fig. 25) differs considerably in shape in the three pairs of legs. The coxa of the prothorax (A) is very stout, ball-like, the mesocoxa (B) is slightly longer and the metacoxa (C) is nearly twice as long as the forecoxa. The proximal end of the fore- and mesocoxa show distinct indications of a basicostal suture (a). In the fore-coxa the basicostal suture is formed into an external ridge ventrally, which becomes lower and indistinct laterally. In the mesocoxa a simple suture (a) indicates the limitation of the basicosta. The basicostal area of the forecoxa (Bc) is about twice as long as the same structure in the mesocoxa. The basicoxite (Bcx) is present as

a marginal flange and is visible in both the fore- and the mesocoxa. The metacoxa does not show the separation of a basicosta by external lines or internal ridges. The extreme proximal end bears a rather indistinct, internal marginal ridge only.

The three articular surfaces (Snodgrass) are largely modified in the different legs. The pleural articular surface of the fore-coxa is present as the medial, proximal margin of the basicosta only. This part is slightly more heavily chitinized. In the mesocoxa the pleural articular surface (b) is more strongly developed. It consists of a

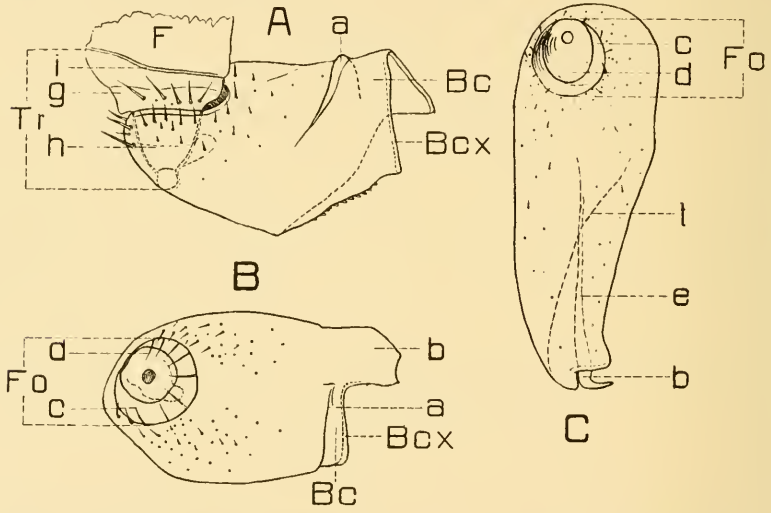

FIG. 25.—*Gnathotrichus materiarius* Fitch: A, forecoxa, lateral aspect; B, mesocoxa, C, metacoxa, both ventral aspect.

Bc, basicosta; *Bcx*, basicoxite; *F*, femur; *Fo*, fossa; *Tr*, trochanter; *a*, basicostal suture; *b*, pleural articular surface; *c*, outer ring of fossa; *d*, inner ring of fossa; *e*, anterior coxal suture; *f*, internal ridge; *g*, basicostal ridge of trochanter; *h*, condyle of trochanter; *i*, trochantero-femoral suture.

projection of the basicosta. In the metacoxa a hooklike structure (b), which is basally fused with the anterior coxal suture, may be considered as the pleural articular surface.

The articulation of the trochantin is monocondylic with the fossa in the coxa. The fossa (Fo) is a circular, conelike, impression on which two main parts are clearly defined; the outer ring (c) with a ridgelike elevation on the external surface of the coxa and the inner ring (d) or bottom which bears a heavily chitinized knob on the inner surface. It is most probable that the outer ring corresponds to the anterior, the inner ring to the posterior or distal articular surface of Snodgrass. Each coxa has opposite to the fossa a circular opening in

the heavily chitinized wall of the coxa which is covered by a thin membrane only. The extreme tip of the trochantinal condyle touches this. Ridges to strengthen the coxal walls do not occur in the fore- and mesocoxa. The metacoxa bears such a ridge on the ventral side

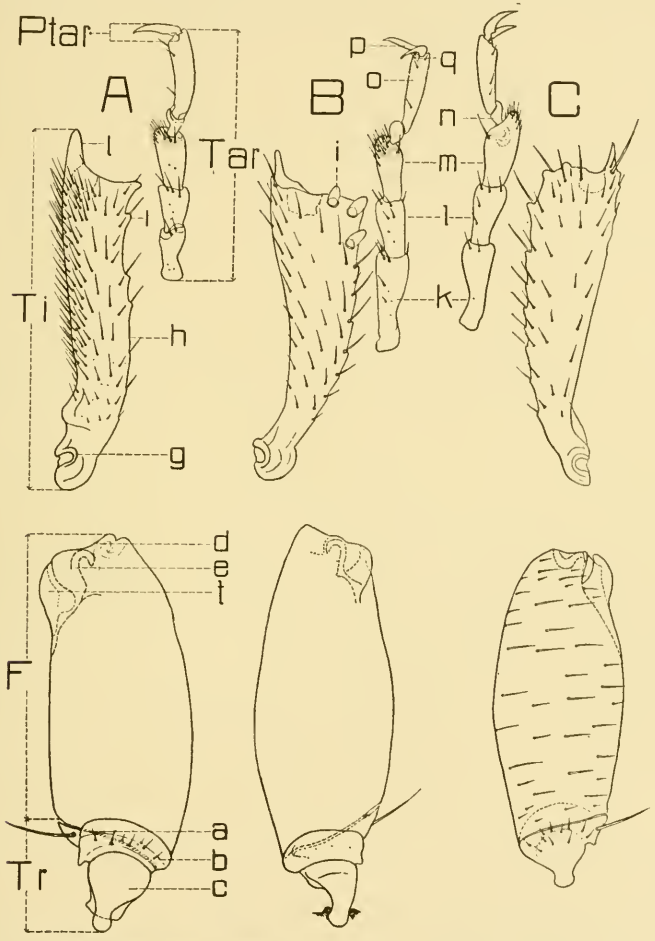

FIG. 26.—*Gnathotrichus materiarius* Fitch: A, fore leg, B, mesothoracic leg, C, metathoracic leg.

F, femur; *Ptar*, pretarsus; *Tar*, tarsus; *Ti*, tibia; *Tr*, trochanter; *a*, trochantero-femoral joint; *b*, basicostal ridge; *c*, condyle of trochanter; *d*, dorsal femoral fossa; *e*, ventral femoral fossa; *f*, anterior groove; *g*, tibial condyle; *h*, outer margin of tibia; *i*, marginal tooth; *j*, apical tooth; *k*, *l*, *m*, *n*, tarsal segments; *o*, apical segment; *q*, arolium; *p*, claw.

which forms a well developed internal ridge (e); this ridge may correspond to the anterior coxal suture (Snodgrass). Another more feebly developed ridge (f) occurs on the dorsal coxal wall.

The hair armature is best explained by the figures. No differences have been found from species to species.

Trochantin.—The trochantin (fig. 26, Tr) is a small structure and is closely attached to the femur. On the ventral or outer side, when the femur is kept close to the body, a deep groove, the trochantero-femoral groove (a) separates the femur from the trochantin. On the dorsal, or inner side, the separation is indicated by a suture only. Structurally, three parts may be distinguished on the trochantin. These are the basicostal ridge (b), the articulatory condyle (c) and the small apical piece (r). The basicostal ridge is a broad, stuffed, ringlike structure which gives the articulation with the coxa an external rest. For the same purpose a hooklike process on the postero-median angle of the basicosta is used. The prominent, cone-shaped articulatory condyle originates basally. The shape of the condyle is alike in all three pairs of legs; the slight differences showing in the plate are due to the different angles from which the drawings were made. The apical piece projects over the basicosta when viewed from above, dorsally, and is fused with the basicosta when seen from below. It bears a long slender spine in all three pairs of legs. The basicosta is externally armed with a few small hairs. From the kind of connection between the femur and the trochantin it can be concluded that but little movement is possible between them.

Femur.—The femur (fig. 26, F) is the strongest segment of the leg and is about equal in length with the tibia (Ti). Basally it is connected with the trochantin; apically, the tibia articulates. The femur is long, oval to rectangular in outline and strongly compressed. The articulation of the tibia is bicondyle (d, e), the femur containing two half circular fossa. There occur no striking differences in the three examined species or in the three pairs of legs in one species. The inner or dorsal surface of the femur is smooth without hairs or bristles; the exposed surface bears numerous rather fine, long hairs which are directed transversely. A deep groove (f) with two lateral winglike extensions occurs latero-apically. This groove allows the tibia to be flexed closely against the femur.

Tibia.—The tibia (fig. 26, Ti) is about as long as the femur, triangular in outline and strongly compressed anteriorly. The proximal end is widened, half circular in outline, and bears the two articulatory condyles. The proximal quarter of the tibia is slightly bent laterally. The dextral margin is without teeth or armations; the sinistral margin bears four to six low serrations and three marginal teeth (i) which are imbedded in sockets. The apical tooth (j) is straight, rather stout and not imbedded in a socket; the subapical tooth is present as a low elevation only. The articulation of the tarsus is membranous.

Tarsus.—The tarsus (fig. 26, Tar) is composed of five joints or segments. They are not articulated by hinges with each other but they are movable by means of inflected connecting membranes. The first three segments (k, l, m) are subequal in length and shape. The basal segment or basitarsus does not show any special armations such as occur in other genera. The fourth segment (n), the smallest of the tarsus, resembles somewhat in shape the trochantin. This segment which is often highly modified in the *Scolytidae,* is short and knob-like in *Gnathotrichus.* The apical segment (o) is longer than segments one to three, more slender and slightly curved. Except the fourth, all tarsal segments bear at least a few hairs scattered over the entire length. The third segment also bears a plushlike arrangement of hairs apically.

Pretarsus: the terminal segment.—The terminal foot structure (fig. 26, Ptar), which has been called praetarsus, Krallenglied, unguis, ungula and pretarsus by different authors, bears two simple claws (p). The areolium (q) is membranous and heartshaped.

THE WINGS

As in all the *Scolytidae, Gnathotrichus* Eichh. has well developed elytra or mesothoracic wings and hind or metathoracic wings. The development of the metathoracic wings would indicate, as has been found to be the case, that the species of this genus are good fliers. No attempt will be made in what follows to speculate on the functions of the different sclerites of the articulation of the wings since the author has had no opportunity to make observations on them. Merely a description of the different parts will be given which it is hoped may be of value for future taxonomic and physiological studies.

MESOTHORACIC WINGS OR ELYTRA

The mesothoracic wings consist as usual of two layers of integument, both of which are chitinized, the outer layer however being much thicker than the inner layer. The space between these two layers contains the tracheal and circulatory systems. The punctures which mark these wings externally indicate, according to Hopkins, the points of union between the two layers. The form and general structure are shown in figures 1, 3, 16 and 27. The elytra when closed and viewed from above are as wide as or slightly narrower than the pronotum, with the sides subparallel, slightly tapering toward the apex and broadly rounded behind, the extreme external margin subacute.

Basal area.—The basal area (fig. 29), as here interpreted, is the basal part of the elytra itself and the sclerites which form the connection with mesonotum and the mesopleura respectively. The articulatory elements of the elytra itself are made up chiefly of the projected costa (Co) and subcostal veins (Sco) and the costal (a) and the subcostal heads (b). These heads articulate with the mesopleural clavicola (fig. 16, d). There are also four distinct axillaries (fig. 29, ax_1 to ax_4) or pteraliae. The first axillary (ax_1) partly encloses

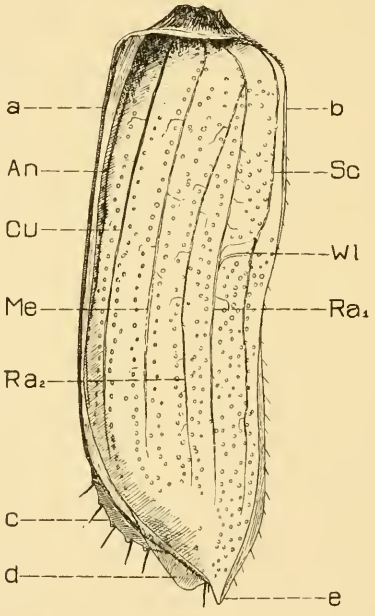

FIG. 27.—*Gnathotrichus retusus* Lec.: Left elytron, ventral aspect.

An, anal; *Cu*, cubitus; *Me*, media; *Ra*, radius; *Sc*, subcosta; *Wl*, lateral wing lock; *a*, dorsal or sutural margin; *b*, costal margin; *c*, lateral convexity; *d*, stridulating scraper; *e*, apex.

the tegula and fuses at its apex with the second axillary. The second axillary (ax_2) articulates at its base with the prealar process (a) of the prescutum. The apex of the second axillary forms a heavily chitinized clamp in which the elytra fits as a tongue. The third axillary (ax_3) corresponds to Hopkins' flexor plate. It commences on the internal surface of the second axillary and ends on the external surface of the elytra. It is believed that a sclerite (ax_4) projecting from the posterior margin of the tegula is the fourth axillary. The tegula (Te) is well developed, having the form of a hairy pad.

