TECHNICAL SERIES, NO. 17, PART I.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY.
L. O. HOWARD, Entomologist and Chief of Bureau.

CONTRIBUTIONS TOWARD A MONOGRAPH OF THE SCOLYTID BEETLES.

I. THE GENUS DENDROCTONUS.

BY

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In Charge of Forest Insect Investigations.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., March 16, 1909.

SIR: I have the honor to transmit herewith manuscript of the first part of a bulletin of the technical series to be entitled "Contributions toward a Monograph of the Scolytid Beetles." This family of beetles includes some of the most important enemies of North American forests, as well as of crude forest products, and therefore must demand special attention in future systematic and economic investigations by this Bureau and by forest entomologists connected with other public institutions and private enterprises. It is necessary, as a foundation for such work, that the heretofore-described species should be accurately identified, that those new to science should be described, and that this information, together with other systematic data based on original research by this Bureau, should be made available in the form of contributions to a monograph. This work has been undertaken by Doctor Hopkins, of this Bureau, and the greater part of the collecting and working up of the material has been completed. Delay in publication will be avoided, and it is believed that the published results will be more useful in future systematic and economic investigation if the results relating to groups of species which have similar characters and characteristics and similar relations to given economic problems are published as parts of a bulletin rather than in one undivided publication. These technical parts are to be supplemented in a like manner by parts of a bulletin of the regular series, giving information of immediate practical importance to the forester and owners and managers of private forests.

The first part of this bulletin is entitled "The Genus Dendroctonus." It embodies the results of extensive systematic investigations of the genus, carried on by Doctor Hopkins during the past seventeen years, and is of especial interest and importance from the fact that it deals with a small group of beetles which are the most destructive enemies of the principal coniferous forest trees of North America.

The discussions and illustrations relating to anatomical and technical details are necessary as a basis for the correct description,

most, to a few closely allied genera. These parts will include synoptic tables, the necessary revisions of old descriptions of species and genera, and descriptions of genera and species which appear to be new to science.

It is proposed to follow these technical contributions with parts of a bulletin in the regular series, to include the determined bionomic and economic facts.

A somewhat comprehensive treatment of the anatomical details, fully illustrated, is given in Part I of this technical bulletin in order that it may serve as a basis for reference and comparison in the subsequent treatment of the other genera and groups of the family.

LABELS AND RECORDS OF TYPE AND OTHER MATERIAL.

A single specimen (a female, if possible) is designated as the type of a described species by a printed red label ("Type No. ——, U.S.N.M."), with the type catalogue number of the U. S. National Museum written in the blank. When additional specimens are available, the type, with one other specimen representing the opposite sex, labeled "♂ type" (or "♀ type") on red label, without type number, together with revision types[a] and other specimens showing range in variation, constitute the type series which is deposited in the type collection of the U. S. National Museum. Other paratypes and typical examples of revised descriptions, comprising one or more specimens of each species described, are marked with small red labels, and together with the duplicate collection of pinned, alcoholic, and biologic material, are kept in the reference collection of the Branch of Forest Insect Investigations, Bureau of Entomology, U. S. Department of Agriculture.

All pinned, alcoholic, and biologic material collected or received from correspondents are referred to in the field or laboratory records and bears number labels, each number referring to a consecutively numbered record of the observations made at the time the specimens were collected or received.

Material collected by the writer during his connection with the West Virginia Agricultural Experiment Station between 1890 and 1902 is designated by "Hopk. W. Va.," number labels. Material collected by the writer during his temporary employment on special explorations and trips of investigation for the U. S. Department of Agriculture between 1899 and July, 1902, as well as that collected during the investigations of forest insects subsequent to April, 1902, or received from correspondents, is distinguished by a "Hopk. U. S." number label. In addition to the note number label each completely

[a] The term "revision type" is used to designate the specimens, male and female, on which a revised description is based.

labeled mounted specimen bears labels which supply the following data: Collector or correspondent, locality, collecting or rearing date, host, and sex. The numbered notes are permanently bound in volumes of 1,000 numbers, each note relating to one or more species and to one or more specimens. The "Hopk. W. Va." numbers begin with 1 and were limited in June, 1902, to 7,791, and in January, 1907, to 7,793. The "Hopk. U. S." numbers began with 1 in April, 1899, and will be limited to the period during which the writer is in charge of the Branch of Forest Insect Investigations in the Bureau of Entomology.

MATERIAL STUDIED.

Unless otherwise mentioned, the material which forms the basis of information and study, so far as it relates to matter in this bulletin, is that bearing the "Hopk. U. S." or "Hopk. W. Va." note numbers. The former is in the forest insect collection of the Bureau of Entomology, U. S. Department of Agriculture; the latter belongs to the collection of the West Virginia Agricultural Experiment Station, but at present is in charge of the author, and forms a distinct part of the forest insect collection of the Bureau of Entomology.

ABBREVIATIONS.

The abbreviations adopted in this publication in referring to material in the different collections examined and that identified by the writer are as follows:

D. A.—Division and Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C., other than *Hopk. U. S.*

Hopk. U. S.—Branch of Forest Insect Investigations, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

Hopk. W. Va.—W. Va. Agricultural Experiment Station, Morgantown, W. Va.

U. S. N. M.—U. S. National Museum, Washington, D. C.

H. & S.—H. G. Hubbard and E. A. Schwarz collection in the U. S. National Museum.

B. & S.—Collected by H. S. Barber and E. A. Schwarz for the U. S. National Museum.

Soltau.—H. Soltau collection in the U. S. National Museum.

Lec.—Le Conte collection, Museum of Comparative Zoology, Cambridge, Mass.

Horn.—Horn collection, American Entomological Society, Philadelphia, Pa.

A. E. S.—American Entomological Society, Philadelphia, Pa.

A. M. N. H.—American Museum of Natural History, New York, N. Y.

N. Y. S. M.—New York State Museum, Albany, N. Y.

Harris.—Harris collection, Boston Society of Natural History, Boston, Mass.

Fitch.—Asa Fitch collection, as represented in the U. S. National Museum.

Wickham.—Wickham collection of Scolytidæ in the U. S. National Museum.

ACKNOWLEDGMENTS.

The writer desires to acknowledge the indispensable assistance and encouragement, during his earlier studies of the scolytid beetles

(1890–94), rendered by Mr. E. A. Schwarz, of the U. S. National Museum, Oberforster W. Eichhoff, of Strasburg, Germany, Mr. W. H. F. Blandford, of London, England, and M. L. Villard, of Lyon, France. Messrs. Eichhoff and Schwarz especially were most kind and generous in furnishing identifications of species and in liberally loaning and donating specimens. Finally, the writer wishes to acknowledge the help of his associates and assistants during the prosecution of the work, and especially Mr. W. E. Rumsey, of the West Virginia Experiment Station, and the office and field force of the Branch of Forest Insect Investigations, in the Bureau of Entomology.