Tracheation.—All six primary veins (fig. 27) are present and these run roughly parallel and equidistant from each other the whole length of the wing. The costal vein is fused with the corrugated and thickened anterior margin (b) forming an anterior ligature of the wing. The subcostal (Sc), medial (Me), cubital (Cu) and anal veins (An) are simple; the radius is split into two branches (Ra_1, Ra_2). The finer divisions of the tracheae permeate the spaces between the veins producing a fine network. Between the adjacent veins there are situated two fairly well defined rows of punctures.

Sculpture and vestiture.—The occurring punctures are as previously mentioned arranged in approximate rows, being more confused

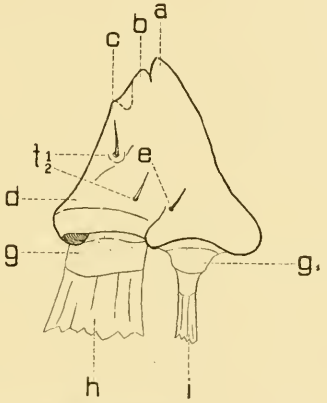

FIG. 28.—*Gnathotrichus materiarius* Fitch: Mandibles of the larva.

a, apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar tooth; *e*, lateral bristle, or seta (seta mandibulae lateralis); f_{1-2}, dorsal setae, or bristles (seta mandibulae lateralis); *g*, retractor tendon; g_1, extensor tendon; *h*, retractor disk; *i*, extensor disk.

laterally and on the declivity. The interspaces are minutely reticulate and punctulate and in all three species about alike. From the punctures originate minute hairs which are slightly longer on the declivity. There also occur longer bristles but they are scarce and scattered over the entire surface, being more numerous on the declivity.

Lateral wing lock.—On the inner lateral side of the elytra at the level of the anterior margin of the hypopleura a short transverse ridge (fig. 27, Wl) is situated. That ridge is recurved, fitting into a similar formation which is formed by the anterior margin of the hypopleura (fig. 1, f, fig. 17, i_1). These two parts interlock and are apparently intended to keep the elytra closed.

Declivity.—The extreme lateral margin of the elytra is subacute. The declivity itself is sloping with a more or less distinct sulcus on

each side of the median suture. The lateral convexities (fig. 27, c) bear at least faint traces of granules from which bristles arise. There also occur a few bristles near the apex of the declivity.

Stridulating accessories.—In both sexes the left elytron bears on the declivity a well developed lobe which lies under the right elytron

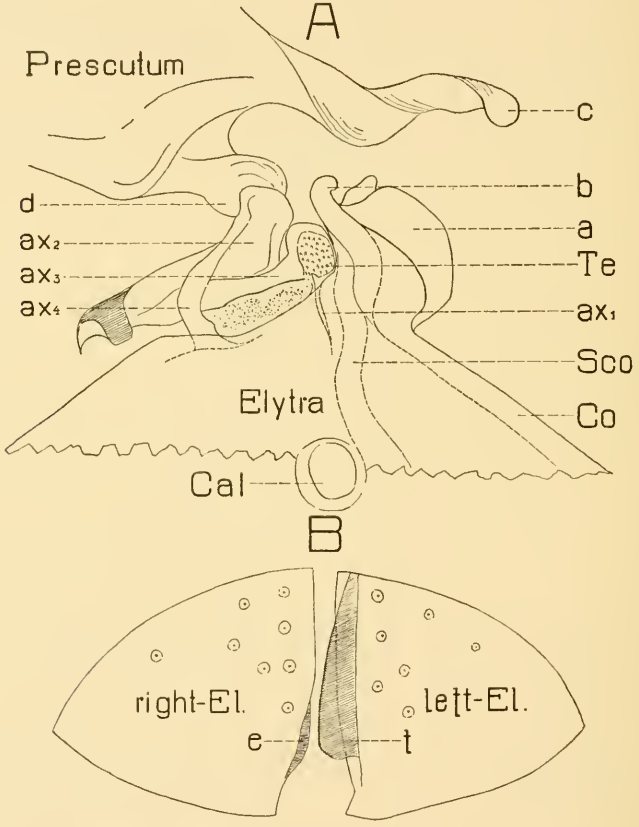

FIG. 29.—*Gnathotrichus retusus* Lec.: A, articulation of the elytra, ventral aspect; B, stridulating apparatus on the apex of the elytra, ventral aspect.

Cal, callus; *Co*, costal ridge; *Sco*, subcostal vein; *Te*, tegula; *a*, costal head; *b*, subcostal head, ax_1, ax_2, ax_3, ax_4, the axillaries; *c*, lateral arm of prephragma Hopk., or pleural hook of scutum; *d*, prealar process; *e*, stridulating rasp; *f*, stridulating scraper.

when the elytra are kept in the closed position. This lobe, the stridulatory scraper (fig. 27 d, fig. 29 f) is finely transversely sulcate on the dorsal side. The corresponding area on the right elytron (fig. 29, c) is also rasplike but only on a narrow strip. If these two parts are grated against each other, it is most probable that they will produce a chirping sound. Up to date this sound has not been heard by the

author and therefore this statement is merely an attempt to explain these two parts of the elytra.

Specific modifications of the elytra.—While *Gnathotrichus* shows the strongest development of the declival sulci, with lateral convexities and granules on the latter, these characters decrease in development in *Gn. sulcatus* Lec. and are faint in *Gn. materiarius* Fitch. There also occur many variations from specimen to specimen so a determination cannot be based on these characters only.

METATHORACIC WINGS OR HIND WINGS

The metathoracic wings (figs. 3, 17) are homologous with the mesothoracic wings but differ considerably in structure and development due to their use as flying apparatus. In the genus *Gnathotrichus* Eichh. no specific modifications of importance have been observed.

As in all genera of this family the wings are folded together and covered by the elytra when the beetles are at rest. The hind wings are twice as long as the elytra and three times as long as wide. Near the base on the inner side occurs a deep emargination separating a distinct lobe from the wing—the posterior wing lobe (fig. 3, WL, 17, L). The shape of the wings is very much alike in all three species, long oval with the anterior and posterior margins nearly parallel.

The wings consist of two layers of integument enclosing the tracheal system. In the hind wings both of these layers are membranous except on the veins and the basal sclerites. Externally they are covered with microscopic hairs, except on the basal heavy parts of the veins and the axillaries (fig. 17).

Veins.—The venation of the wings shows considerable reduction. The only visible veins are the costa (fig. 3, Co), subcosta (Sco), radius (R_1+R_2), media (M_1, M_2) and cubitus (Cu_1). The radial and the medial veins are split into two branches.

Costa.—As Hopkins has shown for the genus *Dendroctonus,* the costal vein (fig. 3, Co, 17, C) is also in *Gnathotrichus* Eichh. confined to a short basal piece. Apically it does not join another vein but is reduced so that the costal margin is occupied by a membrane only up to the point where the radial vein is bent forward and structurally replaces the costa. The base of the costa is produced into the so-called costal head (fig. 30, CoH). It consists of two parts, the costal condyle (fig. 30, a), and the costal pocket (b). The former articulates with the clavicle process of the metacpisternum (fig. 17, d_1). From the base of the costal condyle a pocket stretches to the subcosta. At about the center of the pocket a projection of the subcostal head, the sub-

costal hinge (fig. 30, c), is attached by tendons giving the motion of a hinge joint. This attachment enables the subcostal head to move in the pocket.

Subcosta.—The subcosta (figs. 3, Sco, 17, Sc, 30, Sco) consists of a chitinous band extending apically as far as the costa and strengthened by two ridges of dense chitin. The basal part, or subcostal head (fig. 30, ScoH), as it was called by Hopkins, is anteriorly formed into a

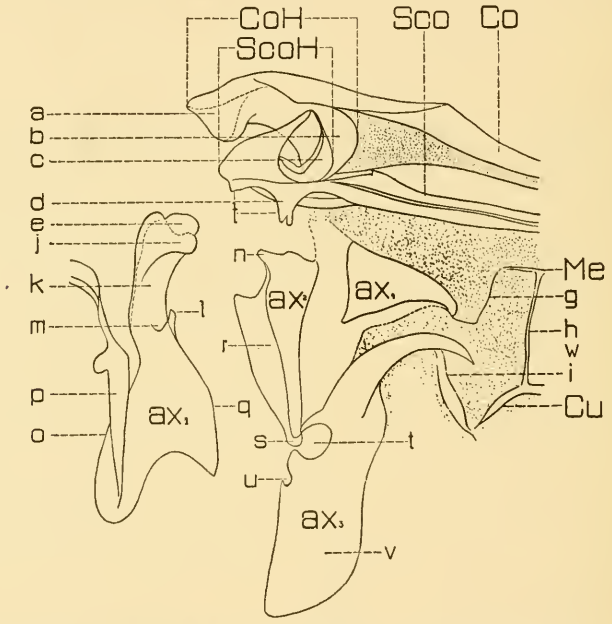

FIG. 30.—*Gnathotrichus retusus* Lec.: Basal area of the wing, wing articulation.

Co, costal vein; *CoH*, costal head; *Cu*, cubital vein; *Me*, medial vein; *Sco*, subcostal vein; *ScoH*, subcostal head; *ax*, axillary plates; *a*, costal condyle; *b*, costal pocket; *c*, subcostal hinge; *d*, subcostal labrum; *e*, condyle of first axillary; *f*, subcostal fossa; *g*, membranous fold connecting *Me* and ax_1; *h*, membranous fold connecting *Me* and *Cu*; *i*, membranous fold connecting *Cu* and ax_3; *j*, epicondyle of ax_1; *k*, scapula arm; *l*, axillary horn; *m*, axilla; *n*, anterior process of ax_2; *o*, articulatory margin; *p*, scapular hook of prescutum; *q*, apical margin; *r*, lateral groove; *s*, axillary tendon; *t*, *u*, lateral emarginations; *v*, posterior part, or handle; *w*, anterior part, or blade.

projection which is composed of a circular band of chitin (fig. 30, c), articulating with the costal pocket. The posterior part forms a fossa, the subcostal fossa (f), which articulates with the condyle (e) of the first axillary. The labrum (d) of the fossa is deeper on the outer side than on the inner. The outer side of the labrum is divided at its free edge by a V shaped groove.

Radius.—The radius (figs. 3, R, R_1, R_2, 17 R) is not directly fused with any of the axillary plates but is basally closely connected with the subcosta. From the point of fusion with the subcosta the radius

extends to the folding hinge on the wing gradually increasing in width. The anterior border of the radius becomes the anterior border of the wing just after the reduction of the costa and subcosta. The folding hinge occurs as a V-shaped plate, the point of the V being anterior. From the folding hinge the radius is divided into two branches (R_1 and R_2). Radius 1 extends as a broad chitinous band along the anterior border of the wing to its apex gradually diminishing in width. Radius 2 is slightly narrower than R_1, running two-thirds with, and parallel to it.

Media.—The media (figs. 3, M, 17, M and 30, Me) is connected to axillary four (fig. 30, ax_4) by a membranous fold (g) of L shape. Another fold (h) runs posteriorly to the cubitus (Cu). From the base to the level of the folding hinge it is continued as a single vein. At the latter point it is divided into two branches (fig. 3, M_1 and M_2), both of which extend to the anal margin. The connection between the single basal part of the media and M_1 is membranous, while M_2 is a direct continuation of the former.

Cubitus.—The cubitus (figs. 3, Cu, 17, Cu and 30, Cu) is connected with axillary three (fig. 30, ax_3) by a membranous fold (i) which runs from the base of the cubitus anteriorly. From its base the cubitus proceeds toward the anal margin which it does not reach. No other branches of the cubitus nor an anal vein are present.

Wing articulation.—The articulation of the wings (figs. 3, 17 and 30) is brought about by means of the costal and subcostal heads, the axillaries of the wings, the clavicle and coracoid process of the metaepisternum, the scapular hook of the posterior prealar process of the prescutum and a series of muscles and tendons connecting and moving these parts. The connection of the costa and subcosta to each other and the costa with the metapleuron was discussed before. In the following lines the axillaries and their connection with the metatergum and metapleuron will be explained.

The axillaries are chitinous plates, differing in number in the different orders and also it seems in the genera of the Scolytoidea, which function as articulatory accessories. In the genus *Gnathotrichus* Eichh. four of such plates are distinctly developed. The heads of the costal and subcostal veins are here not counted as axillaries because they are fused with the veins in such a way that separations seem unnecessary.

First axillary.—The first axillary (fig. 30, ax_1) or scapular plate, as it was called by Hopkins, is very similar in shape to that of *Dendroctonus valens* Lec. as it was illustrated by Hopkins. Anteriorly it is produced to a condyle (e) with a distinct epicondyle (j), articulat-

ing with the fossae (d) of the subcosta. The slender part posterior to the condyle, which was called the scapular arm by Hopkins (k), bears a hornlike process (l), the axillary horn. The horn forms with the scapular arm an axilla (m) in which the anterior process (n) of the second axillary rests. The margin towards the notum or articulatory margin (Hopkins) (o) is connected with the posterior prealar process of the prescutum by the scapular hook (p) and tendons. The scapular hook is a heavily chitinized hooklike plate on the lateral margin of the prealar process. The margin towards the apex (q) of the wing fits into the lateral groove (r) of the second axillary. The base of the scapular plate is deeply emarginated.

Second axillary.—The second axillary (fig. 30, ax_2) or subscapular plate has the shape of an equilateral triangle with its base anteriorly. The side towards the first axillary bears a deep groove, the lateral groove (r), which encloses the apical margin of the first axillary (q). With axillary four it is connected by a membrane only while a well developed tendon (s) connects axillaries two and three on its posterior end. By means of this tendon a strong connection is brought about from the posterior prealar process to the first, second and third axillaries.

Third axillary.—The third axillary (fig. 30, ax_3) or flexor plate (Hopkins) has the shape of a sickle with two emarginations (t, u) on its inner side. The anterior one (t) ends in the tendon connecting axillaries two and three. The handle of the sicklelike plate (v) is without special characters. The blade (w) shows on its posterior margin near the apex a membranous fold (i) connecting this plate with the cubital vein.

Fourth axillary.—The median plate (Hopkins) corresponds to the fourth axillary (fig. 30, ax_4). It is triangular in shape, connected to the median vein by a membranous fold (g) and to the other axillaries by membranes only.

When the radial plate (Hopkins) is not considered as a distinct plate but as a connecting tendon between the second axillary and the radial vein only, the shape and structure of the other axillaries are very much alike in the widely separated genera *Dendroctonus* Er. and *Gnathotrichus* Eichh. Further studies will show if this means a parallel modification or if we have to deal with a character common to the superfamily of the *Scolytoidea*.

Lateral impression.—An area distinctly impressed on the metascutum (fig. 17, q), according to Hopkins, accommodates the flexor plate at rest when the wings are closed.

Lateral emargination.—The lateral emargination (Hopkins) (fig. 17, p) is an emargination on the scutum on the lateral margin of the scutellar lobe in which is implanted the inner posterior lobe of the scapular plate and the scapular hook. The latter connects the posterior prealar process with the scapular plate and the scutellar lobe, respectively.

The Male Reproductive Organs

The male reproductive organs consist, as shown by Nuesslin for this family, of elements of endodermal and of ectodermal origin. These two groups of elements are separated in the larvae and become connected during the pupal stage. Of endodermal origin are the testi (fig. 31, Te), the vasa deferentia (fig. 31, Vd) and the

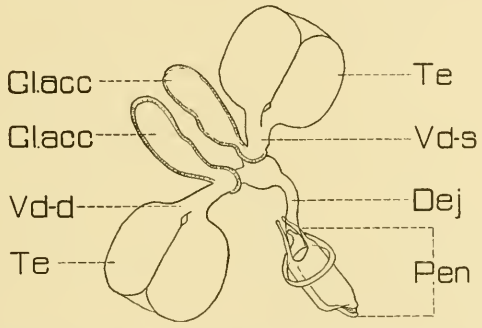

Fig. 31.—*Gnathotrichus materiarius* Fitch: Male reproductive organs.
Dej, ductus ejaculatorius; *Gl. acc,* accessory glands; *Pen,* penis; *Te,* testi; *Vd-d,* vasa deferentia, duplex; *Vd-s,* vasa deferentia, simplex.

mesadenic, or mucous glands (fig. 31, Gl. acc). On the other hand, the seminal vesicle (in part, fig. 33, Rec.), the ductus ejaculatorius (fig. 31, Dej) and the penis (fig. 3, Pen) are of ectodermal origin. The point of connection of these elements is plainly visible in the adults. The distal part of the vasa deferentia and the mucous glands join a short, usually narrow tube, " Zunge " (Nuesslin) ; the latter connects with the ductus ejaculatorius. Externally the Zunge, an endodermal structure, is encircled by a wider tubelike or sphericle envelope, which consists of two parts, the distal end or " Mantel " (Nuesslin) of endodermal, and the basal part or " Becher " (Nuesslin) of ectodermal origin. These last mentioned structures are seen commonly as a ball-like widening of the ductus ejaculatorius and are usually called the seminal vesicle.

The following description is based on *Gnathotrichus materiarius* Fitch only.

The testes consist of two oval structures which are closely connected medially. The vasa deferentia is Y shaped. The mucous glands are wide and stout and about as long as the testi. The seminal vesicle is represented by a subsphericle structure to the upper side of which the glands are joined. The ductus ejaculatorius is comparatively short, stout, and as long as the testi. In Nuesslin's key to the larger groups of Scolytidae, based on the male reproductive organs except the penis, *Gnathotrichus* falls near to the *Ernoporinae*.

Penis.—In order to consider the penis of *Gnathotrichus,* it is first necessary to discuss in a general way the *Scolytid* penis.

Lindeman, who was the first investigator of the *Scolytid* penis, distinguished two main groups of elements, the primary and the accessory. He states that the primary elements, which comprise the body (Koerper), the fork (Gabel) and the stalk (Stengel), are constant throughout the family *Scolytidae,* while the accessory elements, which form together the so-called Aufsatz, vary considerably in the different genera as well as from species to species in one genus. Verhoeff, the second to deal with the subject, did not agree with this classification, while Nuesslin supported Lindeman's opinion. The last of the more important investigators of the *Scolytid* penis, Dr. Fuchs, constructed a new system for such a classification, without consideration of the phylogeny, and distinguished covers (Huellen), inclosed parts and parts external to the covers. The author cannot agree with Lindeman and Nuesslin that the primary elements always included in the Scolytid penis consist of the fork (parameren Verhoeff) and the stalk (spiculum ventrale (Fuchs)). Already Fuchs has shown how far the reduction of the parameren and the spiculum ventrale in the European *Hylesinidae* has gone and the author is convinced that more intensive investigations of this subject will bring up many new facts. Without doubt more than three-quarters of the genera and ninety per cent of the species of the *Scolytidae* have not been studied at all or not thoroughly enough. For example, it was found in the present study that the spiculum ventrale is absent in *Gnathotrichus,* and it will not be long until genera are found in which the complete loss of the parameren occurs. If it is desirable to distinguish between primary and accessory elements, the author would prefer that the primary elements be considered the body only, the accessory elements all the parts outside of it. For further studies of this subject, the author will adopt Dr. Fuchs' classification and nomenclature until a time when sufficient new material is available to furnish new conclusions.

The penis presents, in the genus *Gnathotrichus,* excellent generic as well as specific characters. The following discussion is based on slides which were made from dried material treated with 10% sodium-hydroxide solution. Dr. Fuchs distinguished two layers of covers, the outer and the inner. These two layers were also found to be present in *Gnathotrichus.* The outer layer consists of a membranous tube

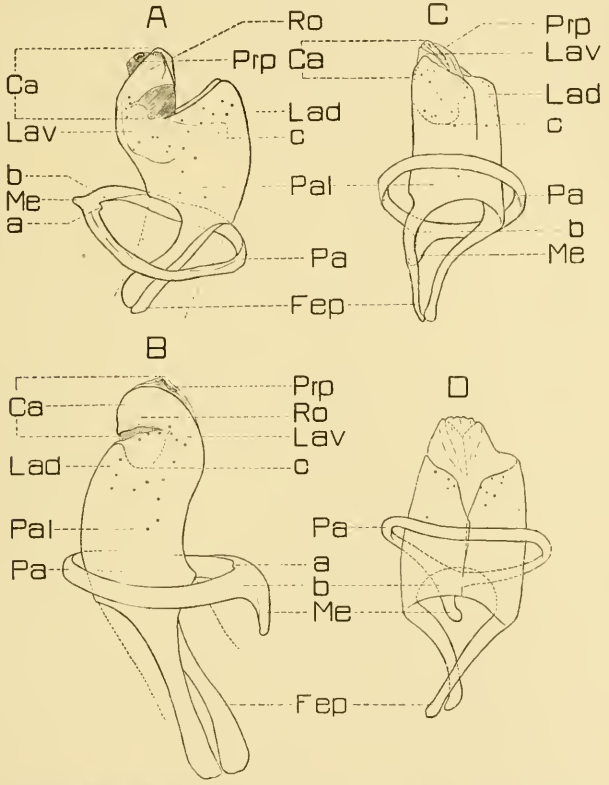

FIG. 32.—A, *Gnathotrichus sulcatus* Lec.; B, *Gnathotrichus retusus* Lec.; C, D, *Gnathotrichus materiarius* Fitch.: A, B, C, lateral aspect; D, dorsal aspect.

Ca, caput; *Fep,* femora penis; *Lad,* laminae dorsales; *Lav,* laminae ventrales; *Mc,* metula; *Pal,* pallidium; *Pa,* parameren; *Prp,* preputial sac; *Ro,* rostrum; *a,* ventral nob of the parameren; *b,* tegmen furcae; *c,* internal ridge on *Lad.*

in which the inner cover slides forward and backward. A ringlike part of this tube is heavily chitinized, and when dried specimens are used only this structure is obtained. It was called by Lindeman the gabel, the parameren by Verhoeff and the tegmen by Hopkins. The inner cover consists of a second tube which is heavily chitinized throughout and which shows remarkable variations from species to species. Figure 32 illustrates the peni of the genus under examination.

Parameren.—In *Gnathotrichus* the parameren (Pa) is a heavily chitinized ringlike structure. It is entire, without a dorsal transverse suture or knoblike projection cephalad, as in *Pityogenes* Bedel, and was called umbellicus by Fuchs. Ventrally, a faint suture is visible in *Gn. sulcatus* Lec. and *retusus* Lec. only. A prominent, heavily chitinized hook extends cephalad from the ventral suture. This structure was called the metula (Me) by Fuchs and the apodemal process by Hopkins. In *Gn. retusus* Lec. and *sulcatus* Lec. a second, caudad, but much smaller knob (a) is present. The tegmen furcae (Fuchs) (b), which are a lateral continuation of the metula, are weakly developed. Lateral widenings of the parameren, Seitenfluegel (Fuchs), are absent.

Specific modifications:—

A—Parameren without small knob ventro-caudad; metula long but slender. *Gn. materiarius* Fitch.

AA—Parameren with small knob ventro-caudad; metula variously modified.

B—Metula short, weakly developed. *Gn. retusus* Lec.

BB—Metula long, strongly developed. *Gn. sulcatus* Lec.

Inner covers.—The inner cover (Fuchs), the body (Hopkins), the penis tube (Nuesslin) is a tubelike structure, bilateral-symmetric. On the inner covers three main parts may be distinguished which are the lamina dorsales (Lad), the laminae ventrales (Lav) and the peduculi penis (Fep). The dorso-caudad portion of the inner covers was called the Endplatten by Lindeman, the laminae dorsales by Fuchs and the dorsal plates by Hopkins. The laminae ventrales (Fuchs) or ventral plates (Hopkins) are the corresponding ventral portion of the laminae dorsales. In the genera *Pityogenes* Bedel, *Ips* de Geer, *Pityokteines* Fuchs, *Neothomicus* Fuchs, and others, the laminae dorsales and ventrales are largely separated by deep emarginations caudad giving the laminae the shape of four free projections which are connected basally only. The basal, fused, entire part of the laminae ventrales is the pallidium (Fuchs (Pal)). The sometimes narrow band connecting the two dorsal plates is the jugum or Steg (Fuchs). In *Gnathotrichus* the laminae dorsales and ventrales are fused laterally. Dorsally, the two laminae dorsales are separated by an obscure suture only. The laminae ventrales are fused ventrally, open on the extreme caudad portion. The laminae dorsales as well as the laminae ventrales bear numerous sensory pores on the caudad half. The latter is strengthened by a stronger chitinized band, the caudad limitation of which (c) is strongly emarginate. This chitinous strengthening was called the

radius by Fuchs and this is well developed in all three species of *Gnathotrichus*. A corresponding strengthening on the laminae dorsales, which as the manubrium (Fuchs) is well developed in the genus *Pityogenes* is obscure in *Gnathotrichus*. The caudad portion of the laminae ventrales, the caput (Fuchs), is variously modified, sometimes bearing a beaklike projection dorsally which was called the rostrum by Fuchs. The caput and rostrum vary considerably in shape and development in the genus *Gnathotrichus*. The area of the pallidium, from which the peduculi penis originate, the radix (Fuchs), is not characterized by a heavier chitinization. The peduculi penis were also called Fuesschen by Lindeman, femora penis by Verhoeff and body apodemes by Hopkins. In the normal position the peduculi penis are parallel; when mounted on slides they usually cross each other. Cephalad the peduculi are slightly widened, their connection with the pallidium is solid, not hingelike.

Enclosed parts.—The enclosed parts are a short part of the ductus ejaculatorius, the preputial sac and chitinous strengthenings of the latter. The ductus ejaculatorius is easily recognized by its enclosing muscle structure. The author was able to trace this structure as far caudad as the radius (c) extends. The preputial sac (Prp) consists of a colorless membrane without any chitinous strengthenings. It seems to be connected with the ductus ejaculatorius at the anterior emargination of the radius. Chitinous structures such as the Rinne (Fuchs) do not occur in the genus *Gnathotrichus*.