A. D. H.

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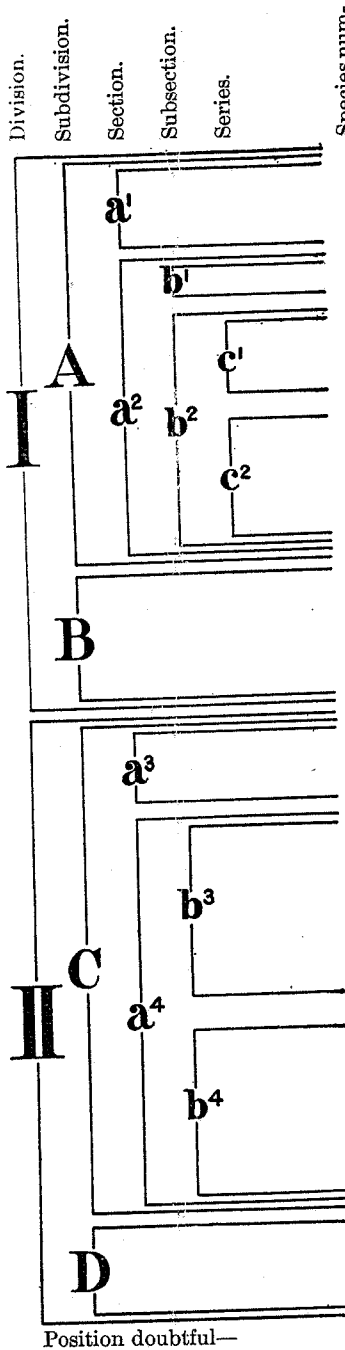

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Classification of the Genus Dendroctonus, Showing Technical and Common Names and Species Numbers.

This diagram will enable the reader to refer at once to the technical and common names of any species number mentioned in the text, and will show at a glance the position and relations of the divisions, subdivisions, sections, subsections, series, and species into which the genus is divided.

U. S. D. A., B. E. Tech. Ser. 17, Pt. I. F. T. I., June 30, 1909.

CONTRIBUTIONS TOWARD A MONOGRAPH OF THE SCOLYTID BEETLES.

I. THE GENUS DENDROCTONUS.

By A. D. Hopkins,
In Charge of Forest Insect Investigations.

INTRODUCTORY.

The active work on forest insects conducted by the West Virginia Agricultural Experiment Station in 1890–91, and by the Division and Bureau of Entomology of the U. S. Department of Agriculture since 1899, has resulted in the accumulation of a mass of systematic and biological data on the principal described and undescribed insect enemies of forest trees and forest products of the United States. Whenever an attempt has been made, however, to work up the material relating to a given species, or group of species, it has been apparent that the publication of anything without first describing the new species and revising the data in both the systematic and economic literature would contribute to confusion rather than to advancement. Indeed, it becomes more and more evident that *in order to give reliable information on applied entomology we must have at our command the knowledge gained by careful technical, or systematic, studies of the insects with which we have to deal.* Therefore, when we find, as we do in many cases, that the published results of systematic work on a given genus or species are meager or otherwise unsatisfactory, it becomes necessary to revise and verify the descriptions and biological records, and to adjust the classification to meet the requirements of the newly discovered facts relating to the described and undescribed species.

The genus *Dendroctonus* presents a striking example of the need of systematic study as a basis for economic investigation. It is both the most important group of insect enemies of the coniferous forest trees of North America and one of the most difficult for systematic study. Le Conte (1876) expressed the difficulty met with in a study of the species when he said in his later revision:

> If I have failed to indicate more strongly the differences between these species, it is because they are not distinguishable by any prominent or definite characters; and the student who may have difficulty in identifying the species as here defined would have almost equal difficulty if the specimens in my collection were before him.

Until within recent years little progress had been made toward the discovery and clear definition of the specific and sexual characters. In consequence the identification of the species was both difficult and uncertain and has led to much confusion in both systematic and economic literature. With our present knowledge of the genus, based on an exhaustive study of the systematic and biologic details, most, if not all, of the difficulties have been removed, so that the identification of the species is comparatively easy.

It is the purpose of this paper to revise and bring up to date the available information on the described species, to describe those that appear to be new to science, and to record the results of original investigations relating to the more technical details that can not well be included in the paper which is to follow as a part of a bulletin in the regular series and which will give full information on the bionomic features.

The material which has served as a basis for the study of this genus consists mainly of the notes and specimens taken by the writer in the field during his connection with the West Virginia Agricultural Experiment Station, between 1890 and July, 1902, including special investigations for the Division of Entomology, U. S. Department of Agriculture, in 1899, 1900, and 1901, and those taken during the investigations by this Bureau between July, 1902, and July, 1908. In addition to the large amount of material thus accumulated the writer has studied the type and other specimens in the larger collections of this country.

The writer desires to acknowledge, in this connection, the assistance rendered by the following gentlemen in providing facilities for the study of specimens in the collections of which they have charge: Mr. Samuel Henshaw, in charge of the Le Conte collection in the Museum of Comparative Zoology, Cambridge, Mass., and of the Harris collection, Boston Society of Natural History; Dr. Henry Skinner, in charge of the Horn collection of the American Entomological Society and the general collection of the American Entomological Society, Philadelphia, Pa.; Mr. E. A. Schwarz, honorary custodian of Coleoptera in the Division of Insects, U. S. National Museum; Dr. W. G. Dietz, who loaned type and other specimens from his collection, and Mr. C. O. Waterhouse, of the British Museum, who compared specimens with the type of *Dendroctonus rufipennis* Kirby.

It also gives the writer pleasure to acknowledge the efficient assistance of Messrs. J. L. Webb, H. E. Burke, and W. F. Fiske in the field and office work, of Mr. E. J. Kraus in the more recent office work, and of Messrs. J. F. Strauss and R. E. Snodgrass in the preparation of the illustrations for this part of the bulletin.

HISTORICAL.

The genus *Dendroctonus* was described by Dr. W. F. Erichson (1836) to include (*Bostrichus*) *micans* Kug., (*Scolytus*) *terebrans* Oliv., (*Dermestes*) *piniperda* L., (*Hylesinus*) *minor* Hartig, and (*Hylesinus*) *minimus* Fab.

Eichhoff (1864) revised the genus and referred *D. piniperda* (L.) and *D. minor* (Hartig) to *Blastophagus* Eichh. and later (1879) to *Myelophilus* Eichh., and *D. minimus* (Fab.) to *Carphoborus* Eichh., leaving *D. micans* (Kug.) as the type.

Lacordaire (1868) referred to the synonymy and revised the description, including *Dendroctonus juniperi* Doeb. [=*Phlœosinus juniperi* (Doeb.)], *D. valens* Lec., and *D. similis* Lec.

Zimmerman (1868) divided the genus into three groups, placing *D. bifurcus* (=*Carphoborus bifurcus* Eichh.) in the first, none in the second, and *D. terebrans* (Oliv.) and *D. frontalis* Zimm. in the third group.

Le Conte (1868) revised the classification for the North American species to include *D. terebrans* (Oliv.), *Hylurgus obesus* Mann., *Hylurgus rufipennis* Kirby, *D. frontalis* Zimm., and two new species, *D. punctatus* Lec., and *D. simplex* Lec. He here referred *D. valens* Lec. to *D. terebrans* (Oliv.), and *D. similis* Lec. to *D. obesus* (Mann.). He recognized two divisions, Division B represented by *D. frontalis*, and Division A by the other five species.

Chapuis (1869) included *D. micans* (Kug.), *D. valens* Lec., *D. terebrans* (Oliv.), *D. obesus* (Mann.), and added one new species, *D. parallelocollis* Chap., but did not recognize *D. frontalis* Zimm.