Parts outside of the covers.—It was stated in the introduction to the discussion of the penis that no indications of the spiculum ventrale are present in the genus *Gnathotrichus*. While in *Xyloterus* Er. and in some genera of the European *Hylesinidae*, the reduction of the Rinne (Fuchs) mostly is followed by a stronger development of the spiculum ventrale, *Gnathotrichus* presents a complete reduction of both.

Generic characters of the penis.—Spiculum ventrale absent; parameren an entire ring, metula well developed; laminae dorsales and ventrales fused laterally, the laminae dorsales dorsally separated by an obscure suture, the laminae ventrales fused except on the extreme caudad portion, the laminae forming a tube, radius distinct, manubrium obscure, jugum and pallidium not clearly defined; sensory pores on the caudad half of the laminae dorsally as well as on the laminae ventrales; the latter always extending farther caudad than the former; the peduculi penis slender, slightly widened cephalad, about as long as the laminae dorsales, connection with the pallidium solid not hingelike; Rinne absent, preputial sac about as long as half of the laminae ventrales.

In the classification of the *Scolytidae,* based on the chitinous skeleton of the penis by Nuesslin, *Gnathotrichus* would have been in contrast to all the other genera. This is easily explained by the fact that only this one character was used in placing the genera. The author has no reason to believe that *Gnathotrichus* is not a highly specialized genus of the *Pityophthorinae.*

Specific modifications:—

A—Parameren without ventro-caudad knob, metula long but slender; laminae dorsales with their dorsal margin straight, the dorso-caudad angle obtuse and broadly rounded, the posterior margin is directed ventro-caudad from this angle; the laminae ventrales with their ventral margin straight, only slightly projecting caudad farther than the laminae dorsales, caput weakly developed, nearly in line with the dorso-caudad margin of the laminae dorsales, rostrum obsolate; peduculi penis about as long as the laminae ventrales, very slender, only very slightly widened at the cephalad end, basal part narrow. *Gn. materiarius* Fitch.

AA—Parameren with ventro-caudad knob opposite the metula, the latter variously modified; laminae dorsales with the dorsal margin broadly arcuate, the dorso-caudad angle variously modified either slightly acute but rather broadly rounded or almost evenly arcuate with the dorsal margin of the laminae dorsales; the laminae ventrales with their ventral margin distinctly incurved, much farther projecting caudad than the laminae dorsales, caput strongly developed, rostrum distinct; peduculi penes vary in length, stouter, more strongly widened at the cephalad end, basal part distinctly widened.

B—Metula short, weakly developed; the dorso-caudad angle slightly acute but rather broadly rounded, the posterior margin is directed ventro-cephalad from this angle, caput not evenly rounded caudad, more tube-like, ventro-caudad margin oblique, the dorsal angle of the rostrum extending to about half of the width of the combined laminae dorsales and ventrales, between the cephalad margin of the rostrum and the caudad margin of the laminae dorsales, a wide, rectangular space membranous; peduculi penis as long as the laminae dorsales on the dorsal margin. *Gn. retusus* Lec.

BB—Metula long, strongly developed; the lamina dorsales with their posterior and caudad margin almost evenly rounded throughout; caput evenly rounded caudad, half sphericle, the membranous space between the cephalad margin of the rostrum and the caudad margin of the laminae dorsales narrow, slitlike, the dorso-cephalad angle of the rostrum and the dorso-caudad angle of the laminae dorsales in one level; peduculi penis distinctly longer than the laminae dorsales. *Gn. sulcatus* Lec.

The Female Reproductive Organs

The female reproductive organs (fig. 33) were examined from *Gn. materiarius* Fitch only. As in all Rhychophora, two pairs of

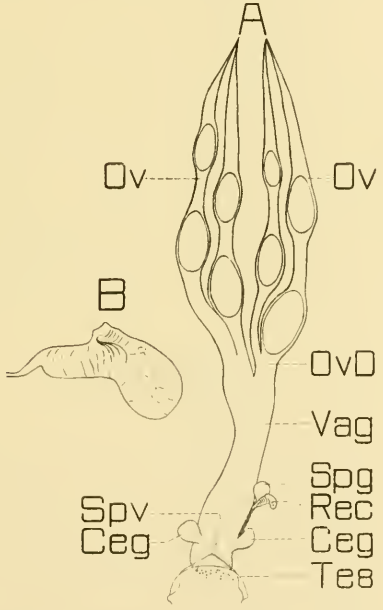

Fig. 33.—*Gnathotrichus materiarius* Fitch.: Female reproductive organs. *A*, the complete organs; *B*, receptaculum seminis; *Ceg*, cement glands; *Ov*, ovaries; *OvD*, paired oviducts; *Rec*, receptaculum seminis; *Te8*, eight tergites, reduced; *Spg*, spermathecal gland; *Spv*, spiculum ventrale; *Vag*. vagina.

ovaries (Ov) are present which are connected distally. The paired oviducts (OvD) are short and stout. The vagina (Vag) is distinctly shorter than the ovaries. Near the basal end of the latter two cement glands (Ceg) originate. They are rather weakly developed, short and ball-like in outline. A bursa copulatrix is not present. The receptaculum seminis (Rec) originates from the vagina at about the

same level as the cement glands; it has the shape of a pipe and bears on its distal end the spermathecal gland (Spg). The receptaculum was examined in all three species but no differences have been found.

In the classification of the *Scolytidae,* based on the female reproductive organs by Nuesslin, *Gnathotrichus* would fall in a group together with the genus *Thamnurgus* Eichhoff.

The Alimentary Canal

The alimentary canal was fully investigated in *Gn. materiarius* Fitch, the proventriculus in *Gn. retusus* Lec. and *sulcatus* Lec., also. The whole alimentary canal of *Gnathotrichus* is illustrated in figure 34, the proventriculus in figure 35.

The alimentary canal is a tube extending from one end of the body to the other. As in most of the mandibulary insects, three main divisions are clearly defined. These are termed the fore, mid, and hind intestine (fig. 34, A, B, C). The ectodermal origin of the fore- and hind intestine are well illustrated by the occurring chitinizations.

Fore-intestine.—On the fore-intestine the following consecutive divisions are well defined: The Pharynx (?), Oesophagus (Oes), Crop (Cr), and the proventriculus (Pve). The well developed proventricula are the characteristicum of the adults.

The pharynx is not distinctly defined from the mouth cavity.

The oesphagus is about as long as the crop and the proventriculus united. It consists of a simple tube, widened distally where it gradually passes over to the crop.

The strongly widened tube situated apically of the proventriculus may be designated as the crop.

Proventriculus.—The proventriculus is a highly specialized organ in which the food is prepared before it enters the more delicate ventriculus. The characteristic features of the proventriculus are a remarkable development of the chitinous intima into folds and teeth and a considerable increase of the size and development of the muscles of this region. On account of the importance of the proventriculus as a taxonomical characteristicum and of the general morphological interest of this structure, a more detailed discussion seems to be necessary.

Lindeman, who was the first investigator of the *Scolytid* proventriculus, distinguished two main parts or longitudinal divisions. The anterior part he called the Sack, the posterior, or caudad part, the Kaumagen. Nuesslin and Fuchs followed Lindeman's nomenclature. The Sack (Lindeman) corresponds to the crop (Hopkins) and forms the intermediate part between the oesophagus and the Kaumagen (Lindeman). Hopkins used the term proventriculus for the Kau-

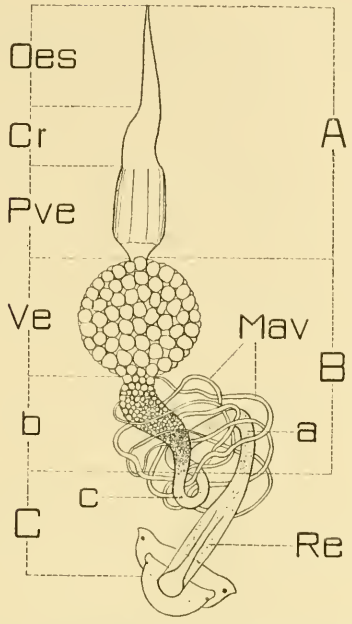

FIG. 34.—*Gnathotrichus materiarius* Fitch: Adult, alimentary canal and its appendages.

A, fore intestine; *B*, mid-intestine; *C*, hind-intestine; *Cr*, crop; *Mav*, malpighian vessels; *Oes*, oesophagus; *Pve*, proventriculus; *Re*, rectum; *Ve*, ventriculus; *a*, large intestine; *b*, posterior tube of the mid-intestine; *c*, small intestine.

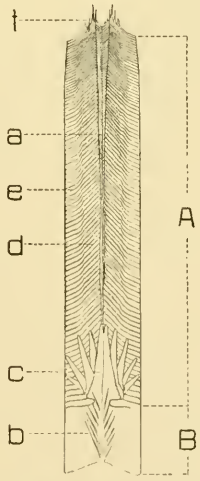

FIG. 35.—*Gnathotrichus materiarius* Fitch: Proventriculus.

a, median line; *b*, sutural teeth; *c*, anterior closing teeth; *d*, dentation of masticatory teeth, all together, masticatory brush; *e*, femora of the masticatory teeth, Abdachungszaehne (Nuesslin); *f*, posterior closing teeth; *A*, masticatory plate; *B*, anterior plate.

magen (Lindeman) only. In the following discussion the interpretations of Hopkins of the terms crop and proventriculus are used.

The proventriculus consists of eight plates arranged to form a tube, as illustrated in figure 35. On each plate two longitudinal divisions are clearly defined. Lindeman called the cephalad part the Plattenteil (A), the caudad part the Ladenteil (B); the corresponding terms of Hopkins are anterior plate and posterior or masticatory plate. The latter terms are adopted in this paper. In *Gnathotrichus,* both of these plates are divided by a median suture (a) which is distinctly visible on the masticatory plate and indicated by a row of bristles (b) on the anterior plate. These bristles, which are of taxonomic importance, have been called Zaehne am medianen Kauplattenrand by Nuesslin and sutural teeth by Hopkins. In *Gnathotrichus* they are present as slender, sharply pointed, and simple bristles. The anterior plate is not quite one-sixth as long as the whole proventriculus. The masticatory plate (A) bears a symmetrical arrangement of teeth which presents the true chewing apparatus of the proventriculus. On each tooth two elements are clearly defined, the instep and the dentation. The totality of the insteps corresponds to the Abdachung (c); that of all dentations to the Buerste (a) of the German authors. Hopkins called the first mentioned the femora of the masticatory teeth, the latter the masticatory brush. The masticatory teeth are all similar in shape and very numerous in the genus *Gnathotrichus.* Cephalad, they are bordered by a few (8-12) longer teeth (c) which differ greatly in shape and which are directed toward the center of the proventriculus. These teeth are apparently intended to regulate the entering of the food. They have been called Sperrborsten by Nuesslin and closing teeth by Hopkins. To distinguish them from a similar arrangement of teeth which occur in *Gnathotrichus* and other genera on the caudad end of the masticatory plate (f) it is proposed to call the former cephalad closing teeth, the latter caudad closing teeth. In *Gnathotrichus,* the following armatures are not present:

(a) Hackenzaehne (Nuesslin), or apical teeth of the anterior plate; the designation of a row of short, often curved teeth on the apical margin of the anterior plate.

(b) Ersatzperrborsten (Nuesslin), marginal bristles or marginal fringe (Hopkins); a longitudinal row of bristles along the lateral margin of the anterior plate.

(c) Kreuzlinie (Nuesslin), a row of short, stout teeth arising from the lateral margin of the anterior plate and converging posteriorly.

(d) Abdachungszaehne (Nuesslin), masticatory teeth which have two dentations, one, the totality of all composing the masticatory brush, and a second smaller tooth on the instep, the totality of which forms a second brush consisting of a single row of teeth only.

In the classification of the *Scolytidae* based on the proventriculus, *Gnathotrichus* should be placed with *Xyloterus* Er., *Xyleborus* Eichh., *Anisandrus* Ferr. and other ambrosia beetles together in one group. There is little doubt that the similarity of the digestive systems in ambrosia beetles of the Superfamily *Scolytoidea* is of no importance in the classification. These are merely parallel modifications of groups deriving from very different ancestors.

The proventriculus is very similar in all three species of *Gnathotrichus* and it is not possible to distinguish them by characters of this part.

Mid-intestine.—The mid-intestine is about one-third of the whole length of the alimentary canal. According to Nuesslin the proportions are the same as in *Anisandrus dispar* Fabr. and *Xyloterus lineatus* Oliv.

In *Gnathotrichus* two subdivisions of the mid-intestines are well defined. The anterior part, which presents the widest part of the whole alimentary canal, has the form of a ball and is covered with short, half spherical gastric coeca. This part is here designated as the ventriculus proper. The posterior, much narrower tubelike part, is here called the posterior tube of the mid-intestine. It bears much smaller gastric coeca which distinctly decrease in size toward the origin of the Malpighian vessels and which are always more filiform in shape. The origin of the Malpighian vessels marks the posterior limit of the mid-intestine. These are rather narrow, long tubelike vessels, strongly entangled around the posterior part of the mid-intestine and do not vary noticeably in size.