Le Conte (1876) included *D. terebrans* Lac. (=Oliv.), *D. similis* Lec., *D. rufipennis* (Kirby), *D. punctatus* Lec., *D. simplex* Lec., *D. frontalis* Zimm., and one new species, *D. brevicomis* Lec. He here restored *D. similis* and omitted *D. obesus*.

Dietz (1890) in his "Notes on the Species of Dendroctonus of Boreal America," revised the classification, principally on the character of the epistoma, which he considered of primary importance in separating the species. He included *D. terebrans*, with varieties *a*, *b*, *c*, *d*, *D. rufipennis*, *D. similis* Lec., *D. simplex* Lec., *D. frontalis*, added one new species, *D. approximatus* Dietz, and referred *D. punctipollis* Lec. to *D. rufipennis* (Kirby) and *D. brevicomis* Lec. to *D. frontalis* Zimm.

Blandford (1897) mentioned *D. terebrans* (Oliv.), *D. parallelocollis* Chap., and an undescribed species from Texas—probably *D. terebrans* (Oliv.)—and added one new species, *D. adjunctus* Blandf.

The writer (Hopkins, 1899a) referred to *D. terebrans*, *D. rufipennis* (Kirby), *D. simplex* Lec., and *D. frontalis* Zimm., with descriptions of

different stages, habits, etc., of *D. frontalis*, and larvæ and habits of *D. terebrans* (=*D. valens*). In 1901 he described *D. piceaperda* in all stages in connection with an account of habits, seasonal history, etc., and referred to the type of *D. rufipennis* (Kirby). In 1902 he described *D. ponderosæ* in all stages, in connection with an account of habits, seasonal history, etc. In 1902, under "Some Notes on the Genus Dendroctonus," he referred to a statistical method of determining natural positions of the species, and gave a list of described species and manuscript names of undescribed species, as follows: *D. pinicida* MSS., *D. arizonicus* MSS., *D. monticola* MSS., *D. ponderosæ* Hopk. MSS., *D. keeni* MSS., *D. fletcheri* MSS., *D. piceaperda* Hopk., *D. dietzi* MSS., *D. californicus* MSS., *D. shoshone* MSS., *D. wickhami* MSS., and *D. borealis* MSS. He restored *D. brevicomis* Lec. and *D. punctatus* Lec. from Dietz's synonymy, and recognized *D. obesus* (Mann). In 1905 he described *D. pseudotsugæ* and *D. monticola* in connection with accounts of habits, seasonal history, etc.

ORIGINAL DESCRIPTION OF GENUS.

Dr. W. F. Erichson (1836) described the genus *Dendroctonus* as follows:

DENDROCTONUS.

[p. 52] Antennæ funiculo 5-articulato, capitulo 4-annulato, suborbiculari, compresso. Tibiæ extus denticulatæ.

Palpi maxillares articulo primo brevissimo, secundo maximo, sequentibus duobus sensim minoribus. Labium fortiter compressum. Palpi labiales articulo primo longiore, subclavato, secundo tenuiore, cylindrico, minuto, tertio obtuse subulato. Antennæ breves, scapo clavato, funiculi articulo primo breviter clavato, secundo obconico, reliquis brevibus transversis; capituli segmentum primum reliquis conjunctis æquale, politum. [p. 53] Corpus oblongum, cylindricum. Rostrum brevissimum. Prosternum antice obsolete impressum. Coxæ anticæ approximatæ. Tibiæ compressæ, extus denticulatæ. Tarsi articulo tertio dilato, bilobo. Elytra margine antico elevato.

[Translation.]

Antennæ with 5-jointed funicle; the club suborbiculate, compressed, with four segments (annulæ). Tibiæ externally denticulate.

Maxillary palpi with the first joint very short, the second the longest, the two following gradually smaller. Labium strongly compressed. The labial palpi with the first joint rather long, subclavate, the second joint more slender, cylindrical, small, the third obtusely subulate. Antennæ short, scape clavate, first joint of funicle shortly clavate, second joint obconical, the remaining joints short, transverse; first segment of club equal to the others conjointly, polished.

Body oblong, cylindrical. Beak very short. Prosternum anteriorly obsoletely impressed. Anterior coxæ approximate. Tibiæ compressed, externally denticulate. Tarsi with the third joint dilated and bilobed. Elytra with the anterior margin elevated.

SYNONYMY.

The following species were included, all but two of which were subsequently referred by Eichhoff (1864) to other genera:

Bostrichus micans Kugelann = *Dendroctonus micans* (Kugelann). (Type of genus.)

Scolytus terebrans Olivier = *Dendroctonus terebrans* (Olivier).

Dermestes piniperda Linnæus = *Myelophilus piniperda* (Linnæus).

Hylurgus minor Hartig = *Myelophilus minor* (Hartig).

Hylesinus minimus Fabricius = *Carphoborus minimus* (Fabricius.)

REVISIONAL NOTES.

The generic characters mentioned by Erichson in the original description are recognized in the type and other species except that the maxillary palpi are not 4-jointed. The first or basal joint has a basal ring or outward curved basal margin for the attachment of the membrane connecting the joint with the palpiger. This might have been mistaken for the "very short first joint" referred to, but it is evident that this or any other structure does not represent such a basal joint. In the type species the first joint of the club is equal to the others, but ranges from shorter to longer in the other species.

Le Conte's added characters in his revision of 1868 and 1876 are generally correct, except that the antennal club is not always concave on one (external) side or anterior face, the sutures are more often curved than straight, and in some species only two sutures are visible on one side of the club. The prosternum is sometimes flat, the fifth joint of the tarsus is never longer than the others united, and the ventral segments are only approximately equal in length, the last one being usually as long as the two preceding combined.

Dietz (1890) called attention to the unreliability of the sutures and joints of the antennal club in dried specimens, and laid special stress on the value of the epistoma in distinguishing the species. It appears, however, that while the form of the epistoma is a good generic and subdivisional character, it is of little or no value in distinguishing the species.

The additional generic characters recognized by the writer will be found described under external and internal anatomy, and the characters distinguishing the major and minor divisions will be found in the synoptic tables.

REVISED DESCRIPTION OF GENUS.

ANATOMICAL.

The following discussion of anatomical details includes the imago, larva, and pupa, and is based primarily on the results of original dissections and anatomical investigations by the author during the

past eighteen years, and of those conducted by assistants under his immediate supervision during the past three years.

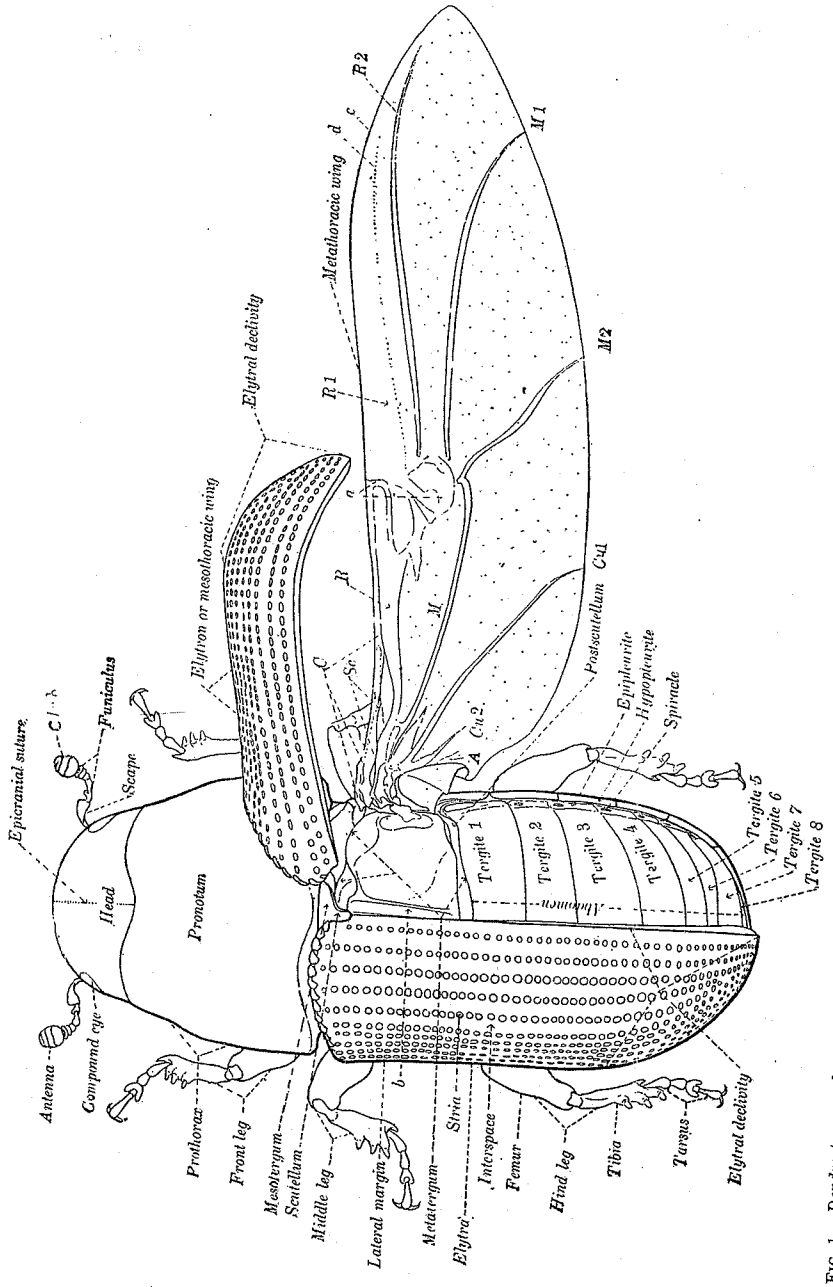

FIG. 1.—*Dendroctonus valens*: Adult, dorsal aspect. *a*, Median fold; *b*, scutellar groove; *c*, costal margin; *d*, inter-radial fold; *Sc*, subcosta; *R*, radius; *R1*, radius 1; *R2*, radius 2; *C*, costa; *M*, media; *M1*, media 1; *M2*, media 2; *Cu 1*, cubitus 1; *Cu 2*, cubitus 2; *A*, anal. (Original.)

Dendroctonus valens Lec. has served as the principal subject for dissection, comparison, and illustration, both on account of the

abundance of material at hand and because of the comparatively large size of the individuals of this species. Sufficient comparative studies have been made, however, of the other species of the genus and of representatives of other genera of the family and suborders to form a reliable basis for the interpretations and conclusions relating to the more important taxonomic characters and the significance of their modifications in the distinction of species, genera, etc.

Through the assistance of Mr. R. E. Snodgrass an extensive investigation has also been made of the thoracic segments of representatives of all of the principal orders of insects. The results have served as additional data and evidence on which to base conclusions in this paper, and will be utilized by Mr. Snodgrass as a basis for a more detailed discussion in a paper entitled "The Thorax of Insects and the Articulations of the Wings," to be published later. This will include a quite complete bibliography and references to the principal systems of nomenclature proposed or adopted by the leading authors, thus rendering it unnecessary to include extensive bibliographic references in the present paper.

In all of this anatomical work the object of the author has been to acquire direct information on the facts as they exist in the subjects examined; such information to furnish a basis for the determination, naming, description, and illustration of the anatomical elements as represented in the scolytid beetles, and at the same time to serve as a guide to the determination of further facts relating to insect anatomy in general.

The literature on insect anatomy has been utilized as a guide in securing additional information on the facts and principles involved, and with the idea of adopting such interpretations and nomenclature as appeared to conform more nearly to the facts and contribute to uniformity. No attempt is made to discuss the merits of opposing opinions or theories, or to prove or disprove them.

In this presentation of the results of independent investigation and discussion of the facts as interpreted by the author, it is hoped that something has been accomplished toward the advancement of information on the general subject of insect anatomy, and that its special reference to the anatomy of the scolytid beetles will make the future systematic study of this troublesome group less difficult and more accurate, and thus lead to the determination of bionomic and economic data of immediate practical importance.

NOMENCLATURE.

There is yet much confusion in the literature and considerable difference of opinion among the best authorities in regard to anatomical nomenclature as applied to the structure of insects in general and especially to representatives of different orders. There is