Hind-intestine.—While the fore- and mid-intestine are situated as a straight tube in the body, the hind intestine forms a distinct loop. The latter does not bear any gastric coeca but is characterized by the muscles which enclose it. The subdivisions, the small and large intestine and the rectum, are not so clearly separated. The ovaries of the female reproductive organs are always situated above the hind intestine; the testi of the male lie under and ventral to it.

The Larvae

On account of the difficulty in getting material of the western species, the following discussion is based on *Gnathotrichus materiarius* Fitch only.

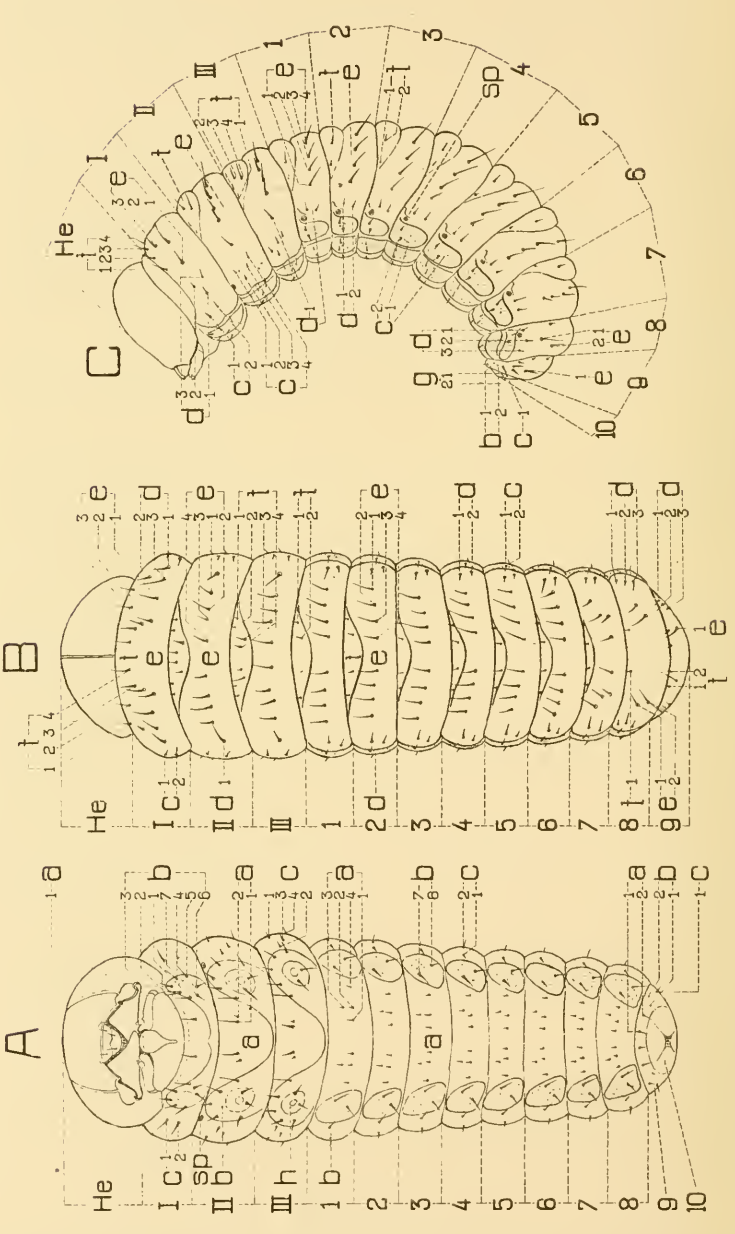
A
B
C
He
I
II
III
sp
1
2
3
4
5
6
7
8
9
10

FIG. 36.—*Gnathotrichus materiarius* Fitch: Fully-grown larva, showing structure and arrangement of setae; A, ventral, B, dorsal, C, lateral aspect.

EXPLANATION OF FIG. 36.

He, head; *I, II, III*, the three thoracic segments; 1-10, the ten abdominal segments; *a*, sternal plate, seta sternalis; a_1, single seta on prothoracic sternum; a_{1-2}, two single setae on meso- and metathoracic sternum, and also on 9th abdominal segment; a_1, 2, 3, 4, four setae on abdominal sternum 1-8; *b*, sternellar plate, seta sternellaris; b_{1-7}, seven setae on the thoracic segments; b_{1-2}, two setae on the abdominal segments 1-9; *c*, hypopleural plate, seta hypopleuricum; c_{1-2}, two setae on hypopleurite of first thoracic segment and abdominal segments 1-7; c_{1-4}, four setae on hypopleurite of second and third thoracic segments; c_{1-3}, three setae on hypopleurite of eighth and ninth abdominal segments; c_1, one seta on hypopleurite of ninth abdominal segment; *d*, epipleural plate, seta epipleuricum; d_{1-3}, three setae on abdominal segments 8 and 9, and first thoracic segment; d_1, one seta on thoracic segments 2 and 3; d_{1-2}, two setae on abdominal segments 1-7; *e*, scutellar scutal plate, seta scutuli; e_{1-3}, three setae on thoracic segment 1; e_{1-4}, four setae on thoracic segments 1 and 2, and abdominal segments 1-7; e_{1-2}, two setae on abdominal segment 8; e_1, one seta on abdominal segment 9; *f*, prescutal plate, seta praescuti; f_{1-4}, four setae on thoracic segments 1-3; f_{1-2}, two setae on abdominal segments 1-7; f_{1-3}, three setae on abdominal segment 9; f_1, one seta on abdominal segment 8; *g*, anal lobes, anal segment; g_{1-2}, two setae on anal segment, seta analis; *h*, foot calli; *sp*, spiracles.

The structure and general appearance of the larva are shown in figure 36. The larva is legless, subcylindrical, white in color except the heavily chitinized and therefore reddish-brown headcapsula. The full grown larva is about 3.7 mm. long. Three thoracic and nine abdominal segments are well developed. The anal lobes may be regarded as a tenth abdominal segment. The three thoracic segments are nearly equal in size and only little larger than the first abdominal segment. The abdominal segments decrease slightly in width and length toward the apex. All segments and the head are armed with constant setae. The statement of Hopkins (38) that "with the exception of scattering hairs on the head and on the scutellar lobes of the thoracic and abdominal segments the body is without distinguishing vestiture" in *Dendroctonus* has been found to be not true. There occur at least in *Dendroctonus valens* distinct setae. That this is not exceptional in the *Scolytidae* has been proved by Russo (57) and the author. The latter has studied many species and has found that every examined species shows distinct setae. The following discussion is based on the full grown larvae only. The fact that the present study was made in a private home did not allow of rearing work and therefore the question of molds, etc., cannot be discussed at present.

THE CHITINOUS SKELETON

THE HEAD

The head of the larva is more simple in structural details than that of the adult. It is distinctly narrower than the first thoracic segment when seen from above, but nearly equal in length and in width to the latter when viewed from the side. The general structure is shown in figure 36, the anatomical details in figure 37. The more striking differences in the larval head are found in the presence of a clearly defined front, clypeus, labrum, and a well developed submentum.

Epicranial suture.—The sutura metopica as well as the sutura fronto-verticale are well developed and double lined (a, b). They are not raised or padded as in the adults.

Front.—The front (fig. 37, Fr) is triangular in outline, plano-convex and clearly defined by the epicranial suture. The lateral sides are bordered with six strong bristles each (d). These setae are here called setae fronto-lateralis. The base of the front is smooth without any armation.

In the discussion of the larval setae it seems to be very useful to compare the results obtained with those of other authors. From the

literature available, only two species have been found to be studied at the present. These are *Dendroctonus valens* Lec., investigated by Hopkins, and *Chactoptelius vestitus* Fuchs studied by Russo. The

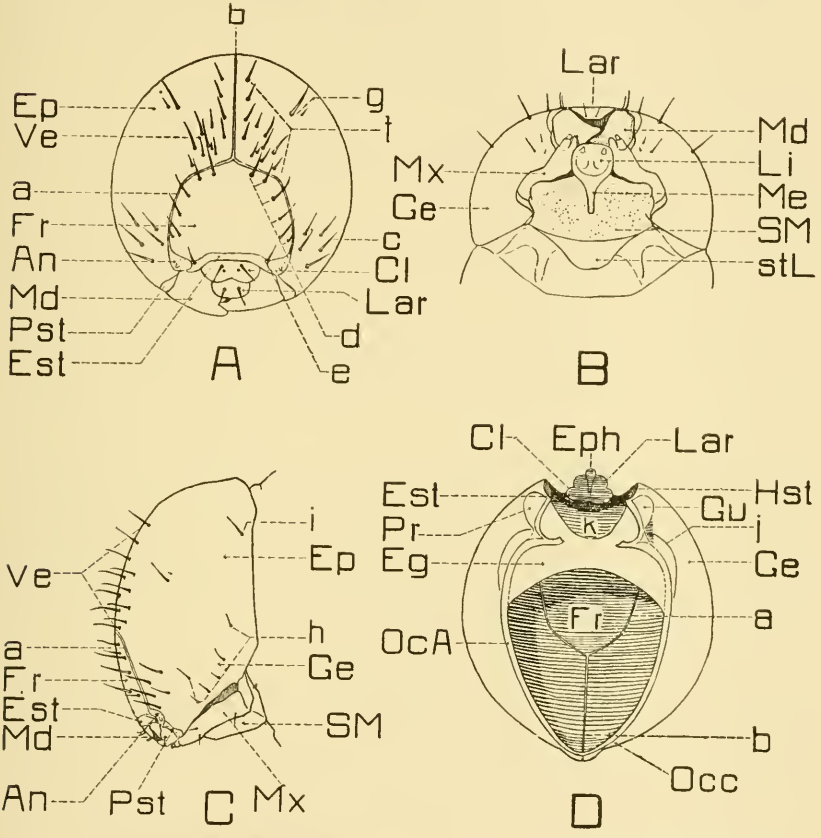

FIG. 37.—*Gnathotrichus materiarius* Fitch: Head of fully-grown larva; A, frontal aspect, B, ventral aspect, C, lateral aspect, D, occipital aspect.

An, antenna; *Cl*, clypeus, seta clypei; *Eg*, entogular plate; *Ep*, epicranium; *Eph*, epipharynx; *Est*, epistoma; *Fr*, front; *Ge*, gena; *Gu*, gula; *Hst*, hypostoma; *Lar*, labrum, setae labralis; *Li*, ligula; *Md*, mandible; *Me*, mentum; *Mx*, maxilla; *Occ*, occiput; *Oc-A*, occipital apodeme; *Pr*, pregena; *Pst*, pleurostoma; *SM*, submentum; *Ve*, vertex; *a*, sutura metopica; *b*, sutura fronto verticale; *c*, seta geno mediana; *d*, seta fronto lateralis; *e*, seta epistomalis; *f*, seta verto mediana; *g*, seta verto lateralis; *h*, seta geno lateralis; *i*, seta epicrano-lateralis; *j*, gular suture; *k*, maxillare foramen; *stL*, sternal lobe.

comparison of the setal arrangement with the latter species will be given at the end of each chapter.

Clypeus.—As mentioned before, the clypeus (fig. 37, Cl) is well developed in the larvae. It consists of a nearly rectangular plate which is heavily chitinized, distinctly emarginate anteriorly and broadly rounded antero-laterally. Basally it is separated from the

epistoma by a faint suture. A pair of bristles and two punctures occur near the basal margin. The setae are called setae clypei.

Labrum.—The labrum (fig. 37, Lar) is basally separated from the clypeus by a distinct suture. It consists of a heavily chitinized half circular plate. It is as long as, and about one-third narrower, than the clypeus and bears several papilla apically. Half way of its length occur two long bristles, the setae labralis.

Epistoma.—Between the front and the clypeus, a narrow thickened transverse band occurs which may be designated as the epistoma (Est). Laterally this structure is slightly bent forward and this part bears the dorsal articulation of the mandibles. On the latero-basal angles, near the suture, a long bristle is situated. The proposed name is seta epistomalis.

Pleurostoma.—A faint suture hems the lateral portion of the oral foramen, parallel to the lateral exposed part of the mandibles, which cuts off a narrow area of the cranium. This area, the pleurostoma, is slightly raised externally; internally it is ridgelike, and connects the epistoma with the hypostoma.

Hypostoma.—The hypostoma (fig. 37, Hst), which bears the ventral articulation of the mandibles, is rather ill-defined externally. Internally it is ridgelike and the articulatory condyles and fossa are submerged. Towards the occipital foramen it is extended in another ridge from which the connecting membranes of the maxilla and the submentum arise.

Occipital foramen.—The occipital foramen (fig. 6, Oct) is situated on the caudad face of the head capsula. It is heart-shaped and is bordered by a ridgelike rim, the occipital apodeme (fig. 37, OcA). The latter is interrupted ventrally. The entogular plate extends into the foramen under the occipital apodeme giving the open space of the foramen the shape of a triangle, the sides of which are broadly rounded.

Gula.—The gula (Gu) is present as two small lobes, each situated along the ventro-lateral angles of the occipital apodeme. The lateral limitation is indicated by an obscure suture.

Entogular plate.—A subchitinous plate (Eg) connects the genal areas and extends ventrally up to the hypostoma. It was called the entogular plate by Hopkins. The open space of the oral foramen is also reduced by the lammella-like extension of this plate. The entogular plate is not visible externally but hidden from the submentum.

Pregena.—A narrow area along the ventral extensions of the hypostoma, and laterally limited by obscure lines, may be considered as the pregena (Pr).

Other topographical regions of the cranium are not defined by sutures but they are somewhat limited by the occurring setae.

Vertex.—The area on both sides of the sutura fronto-verticale, the vertex (Ve), bears two groups of setae. Eleven bristles (f) are situated along each side of the sutura fronto-verticale. Four of them are arranged in a single row along the suture; the rest occur in the angle formed by the sutura fronto-verticale and the sutura metopica. They are called setae verto-mediana. A single bristle widely separated from the setae verto-mediana, the seta verto-lateralis (g) presents the second group. Sometimes a minute hair is also visible near the latter mentioned bristle.

Gena.—The area between the sutura metopica and the occipital apodeme ventro-laterally to the vertex is here designated as the gena (Ge). It bears two groups of setae, one on the level of, and close to, the antennae (c) and one laterally (h) to them but widely separated from them. The former consists of five, the latter of six long bristles. The corresponding names are the setae geno-mediana and the setae geno-lateralis.

Epicranium.—The area dorsally to the genae and laterally to the vertex is called the epicranium. A single bristle (i) sometimes associated with a minute hair, is situated near the occipital apodeme. It is called the seta epicrano-lateralis.

THE APPENDAGES OF THE HEAD

THE ANTENNAE

The antennae (fig. 37, An) are present as small membranous lobes next to the ventral end of the sutura metopica. Each bears one papilla and numerous minute hairs.

THE MOUTHPARTS

Mandibles.—The mandibles (fig. 28) differ somewhat from those of the adults, in contrast to which only one median tooth is present and the shape of the mandible is more slender and triangular. The setae are present in the same number as in the adults but their position in relation to each other is different. Proposed names: setae mandibulae dorsalis and setae mandibulae lateralis.

Maxillae.—The maxilla of the larva (fig. 38, A) is much simpler in structure than that of the adult. However, all parts present in the adult maxilla are also distinguishable in the larva.

The cardo (Ca) is present as a distinct sclerite, triangular in outline and connected with the extended hypostomal ridge, the mentum and the stipes respectively. This is, as in the adult, not the only con-

nection of the maxillae with the mentum. The subgaleal area is also connected with the mentum along its interno-lateral margin. The stipites (St) are distally not subdivided into a palpifer, and are fused internolaterally with the subgalea.

A single bristle (b) occurs near the externo-lateral margin. It was called the setole laterale dello stipite by Russo. In the present paper the name is modified into seta stipitis maxillaris. The palpiferal area

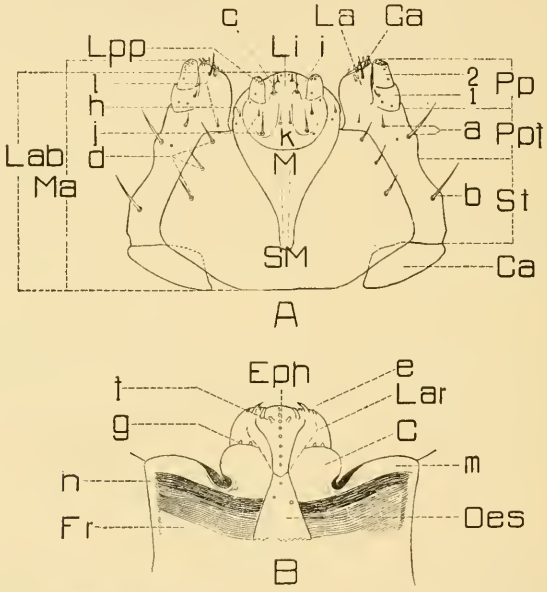

FIG. 38.—*Gnathotrichus materiarius* Fitch: A, labium and maxilla, ventral aspect: B, clypeus and labrum, ventral aspect.

Ca, cardo; *Fr*, front; *Eph*, epipharynx; *Ga*, galea; *La*, lacinia; *Lab*, labium; *Lar*, labrum; *Lpp*, labial palpi; *Li*, ligula; *M*, mentum; *Ma*, maxilla; *Oes*, oesophagus; *Pp*, maxillar palpi; *Ppf*, maxillar palpifer; *SM*, submentum; *St*, stipes; *C*, clypeus; *a*, seta palpifera maxillaris; *b*, seta stipitae maxillaris; *c*, seta ligulae distalis; *d*, seta submento-lateralis; *e*, papilla labro-apicalis; *f*, papilla epipharno-distale; *g*, papilla clypei; *h*, seta menti; *i*, seta ligulae mediana; *j*, seta labio-palpiferis, and palpiferal area; *k*, seta ligulae basalis, and basal area; *l*, seta lacinio-maxillaris; *m*, epistomal apodeme; *n*, apodeme between lateral angle of epistoma and dorsal angle of pleurostoma.

bears two bristles (a) and one puncture; the outer corresponds to the setola laterale dello palpifera, and the inner to setola mediana dello palpifera (Russo), here called seta palpiferae (maxillaris). The palpus is two-segmented, telescopic, the first segment armed with a short fine hair and two punctures, the second with punctures only. The bristle on the first segment is the setola palpiale (Russo) but to distinguish it from possible setae on other joints, it should be called seta palpo-maxillaris 1°. The lacinia is present as a well developed lobe distally armed with two long bristles (setae lacinio-maxillaris)

and a few papillae. The galea is largely fused with the lacinia. Distally a rather shallow fold indicates the separation of these two sclerites.

The setae of the maxillae have not been studied thoroughly enough to decide if they are of taxonomic importance or not. In *Dendoctonus valons,* no setae or punctures occur on the palpus and none of them on the lacinia, according to the drawings published by Hopkins. On the other hand it was found that the setal arrangement of

TABLE I.—*Setae of the head, nomenclature.*

Nomenclature of Dr. Russo	Used on	New nomenclature	Used on
Setole mediane-distale Setole submediane Setole laterali	Frons	Seta fronto-lateralis	Frons.
Setole basali	Frons-epistoma	Seta epistomalis	Epistoma.
Setole basali clypeali	Clypeus	Seta clypei	Clypeus.
Setole mediane distali Setole premediane Setole sublaterali Setole basali-laterali	Labrum	Seta labralis	Labrum.
		Seta verto-mediana Seta verto-lateralis	Vertex.
Setole laterale del vertice Setole mediane Setole basale Setole interna del vertice	Genae	Seta geno-lateralis	Genae.
Setole della gena Setole mediane Setole esterna Setole basale	Genae	Seta geno-mediana	Genae.
		Seta epicrano-lateralis	Epicranium.
Setole dorsali	Mandible	Seta mandibulae dorsalis	Mandible.
Setola sublaterale-basale	Mandible	Seta mandibulae lateralis	Mandible.
Setola laterale dello stipite	Stipes	Seta stipitae maxillaris	Stipes.
Setole mediane del palpifero	Palpifer	Seta palpiferae maxillaris	Palpifer.
Setole laterale del palpifero Setole palpiale	First joint of palpus.	Seta palpo-maxillaris 1°	First joint of palpus.
		Seta lacinio-maxillaris	Laciniae.
Setole distale Setole mediane Setole subbasali	Submentum	Seta submento-lateralis	Submentum.
		Seta menti	Mentum.
Setole subbasali	Mentum	Seta labio palpiferis	Palpifer of labium.
Setole distale Setole mediane	Ligula	Seta ligulae distalis. Seta ligulae mediana. Seta ligulae basalis.	

Gn. materiarius Fitch is exactly the same as that of *Chactoptelius vestitus* Fuchs, illustrated and described by Russo.

Labium.—The labium (Lab) of the larva is very different in structure from that of the adult. Indications are that the labium of the larva as well as that of the adult will become more and more important as the bearer of taxonomic characters in the *Scolytidae.*

The submentum (SM) is present as a large sclerite and is trapezoid in outline. The shape is more like that of *Chactoptelius vestitus* Fuchs. It is slightly chitinized, laterally connected with the maxillae and bears three pairs of setae (d), the same number and in a similar arrangement as in *Chactoptelius vestitus* and *Dendroctonus valens.* Russo called these setae setole subbasale, setole mediane and setole distale in order proceeding distad. The anterior margin of the sub-

mentum does not extend as far as the origin of the palpi as in the two other species mentioned above.

The mentum (M) is a submembranous triangular plate the base of which is anterior. The posterior angle is narrow and strongly produced. Anteriorly it is fused with the palpiferal area of the labium. A single bristle and a puncture (h) are situated on the antero-lateral angles. The name proposed is seta menti.

TABLE II.—*Comparison of head setal arrangement.*

Seta	*Chactoptelius vestitus* Fuchs.	*Dendroctonus valens* Lec.	*Gnathotrichus materiarius* Fitch.
Fronto-lateralis	4	4	6
Epistomalis	1	1	1
Clypei	2	1	1
Labralis	5	2	1
Verto-mediana	0	?	12
Verto-lateralis	0	?	2
Geno-lateralis	8	?	6
Geno-mediana	4	?	5
Epicrano-lateralis	0	?	1
Mandibulae-dorsalis	2	2	2
Mandibulae-lateralis	1	1	1
Stipitis maxillaris	1	?	1
Palpiferae maxillaris	2	?	2
Palpo-maxillaris	1	0	1
Lacinio-maxillaris	1	0	3
Submento-lateralis	3	3	3
Menti	0	0	1
Labio-palpiferis	1	1	2
Ligulae-distalis	1	1	1
Ligulae-mediana	0	0	1
Ligulae-basalis	1	1	1

The ligula (Li) consists of a circular plate largely surrounded by the mentum. From subdivisional parts the base of the ligula is visible from which it is well defined by faint sutures and the palpi (Pp). The base bears a single pair of setae. They are present as two short bristles and are called the setae ligulae basalis. The palpiferal area is situated on both sides of the base. The part anterior to the base of the ligula and between the palpi may be designated as the distad end of the ligula. The palpi are two-jointed. The palpiferal area bears two setae (j) which are called setae labio-palpiferis. The distal area of the ligula is armed with two pairs of setae. Proposed names: setae ligulae mediana and distalis.

THE THORAX

The thoracic segments are somewhat larger in size than those of the abdomen. They do not differ from each other in shape but are distinguished by the structure and the development of the setae. The thoracic segments are legless as in the whole superfamily but the foot calli are distinct.

Dorsally, the prothorax is distinguished from the other two thoracic segments by the lack of the suture which divides the prescutum (fig. 36) from the fused scutal-scutellar area. However, the prescutum is indicated by the corresponding setae. On the meso- and metathorax, the prescutum is present as a narrow transverse sclerite (f), near the anterior margin of which the prescutal setae (f_{1-4}) are situated. The scutum (e) and the scutellum are in all three segments fused. The pleural area is fairly well defined by a longitudinal fold ventrally. Latero-dorsally it is fused with the scutal-scutellar area. Another longitudinal fold divides the pleural area into two distinct parts. The part next to the scutal-scutellar area represents evidently the epipleurite (d), the ventral part the hypopleurite (c). The former has a smooth surface bearing setae only; the latter has the surface covered with minute spines beside the setae. On the sternum two subdivisions are plainly visible, the sternal (a) and the sternellar area (b). The sternellar area or sternellum consists of two large lateral lobes which are connected by a very narrow band medially. The lateral lobes which bear the foot calli are covered with minute spines similar to those in the hypopleurites. There is not enough evidence to speak about a poststernellar area in *Gnathotrichus* as it should be present in *Dendroctonus* according to Hopkins. The setal arrangement will be discussed with that of the abdomen.

THE ABDOMEN

The abdomen (fig. 36) consists of ten segments, the tenth of which is strongly reduced and present as the anal lobes. The segments decrease in size slightly towards the apex. Segments one to seven inclusively are alike in structure and setal arrangement. They differ in structure from the meso- and metathorax in having longitudinal folds which separate the epipleural area from the sternum and the scutal-scutellar area. Also the sternal-sternellar suture is restricted to a membranous fold. The two lateral lobes of the sternellum are apparently not connected medially. The eighth segment does not show signs of the prescutal-scutal suture. Still more reduced is the ninth segment; it has no sutures or folds but the different sclerites can be

determined very plainly from the position of the setae. The anal or tenth segment is separated from the ninth by an obscure suture. It consists chiefly of the four anal lobes. There is no difference in the structure of these lobes and also armations do not occur as in other genera.

THE SPIRACLES

Nine pairs of spiracles are present, eight of which are situated on the epipleurites of the first eight abdominal segments. The ninth spiracle is on the same sclerite of the prothorax very close to the mesothorax.