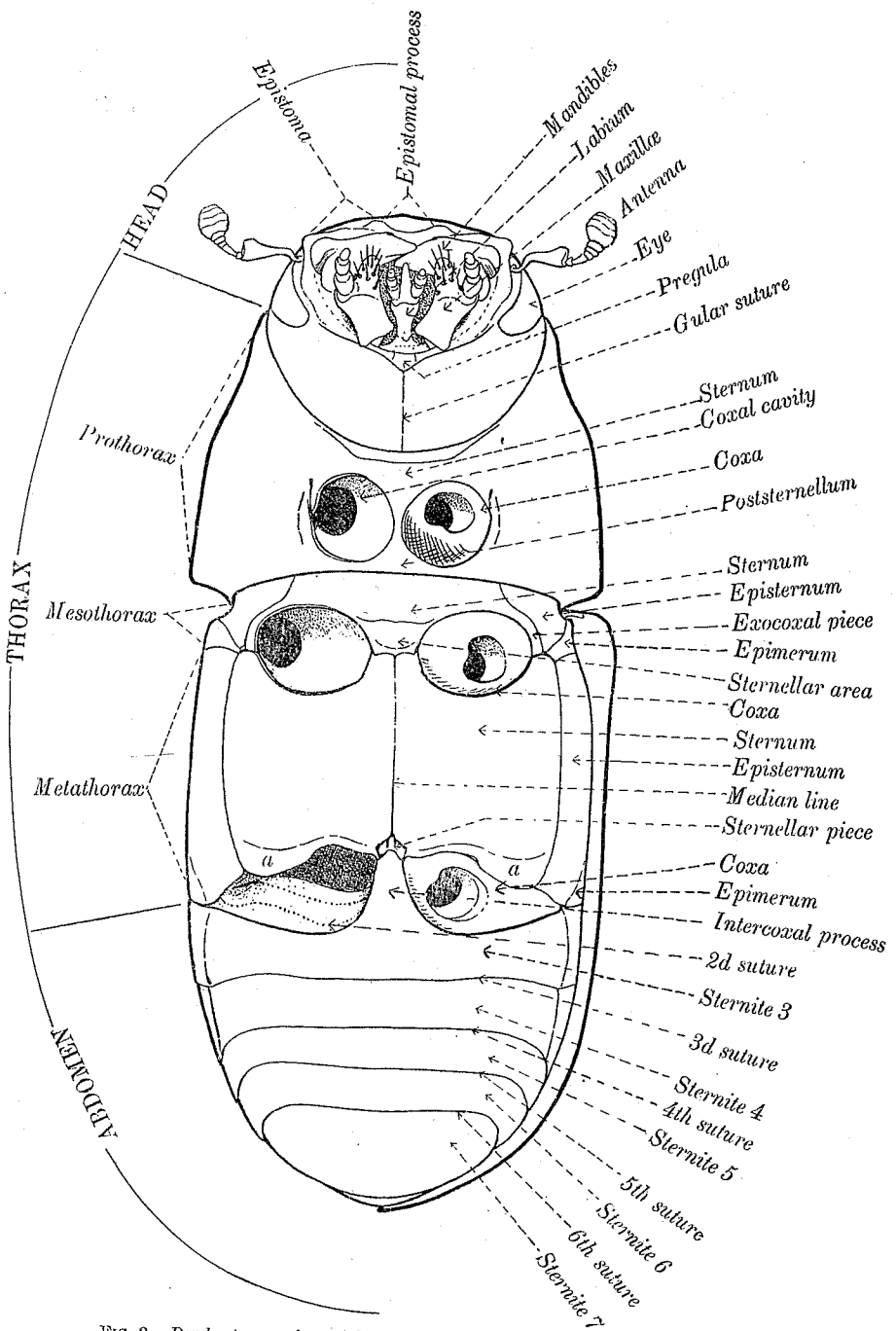

FIG. 2.—*Dendroctonus valens:* Adult, ventral aspect. *c*, Sternellar area. (Original.)

evidently much room for improvement in the line of uniformity in names and interpretations. In the present paper the writer has endeavored to adhere to the more generally accepted names proposed

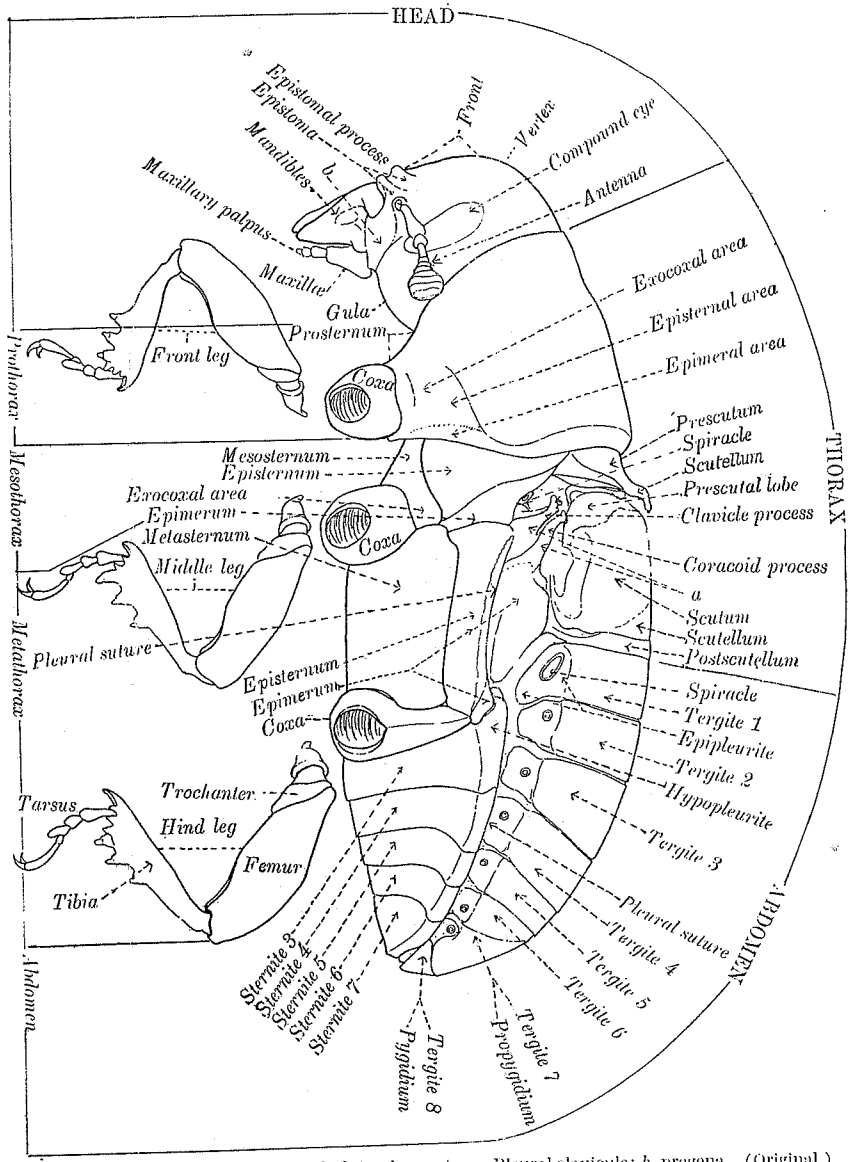

FIG. 3.—*Dendroctonus valens:* Adult, lateral aspect. *a*, Pleural clavicula; *b*, pregena. (Original.)

by Audouin and other writers for the principal parts, and to suggest only such revisions and new names as the immediate requirements of clear definition in comparative anatomy and taxonomy appear to demand.

ILLUSTRATIONS.

The figures are intended to be sufficiently complete to leave little to be added in the way of description, except to emphasize and elucidate some of the more important features, or to call attention to the variation within the genus or species.

EXTERNAL CHARACTERS OF THE IMAGO.

The structural details and general external anatomy and sculpture are shown in figures 1, 2, and 3. The principal characters peculiar to the genus are found in the large, prominent head, the epistomal process (figs. 2, 3, 4, 6, 10) (referred to by Dietz as the median segment of the epistoma), the form of the antenna (figs. 11, 12, 13), the approximate or subcontiguous anterior coxæ (fig. 2), and the strongly recurved hypopleural sutures 4, 5, and 6 of the abdominal sternites (fig. 25).

Length and relative proportions.—The length of the imago ranges from 2.5 mm. in *D. frontalis* to 9 mm. in *D. valens*. There is considerable range in length within the limits of some of the species, while in others the length is more constant. The relative proportions of the width of the head, width and length of the prothorax, width and length of the elytra, or a composite of the ratios, serve as a taxonomic index for the classification of the species, and, together with other characters, serve to distinguish the major and minor divisions and, to a certain extent, the species. The progressive modification appears to be from a head nearly as broad as the pronotum and the latter as broad as the elytra, with the sides nearly parallel, to a head much narrower than the pronotum, the latter slightly narrower than the elytra, with the sides narrowed and constricted toward the head; also, from a slender, subelongate, to a stout body.

Color.—The color ranges from pale yellowish-red to brown and deep black, but is fairly constant in the matured individuals of a species. The immature individuals are always lighter, and some of those of the black species are reddish. In some species the head, prothorax, and ventral surface of the body are darker than the elytra, while in others little or no difference is noticeable.

Vestiture.—The body is more or less clothed with short to long hairs, the presence or absence of which on different areas is of far more taxonomic significance than was at first recognized. Except in old rubbed specimens, the vestiture serves as one of the important characters distinguishing the major, as well as some of the minor, divisions. See synopsis, Divisions I and II, sections a1 and a2 (Pl. I).