THE THORACIC AND ABDOMINAL SETAE

It was found that the setal arrangement is very constant from specimen to specimen. The number of setae varies in the different segments. The smallest number of setae was found to be present in the anal segment (2 x 2) and the eighth abdominal segment (2 x 11); the greatest number was borne by the meso- and metathorax (2 x 22). The number of setae in the different segments is best explained by

TABLE III.—*Setae of thorax and abdomen, nomenclature.*

Nomenclature of Dr. Russo	Used on the segments	New nomenclature	Used on the segments	Fig. 36
Setole tergali mediana	I, II, III, 1	Seta praescuti	I, II, III, 1-9	t
Setole protergali	1-8			t
Setole posttergali	I, II, III, 1-8			
Setole tergali-laterali	1	Seta scutuli	I, II, III, 1-9	e
Setole tergali	9			
Setole epipleuri	I, 1-8			
Setole pleuri-sternali	9 [1]	Seta epipleuricum	I, II, III, 1-9	d
Setole tergali-pleurali	II, III,			
Setole ipopleurali	I, 1-8			
Setole pleurali-sternali	9 [2]	Seta hypopleuricum	I, II, III, 1-9	c
Setole epipleuri	II, III			
Setole sternali-anteriori-externe	I			
Setole sternali-posteriori-externe	I			
Setole sternali-mediane	I			
Setole ipopleurale	II, III	Seta sternellaris	I, II, III, 1-9	b
Setole sternali-laterali	II, III			
Setole sternali mediane	II, III			
Setole sternali	1-8			
Not investigated		Seta sternalis	I, II, III, 1-9	a
Setole anali	10	Seta analis	10	g

[1] The two dorsal setae.
[2] The two ventral setae.

table No. III and figure 36. It should only be mentioned that the meso- and metathorax and also the abdominal segments one to seven are alike. The prothorax, the eighth, ninth and tenth abdominal segments differ considerably. It also should be noted that the first abdominal segment does not show any difference from the following one, as shown in *Chaetoptelius vestitus* Fuchs, according to Russo.

The nomenclature of Russo has been adopted to a great extent but several changes have become necessary as illustrated in table III.

TABLE IV.—*Comparison of the arrangement of the setae of the thorax and abdomen.*

	I			II			III			1			2-7			8			9			10		
	Dendroctonus valens Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch.	*Dendroctonus valens* Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch.	*Dendroctonus valens* Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch.	*Dendroctonus valens* Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch.	*Dendroctonus valens* Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch.	*Dendroctonus valens* Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch.	*Dendroctonus valens* Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch	*Dendroctonus valens* Lec.	*Chaetoptelius vestitus* Fuchs.	*Gnathotrichus materiarius* Fitch.
Seta sternalis	...	(?)	1	...	(?)	2	...	(?)	2	...	(?)	4	...	(?)	4	...	(?)	4	...	(?)	2	...	...	...
Seta sternellaris	...	13(?)	7	...	11(?)	7	...	8(?)	7	...	2	2	...	2	2	...	2	2	...	(?)	2	...	...	...
Seta hypopleuricum	...	4	2	...	4	4	...	4	4	...	2	2	...	2	2	...	2	2	...	2	1	...	...	...
Seta epipleuricum	...	3	3	...	3	1	...	3	1	...	2	2	...	2	2	...	2	3	...	2	3	...	...	...
Seta prescuti	...	1(?)	4	...	1(?)	4	...	1(?)	4	...	2	2	...	1	2	...	1	1	...	2	2	...	...	...
Seta scutuli	...	5(?)	3	...	3	4	...	4	4	...	4	4	...	4	4	...	4	2	...	2	1	...	...	...
Seta analis	...	.....	...	...	.....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2

THE ALIMENTARY CANAL

The alimentary canal (fig. 39) of the larva shows some of the more primitive conditions of the highly specialized digestive system of the adult. It is about $1\frac{1}{2}$ times as long as the body. The same chief divisions as in the adult stage are clearly defined, but the proportions of the length of these are quite different. The fore-intestine occupies only one-ninth of the whole alimentary canal while the mid-intestine is

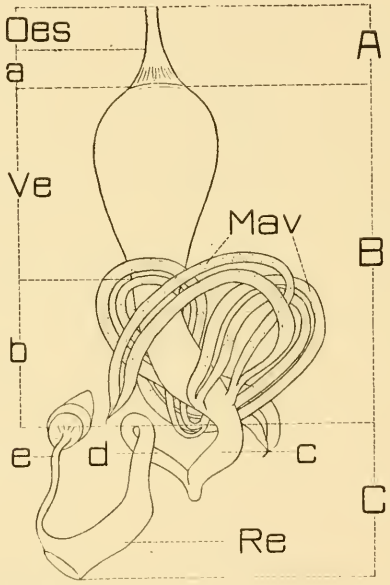

FIG. 39.—*Gnathotrichus materiarius* Fitch: Alimentary canal and its appendages of a full-grown larva.

A, fore intestine; *B*, mid-intestine; *C*, hind intestine; *Mav*, malpighian vessels; *Oes*, oesophagus; *Re*, rectum; *Ve*, ventriculus; *a*, region corresponding to crop and proventriculus; *b*, posterior tube of mid-intestine; *c*, large intestine; *d*, small intestine; *e*, reproductive canal.

enlarged to spread over five-ninths of the same length. The gastric coeca are small, the proventriculus absent and the Malpighian vessels are very strongly developed.

Fore-intestine.—The epipharynx (fig. 38, Eph) is well developed and projects distally slightly over the anterior margin of the labrum. It is distinctly defined from the labrum and clypeus; four papillae occur anteriorly and a row of sensory pores medially. The latter punctures are reduced to a single puncture in *Ch. vestitus* and are absent in *Dendroctonus valens*. according to the respective authors. The hypopharynx does not show any armature or sensory organs.

The oesophagus is a short tube of about equal diameter throughout. The caudad widened part, which is also encircled by strong muscles, may correspond to the united crop and proventriculus.

Mid-intestine.—The mid-intestine occupies the greatest area of the whole digestive system of the larva. The ventriculus is pearlike in shape, having the blunt end anteriorly. The gastric coeca are not so densely placed and are smaller than in the adult. The posterior tube is distinctly separated from the ventriculus. It gradually decreases in diameter towards the apex and bears on its caudad end the Malpighian vessels. These originate as a single tube and become divided shortly after their origin. Three pairs of vessels are present.

Hind-intestine.—As in the adults the hind-intestine forms a loop. The hind-intestine is encircled by ring muscles. The small and large intestines are not very distinctly separated from each other. More clearly defined is the rectum. The latter is distinctly wider than the rest of the hind-intestine, and the muscles encircling it are much more strongly developed.

From the anus originates a glandlike structure which is strongly widened distally. This evidently represents the ectodermal part of the reproductive organs of the adult. See also the discussion of the reproductive organs of the adult.

THE PUPAE

In the study of the pupa of *Gnathotrichus,* special attention was given to the changes of the setal arrangement from larva to pupa. The only illustration of a pupa of the *Scolytidae* showing the setal arrangement was found in the monograph of the genus *Dendroctonus* by Hopkins (38). It seems that Hopkins, who has usually overlooked the setae of the larva, did not realize the origin of the setae of the pupa, which he called spines. Russo, on the other hand, shows plainly the setae of the larva but has ignored those of the pupa. In fact, it is a difficult undertaking to study the setae of such small larvae or pupae. In *Gnathotrichus,* it is not possible to find the setae by working with a binocular but slides had to be made and those carefully examined under the microscope. The following discussion is illustrated by figure 40. The setae are only barely visible soon after the last molting of the larva. In the young pupa they are most distinct before the pupa starts to become the mature color, and they disappear gradually with the ripening of the adult.

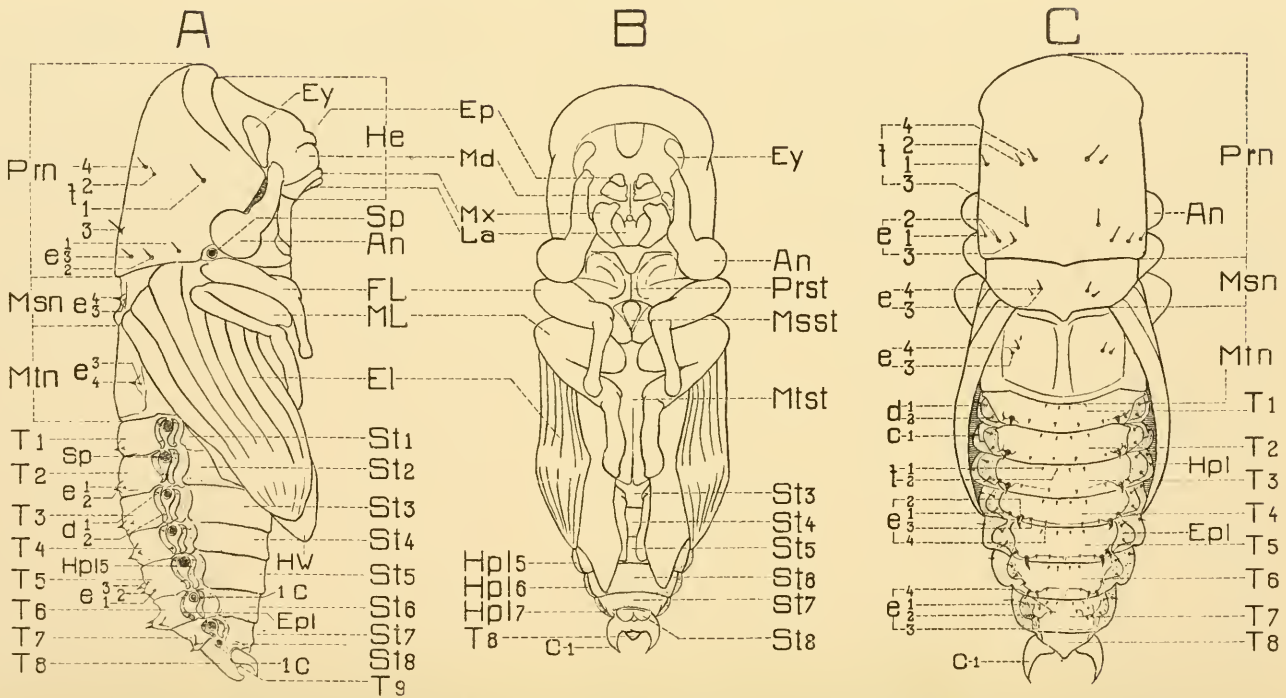

FIG. 40.—*Gnathotrichus materiarius* Fitch: Pupa; A, lateral aspect, B, ventral aspect, C, dorsal aspect.

An, antenna; *El*, elytra; *Ep*, epistoma; *Epl*, epipleurite; *FL*, fore legs; *He*, head; *Hpl*, Hypopleurite; *HW*, hind wings, or metathoracic wings; *La*, labium; *Md*, mandible; *ML*, middle legs, or mesothoracic legs; *Msn*, mesonotum; *Msst*, mesosternum; *Mtn*, metanotum; *Mtst*, metasternum; *Mx*, maxilla; *Prn*, pronotum; *Prst*, prosternum; *Sp.*, spiracle; *St*, sternum, 1-8, sterna of abdomen; *T*, tergum, 1-8, terga of abdomen; c_{1-3}, setae hypopleuricum; d_{1-2}, setae epipleuricum; e_{1-4}, setae scutali; f_{1-4}, setae prescuti.

THE HEAD

The elements of the adult and larval head are also recognizable in the pupa. The antennae are among the first parts to be fully developed. The mandibles, the maxilla and the labium are first indicated by low elevations which become gradually the shape of the corresponding elements in the adult stage. A lobe, situated dorsally of each mandible (Ep) is more distinct in the younger pupa and gradually disappears. It is apparently the reduced labrum and clypeus. A similar development takes place with the frontal groove which is a distinct wide groove at first and later on becomes reduced to the narrow simple sutura fronto-verticale. The larval setae of the head are all completely lost in the pupa.

THE THORAX

Prothorax.—The shape and the relative proportions of the prothorax resemble very much that of the adult. The sternum and the extreme anterior margin of the pronotum are more strongly developed at first. The latter is padded at first and densely covered with minute spines. The setae are all lost with the exception of those of the prescutum and the scutum. The setae f_{1-4} of the prescutum are arranged similarly as in the larva while f_3 is widely separated from the rest in the direction toward the caudal margin of the sclerite. The setae scutali e_{1-4} are, as in the larva, situated in a nearly straight transverse line near the caudad border of the pronotum. The arrangement of the setae shows that the pronotum of the adult belongs with its anterior three-quarters to the prescutum and that only the caudad narrow portion originates from the scutum. The spiracle is plainly visible in the young pupa and becomes covered by the caudad lateral angles of the pronotum.

Mesothorax.—The mesothorax is somewhat more strongly developed in the pupa than in the adult. The mesonotum is not overlapped by the pronotum and is present as a nearly rectangular plate extending the full width of the mesothorax. The only setae found were the e_{3-4} of the larval stage; they are in a position similar to that in the larva. The elytra are thicker than in the adult, the tracheal vein is well developed, and the articulation occurs along their whole bases occupying the greatest part of the pleural area.

Metathorax.—In the metathorax the scutum with the scutellar groove is first recognizable. The prescutum and the postscutellum or postnotum are indicated by two narrow transverse bands only. The scutum bears the setae e_{3-4} corresponding to the larva. The meta-

thoracic wings at first extend over the elytra. The pro- and mesothoracic legs are exposed, the metathoracic or hind legs are largely hidden by the elytra and the hind wings. None of the legs show remainders of the sternal setae of the larva as was found by Hopkins to be the case in *Dendroctonus*.

All the setae of the thorax consist of rather fine hairs, the longest of which are F_{2-4} of the pronotum.

THE ABDOMEN

The abdomen is that part of the body where the external changes from larva to pupa are less pronounced. The united scutum and prescutum, the pleuron and the sternum are defined by sutures or folds. The pleuron is also subdivided into an epi- and hypopleurite.

There are eight tergites well developed. Tergites one to seven are similar in form. The outline is nearly regular rectangular. The first five of them have the same number of setae as well as setae developed in a similar manner. The setae e_{1-4} are arranged in a transverse line near the caudal border of the tergites. The seta e_2 is always hornlike and enlarged with secondary hairs arising from it; e_1 is always small and simple.

The area around e_2 is strongly padded, raised, more steeply sloping externo-laterally and gradually decreasing towards the setae e_3 and e_4. In tergite six the setae e_3 and e_4 are of the same shape and appearance as e_2 in the foregoing tergites. The corresponding setae of the seventh tergite are also more strongly developed than the others but never reach the size and development of seta e_2 in other segments. The eighth tergite does not bear any setae.

The prescutal area is not defined by sutures or lines but the setae f_{1-2} are visible near the anterior border of tergites one to seven as minute hairs. They change neither in development nor in position during the transformation from larva to pupa, but are completely reduced on the eighth tergite.

Pleurites.—The pleural area is, as in the larval stage, subdivided into two subdivisions, the epipleurites and the hypopleurites. Between them are situated the spiracles. The epi- and hypopleurites are narrow transverse bands, strongly padded and densely covered with minute spines. The epipleurites one to seven inclusive are similar in shape and bear, as in the larva, two small hairs each. The only differences are in regard to their position. In the larva these setae are diagonal to each other; in the pupa, in a horizontal plane. The hypopleurites are similar in shape and sculpture but bear only one hair

each. These setae are situated near the cephalad margin of the hypopleurites.

The eighth pleurite resembles even in the young pupa more that of the adult than of the larva. No subdivisional plates are visible and no setae occur. The spiracle is situated on the laterocephalad angle of the united tergo-pleural plate.

The caudal spine (Hopkins), most probably represents the only external remainder of the ninth abdominal segment of the larva and it is in the opinion of the author a greatly enlarged seta of the pleural area.

Sternites.—In the young pupa the same number of sternites occur as visible tergites, namely eight. The first two sternites are present as two short plates dorsal to the metasternum. They disappear when the pupa becomes older. The sternites three to seven are fully exposed and have the shape of small sclerites in the adults. The eighth sternite is visible as two half circular lobes which indicate the future development of the spiculum ventrale. None of the sternites bear setae and also no subdivisional plates are recognizable.

BIBLIOGRAPHY

(1) 1859. Fitch, Asa, Fourth report on the noxious and other insects of the State of New York, pp. 40-42.
(2) 1868. Leconte, J. L., Trans. Amer. Ent. Soc., vol. 2, pp. 154, 155.
(3) 1868. Eichhoff, W., Neue Borkenkäfer. Berl. Ent. Zeitschr., p. 275.
(4) 1868. Zimmerman, C., Synopsis of the *Scolytidae* of America north of Mexico. Trans. Am. Ent. Soc., vol. 15, p. 143.
(5) 1869. Packard, A. S., Guide to the study of insects, p. 493.
(6) 1875. Lindeman, C., Vergleichende anatomische Untersuchungen über das männliche Begattungsglied der Borkenkäfer. Bull. Soc. Imp. Nat. Moscow, vol. 49, pp. 196-252.
(7) 1875. Lindeman, C., Kauapparat bei Scolytiden. V. Tageblatt der 48. Versammlung Deutscher Naturforscher und Ärzte in Graz., p. 102.
(8) 1876. Lindeman, C., Monographie der Borkenhäfer Russlands. Die cryphaloiden Tomiciden. Bull. Soc. Imp. Nat. Moscow, vol. 54, No. 4.
(9) 1876. Leconte, J. L., and Horn, H. G., The Rynchophora of America north of Mexico. Proc. Amer. Phil. Soc., vol. 15, pp. 349, 350.
(10) 1877. Provancher, L'Abbé L., Petite Faune Entomologique du Canada, vol. 1, pp. 563-566.
(11) 1878. Eichhoff, W., Ratio, descriptio emendatio eorum Tomicinorum. Extrait Mém. Soc. Roy. Sci. Liège, 2e série, vol. 8.
(12) 1881. Packard, A. S., Insects injurious to forest and shade trees. U. S. Ent. Com., Bull. 7, pp. 173-175.
(13) 1883. Leconte, J. L., and Horn, H. G., Coleoptera of North America, pp. 512-517.

(14) 1886. Schwarz, E. A., Remarks on North American Scolytids. Ent. Amer., vol. 2, p. 40.
(15) 1890. Packard, A. S., U. S. Ent. Com., 5th Rep., pp. 718-20 and 816.
(16) 1890. Schwarz, E. A., Proc. Ent. Soc. Wash., vol. 1, pp. 44 and 80.
(17) 1893. Hopkins, A. D., Catalogue of West Virginia Scolytidae and their enemies. W. Va. Agric. Expt. Sta., vol. 3, Bull. 31.
(18) 1893. Verhoeff, C., Vergleichende Untersuchungen über die Abdominalsegmente und die Kopulationsorgane der männlichen Coleoptera, ein Beitrag zur Kenntnis der natürlichen Verwandtschaft derselben. Deutsch. Ent. Zeitschr., 1893.
(19) 1893. Verhoeff, C., Vergleichende Untersuchungen über die Abdominalsegmente, insbesondere die Legeapparate der weiblichen Coleoptera, ein Beitrag zur Phylogenie derselben. Deutsch. Ent. Zeitschr.
(20) 1894. Hopkins, A. D., Sexual characters in Scolytidae. Can. Ent., vol. 26, p. 277.
(21) 1894. Verhoeff, C., Zur Kenntnis der vergleichenden Morphologie des Abdomens der weiblichen Coleoptera. Deutsch. Ent. Zeitschr.
(22) 1894. Verhoeff, C., Vergleichende Morphologie des Abdomens der männlichen und weiblichen Lampyriden, Canthariden und Malachiden, untersucht auf Grund der Abdominalsegmente, Copulationsorgane, Legeapparate und Dorsaldrüsen. Ein Beitrag zur Kenntnis der Phylogenie der Coleopteren. Archiv f. Naturgesch.
(23) 1895. Hamilton, J., Catalogue of the Coleoptera of southwestern Pennsylvania, with notes and descriptions. Trans. Am. Ent. Soc., vol. 22, pp. 346, 378.
(24) 1895. Blandford, W. F. H., Biol. Centr. Amer., vol. 4, pt. 6.
(25) 1896. Verhoeff, C., Ueber das Abdomen der Scolytiden, ein Beitrag zur vergleichenden Morphologie der Coleopteren. Archiv f. Naturgesch.
(26) 1897. Hubbard, H. G., The ambrosia beetles of the United States. U. S. Dept. Agr., Bull. 7, n. s., pp. 9-30.
(27) 1899. Hopkins, A. D., Report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880-1893. W. Va. Agr. Expt. Sta., Bul. 56.
(28) 1901. Felt, E. P., Forest, Fish and Game Comm., Report 7, pp. 495-96.
(29) 1901. Kolbe, Vergleichend-morphologische Untersuchungen an Coleoptera nebst Grundlagen zu einem System und zur Systematik derselben. Archiv f. Naturgesch.
(30) 1902. Sedlaczek, Ueber den Darmkanal der Scolytiden. Centralblatt f. d. ges. Forstwesen.
(31) 1904. Hopkins, A. D., Exhibits of insect enemies of forests and forest products at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. U. S. Div. Ent., Bull. 48, p. 15.
(32) 1905. Currie, R. P., Catalogue of the exhibit of economic entomology at the Lewis and Clark Centennial Exposition, Portland, Ore. U. S. Div. Ent., Bull. 53, p. 70.
(33) 1905. Garman, H., Kentucky Agr. Exp. Sta., Bull. 120, p. 69.
(34) 1905. Hopkins, A. D., Proc. Ent. Soc. Wash., vol. 7, p. 73.

(35) 1906. Felt, E. P., Insects affecting park and woodland trees. N. Y. State Mus., Mem. 8, pp. 339, 371, 372.
(36) 1907. Fall, H. C., and Cockerell, T. D. A., The Coleoptera of New Mexico, p. 217.
(37) 1909. Berlese, A., Gli Insetti, vol. 1, Milano.
(38) 1909. Hopkins, A. D., The genus Dendroctonus. U. S. Dept. Agr., Bur. of Ent., Tech. ser., Bull. 17, pt. 1.
(39) 1909. Snodgrass, R. E., The thorax of insects and the articulation of the wings. Proc. U. S. Nat. Mus., vol. 36, pp. 511-595.
(40) 1909. Swaine, J. M., Catalogue of the described Scolytidae of America, north of Mexico. N. Y. St. Mus., Bull. 134, 24th Rep. State Entomologist, 1909.
(41) 1910. Hagedorn, M., Genera Insectorum par P. Wytsman, Coleoptera, Fam. Ipidae, 111me Fasc.
(42) 1910. Hagedorn, M., Coleopterum Catalogus, von W. Junk und Schenkling. Pars 4, Ipidae.
(43) 1911. Fuchs, G., Morphologische Studien über Borkenkäfer. I. Die Gattungen Ips De Geer und Pityogenes Bedel.
(44) 1911/12. Neusslin, O., Phylogenie und System der Borkenkäfer. Zeitschr. Wiss. Insektenbiologie, Bd. 7, Nos. 1-12, Bd. 8, Nos. 1-7.
(45) 1912. Fuchs, O., Morphologische Studien über Borkenkäfer. II. Die europäischen Hylesinen.
(46) 1912. Sharp, D., and Muir, F., The comparative anatomy of the male genital tube in Coleoptera. Proc. Ent. Soc. London, Pt. 3, pp. 477-642.
(47) 1914. Swaine, J. M., Forest insect conditions in British Colombia, Dom. of Canada, Dept. Agr., Div. Ent., Bull. 7.
(48) 1915. Hopkins, A. D., Preliminary classification of the superfamily Scolytoidea. U. S. Dept. Agr., Bur. Ent., Tech. Ser. No. 17, pt. 2.
(49) 1918. Swaine, J. M., Canadian barkbeetles, II. Dom. of Canada, Dept. Agr., Ent. Branch, Tech. Bull. 14.
(50) 1922. Blackman, M. W., Mississippi barkbeetles. Miss. Agr. Exp. Sta., Tech. Bull. No. 11.
(51) 1922. Hopping, R., Coniferous hosts of Ipidae of Pacific Coast and Rocky Mountain region. Can. Ent., vol. 44, p. 128.
(52) 1923. MacGillivray, A. D., External insect-anatomy. Urbana, Ill.
(53) 1923. Seitner, M., Beobactungen und Erfahrungen aus dem Auftreten des achtzähnigen Fichtenborkenkäfers, Ips typographus L. in Oberösterreich und Steiermark in den Jahren 1921 und 1922. Centralblatt für das gesamte Forstwesen.
(54) 1924. Korschelt, E., Bearbeitung einheimischer Tiere. Erste Monographie: Der Gelbrand, *Dyliscus marginalis* L.
(55) 1926. Golovjanko, Z. S., Zur Methodik der Bestimmung des Borkenkäferbefalls der Kiefern. Arbeiten über Forstvesuchswesen in der Ukraine, vol. 4, Kiew.
(56) 1926. Golovjanko, Z. S., Instruktion für die Förster zum Kampf mit den Borkenkäfern des Kiefernwaldes. Charkow.
(57) 1926. Russo, G., Contributo alla conoscenza degli Scolytidi. Studio Morfo-Biologico del *Chaètoptelius vestitus* (Muls. e Rey) Fuchs—e dei suoi simbionti. Laboratorio di Zoologia generale ed agraria—Portici.

(58) 1927. Snodgrass, R. E., Morphology and mechanism of the insect thorax. Smithsonian Misc. Coll., vol. 80, No. 1.

(59) 1928. Blackman, M. W., The genus Pityophthorus Eichh. in North America. N. Y. State Coll. For., Syracuse Univ., Tech. Publ. No. 25.

(60) 1928. Iljinsky, A., Gesetzmässikgeiten in der Vermehrung des kleinen Waldgärtners (*Blastophagus minor* Hartig.) und theoretische Begründungen der Massnahmen zu seiner Bekämpfung im Walde. (Vorläufige Mitteilungen). Mitteilungen aus dem forstlichen Versuchswesen in der Ukraine, vol. 9, p. 54-110.

(61) 1928. Snodgrass, R. E., Morphology and evolution of the insect head and its appendages. Smithsonian Misc. Coll., vol. 81, No. 3.