Sculpture.—Within the genus and also within each species there is considerable variation in the sculpture of the front, pronotum, and elytra. Nevertheless, such characters as the presence or absence

of frontal grooves and tubercles serve to distinguish some of the minor divisions of the genus, while the presence or absence of a posterior median impression in those species without a frontal groove is of considerable importance in distinguishing some of the minor divisions. The relative size, density, and arrangement of the punctures of the pronotum, while variable within the species, is of considerable taxonomic value. The character of the rugosities of the interspaces and the punctures of the striæ are also variable within the species and are of secondary value in distinguishing minor divisions. The sculpture of the elytral declivity is of special specific and sexual importance, and in some cases the characters are of value in distinguishing minor divisions.

THE HEAD.

The general characters and details of the external skeleton and appendages of the head are shown in figures 4, 5, and 6. It will be noted that the elements which in some other Coleoptera and other insects are more or less clearly defined are quite completely fused and obscured in this genus as in other rhynchophorous beetles. The labrum and clypeus are obsolete. The epistoma, or "post-clypeus," or "pre-front," as recognized by different authors, is not separated from the front by a line or suture, but is quite clearly defined, and the epistomal process is far more prominent than in other allied genera. The front is completely fused with the epicranium, which in turn is fused with the genæ, the latter joined beneath with a single gular suture. Anterior to the gular suture there are three quite clearly defined sclerites, which may be designated as pregula, pregena, and hypostoma (fig. 5, *E*). By comparing the head of *Dendroctonus* with that of a carabid beetle, *Pterostichus* (fig. 7), and a typical curculionid beetle, *Pissodes strobi* (figs. 8, 9), the striking difference in structure and relative position of the corresponding elements and their extreme modification are at once apparent.

Labrum.—The labrum is not present as a distinct element, but may be represented by a part of the anterior margin of the epipharynx beneath the anterior median section of the epistoma (fig. 6, *A*).

Clypeus.—The clypeus is not represented unless it is by the produced anterior margin of the epistoma, and by the long epistomal bristles.

Epistoma (figs. 2, 3, 4, 5, 6, 7, 10, 40, *B*, *D*, *E*.)—The epistoma is apparently represented in both the larvæ and adults of all true mandibulate insects, but is more distinctly defined in some than in others. In some insects it is separated from the clypeus by a suture, line, or articulating membrane, while in others there is no evidence of separation or the clypeus is not represented. Its separation from the front is often defined by a line, impression, elevation, or otherwise, although sometimes it is so completely fused that the line of junction

is entirely obscured, as in *Pterostichus*. It serves the important function of a rigid bridge over the oral foramen and support for the clypeus, labrum, and epipharynx, and at its lateral angles provides the necessary rigid support for the dorsal articulation of the man-

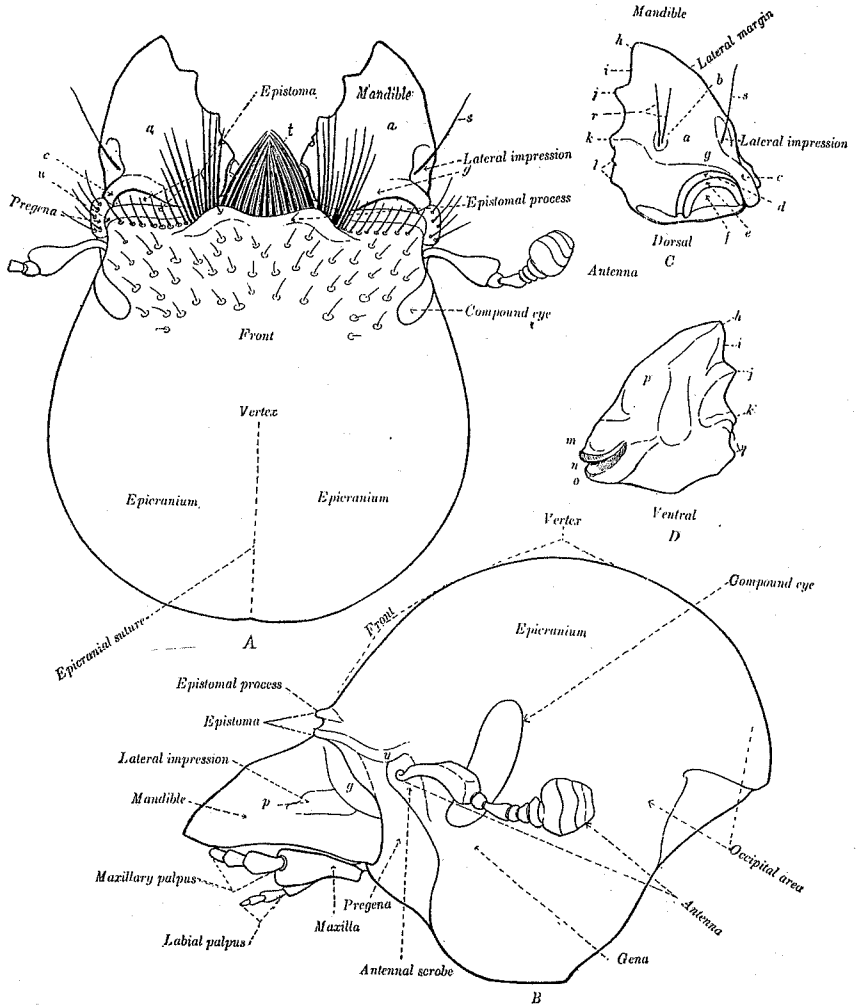

FIG. 4.—*Dendroctonus valens:* Head, dorsal and lateral aspects. *A*, Dorsal aspect of head; *B*, lateral aspect of head; *C*, dorsal aspect of right mandible; *D*, ventral aspect of right mandible; *a*, dorsal area; *b*, dorsal impression; *c*, anterior condyle; *d*, median fossa; *e*, median condyle; *f*, posterior fossa; *g*, basal ridge; *h*, apical tooth; *i*, acute margin; *j*, subapical tooth; *k*, median tooth; *l*, molar; *m*, anterior condyle; *n*, median fossa; *o*, posterior condyle; *p*, lateral area; *r*, dorsal bristles of mandible; *s*, lateral bristles of mandible; *t*, epistomal bristles; *u*, lateral angle of epistoma. (Original.)

dibles. In fact the latter function serves to distinguish it from other parts. The median area is variously and sometimes greatly modified in insects of the same order or family, and it appears that in Coleoptera generally this element is of much greater taxonomic value than has been usually recognized heretofore.

Epistomal process.—In *Dendroctonus* the epistomal process serves to clearly distinguish the genus from other genera of the suborder to which it belongs. This process is usually composed of a median and

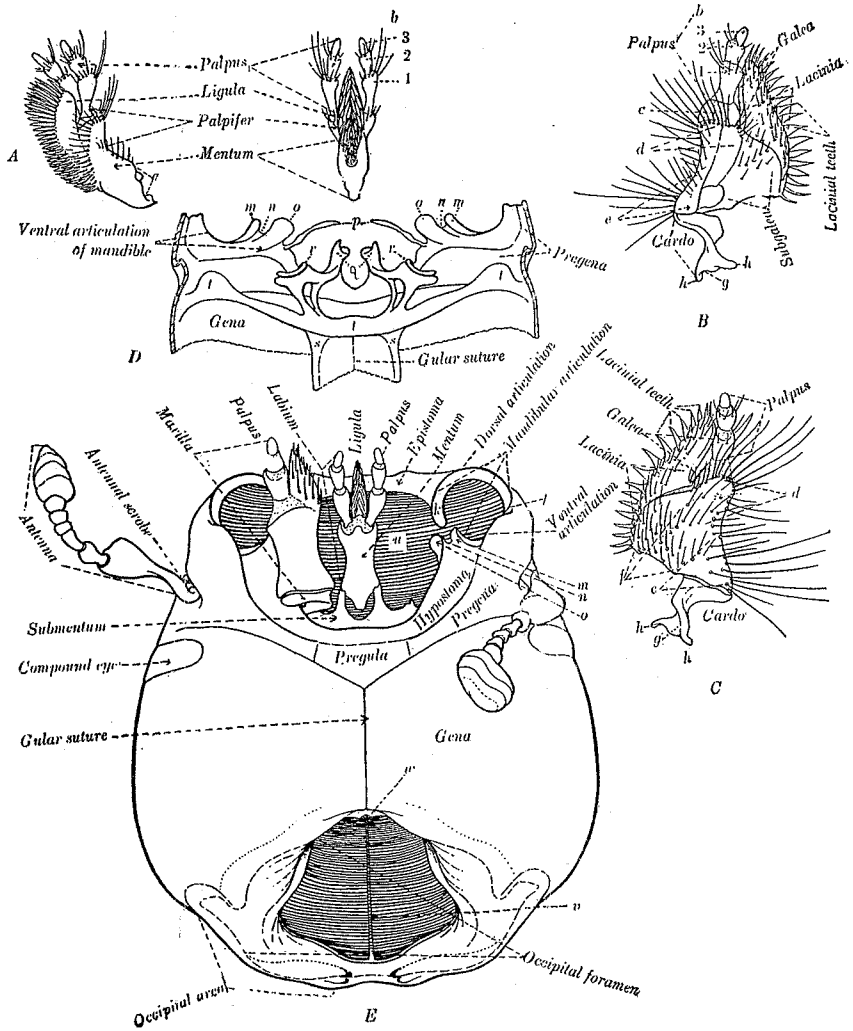

FIG. 5.—*Dendroctonus valens:* Head, ventral aspect, and mouthparts. *A*, Labium; *B*, maxilla, interno-lateral aspect; *C*, same, externo-lateral aspect; *D*, hypostomal region, dorsal aspect; *E*, head, ventral aspect; *a*, basal fossa of mentum; *b*, joints; *c*, basal membrane; *d*, palpiferal area; *e*, stipal area; *f*, subgaleal area; *g*, fossæ; *h*, muscle processes; *k*, median condyle: *l*, lateral fossa; *m*, anterior condyle; *n*, median fossa; *o*, posterior condyle; *p*, hypopharyngeal bracon; *q*, submental process; *r*, maxillary condyle; *s*, gular apodeme; *u*, oral foramen; *v*, occipital apodeme; *w*, postgular piece. (Original.)

two lateral sections and is fringed anteriorly with thickly set, long bristles which completely cover the anterior median epistomal area.

Hypostoma (fig. 5).—This, as here interpreted, is a ventral piece or area which corresponds in general function to the epistoma in forming a rigid ventral rim of the oral foramen for the support of the

articulatory accessories of the labium and maxillæ, and at the lateral angles supports the ventral articulations for the mandibles. It seems to the writer that this part or area, whenever sufficiently distinct to be recognized, should be designated as the hypostoma, not

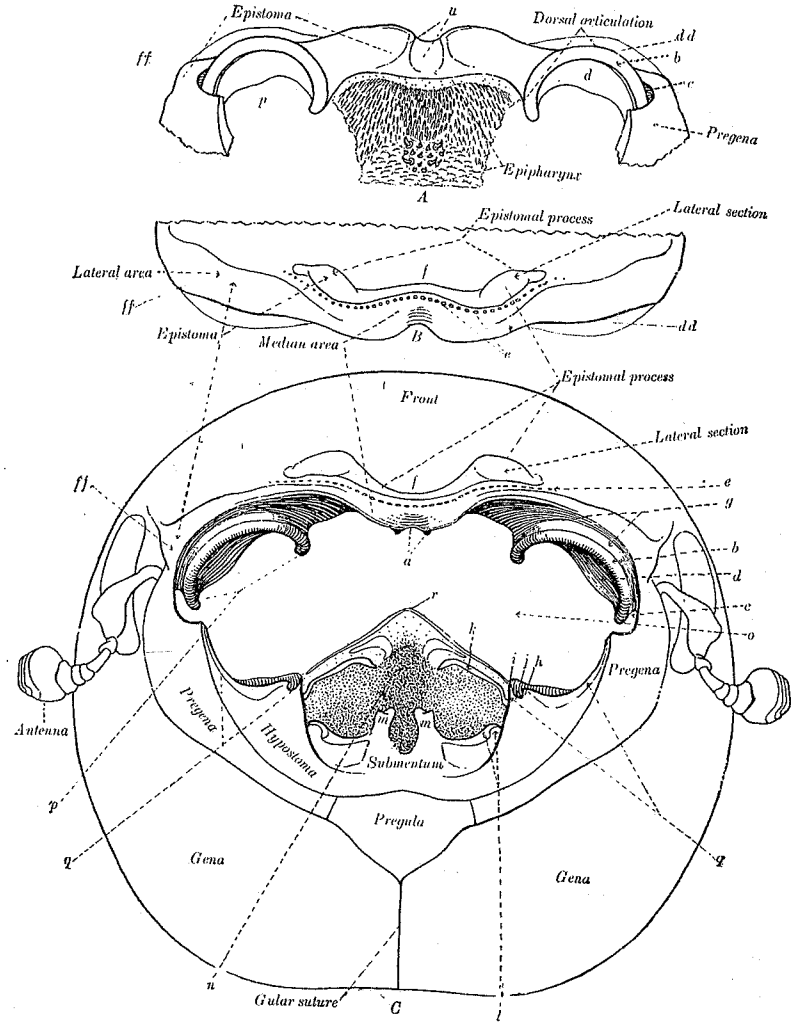

FIG. 6.—*Dendroctonus valens:* Head, oral aspect, epistoma, etc. *A*, Ventral aspect of epistomal region; *B*, dorsal aspect of epistomal region; *C*, oral aspect of head; *a*, median impression and longitudinal elevations; *b*, median condyle; *c*, lateral fossa; *d*, posterior fossa; *dd*, projection over median condyle; *e*, base of epistomal bristles; *f*, median section of epistomal process; *ff*, lateral angles of epistoma; *g*, anterior fossa; *h*, anterior condyle of ventral articulation; *i*, posterior condyle of ventral articulation; *j*, median fossa of ventral articulation; *k*, hypopharyngeal bracon; *l*, maxillary condyle; *m*, submental processes; *n*, ventral view of hypopharynx; *o*, oral foramen; *p*, dorsal articulation of mandible; *q*, ventral articulation of mandible; *r*, apex of hypopharynx. (Original.)

on account of any theory of origin from a primitive segment, but because its location and function are similar to those of the epistoma.

Front (figs. 3, 4).—The front is not defined by sutures or lines, but is fused anteriorly with the epistoma and laterally and posteriorly with

the epicranium. It is represented by a frontal area, however, which not only in this genus but in other scolytids presents characters of special value in distinguishing major and minor divisions, species, sexes, etc. The significance of frontal characters in this genus is defined in the synopses of adult and secondary sexual characters and shown in the figures.

Antennæ (figs. 1–6, 11–13).—The characters of the antennæ are clearly shown in the figures. The scape, funiculus, and club are

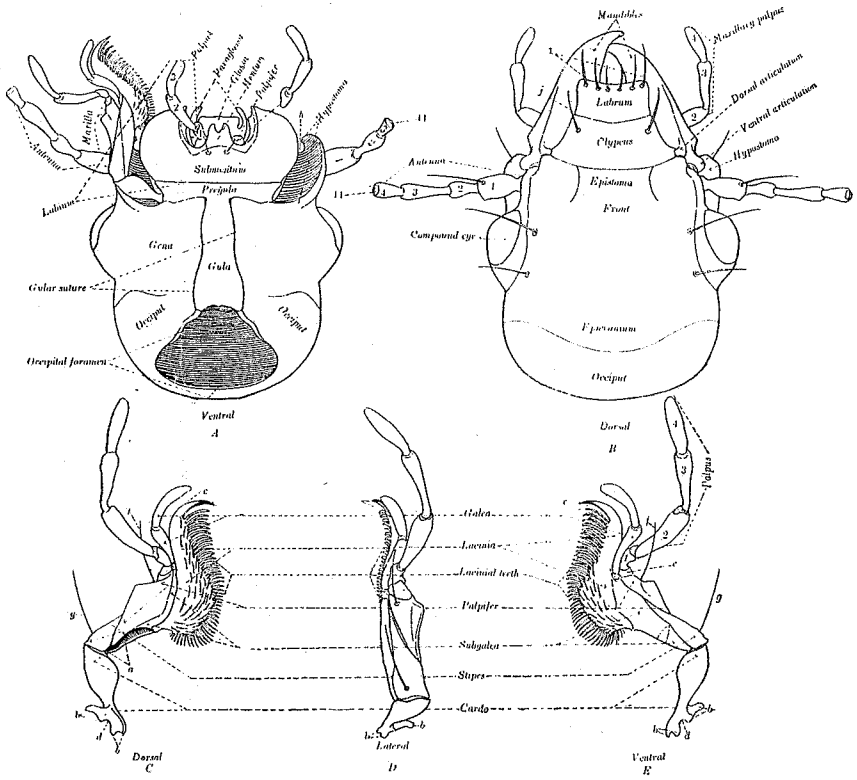

FIG. 7.—*Pterostichus californicus:* Head, dorsal and ventral aspects, and maxillæ. *A*, Ventral aspect; *B*, dorsal aspect; *C*, dorsal aspect of left maxilla; *D*, lateral aspect of left maxilla; *E*, ventral aspect of left maxilla; *a*, stipal foramen; *b*, muscle processes; *c*, lacinial digitus; *d*, cardo fossa; *e*, basal membrane; *f*, palpiferal bristle; *g*, stipal bristle; *h*, median fossa of ventral articulation of mandible; *i*, labral bristles; *j*, clypeal bristles. (Original.)

nearly equal in length. The scape toward the apex is clavate—cylindrical to angular. The funiculus is 5-jointed and always slightly longer than the club. The first joint (or pedicel of some authors) is of the usual form and as long or longer, rarely shorter, than the second. The second joint is as long as the third, fourth, and fifth together, or slightly shorter in some species, and the second to fifth increase in width toward the club, which is broad, thickened toward the base and compressed toward the apex, and has three or four distinct segments, with two or three slightly to strongly curved

sutures. The relative concavity or convexity of the anterior face, as well as the relative lengths of the segments on the opposite faces,

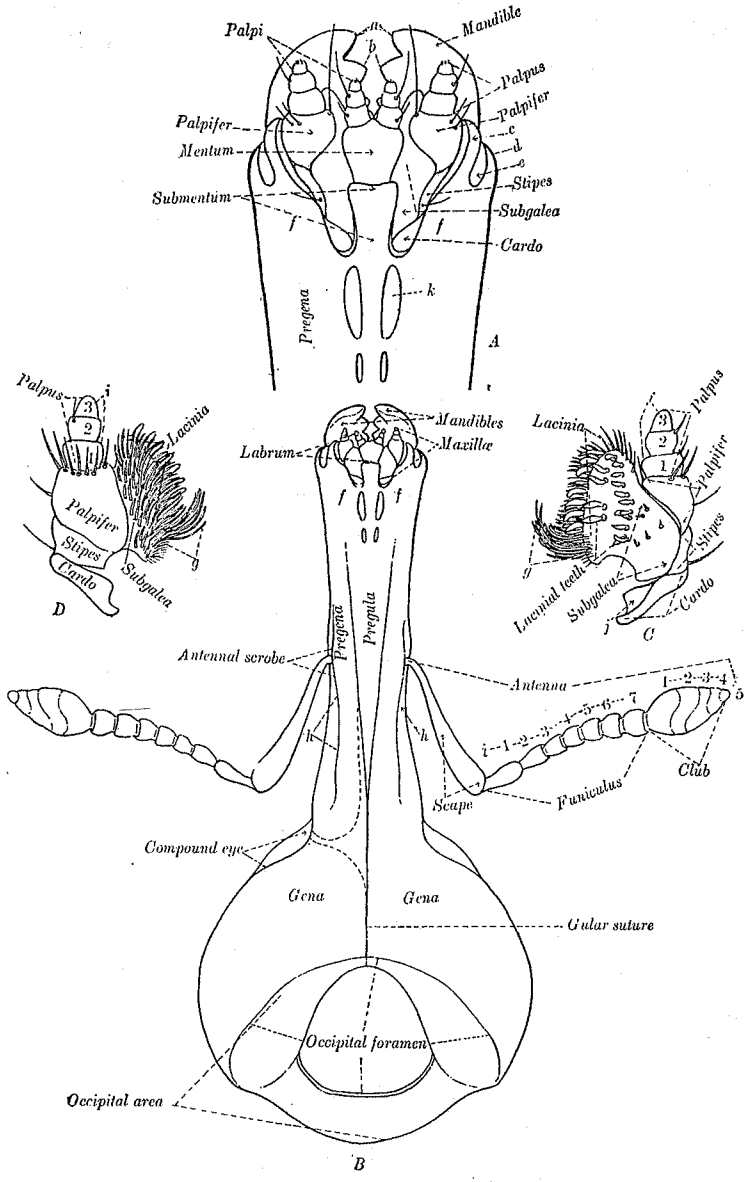

FIG. 8.—*Pissodesstrobi:* Head, ventral aspect, and mouthparts. *A*, Ventral aspect of apical region of beak; *B*, ventral aspect of head; *C*, interno-lateral aspect of maxilla; *D*, externo-lateral aspect of maxilla; *a*, apical tooth; *b*, subapical tooth; *c*, lateral arm of hypostoma; *d*, pleurostoma; *e*, mandibular scrobe; *f*, hypostomal area; *g*, lacinial bristles; *h*, antennal groove; *i*, joints; *j*, cardo fossa; *k*, hypostomal puncture. (Original.)

contour of the suture, etc., are shown in figures 11 to 13, but often appear different in dried specimens. The articulatory attachment

of the scape is in a rather deep scrobe (figs. 4, 5), situated in front of the eye near the base of the mandible and lateral angle of the epistoma.

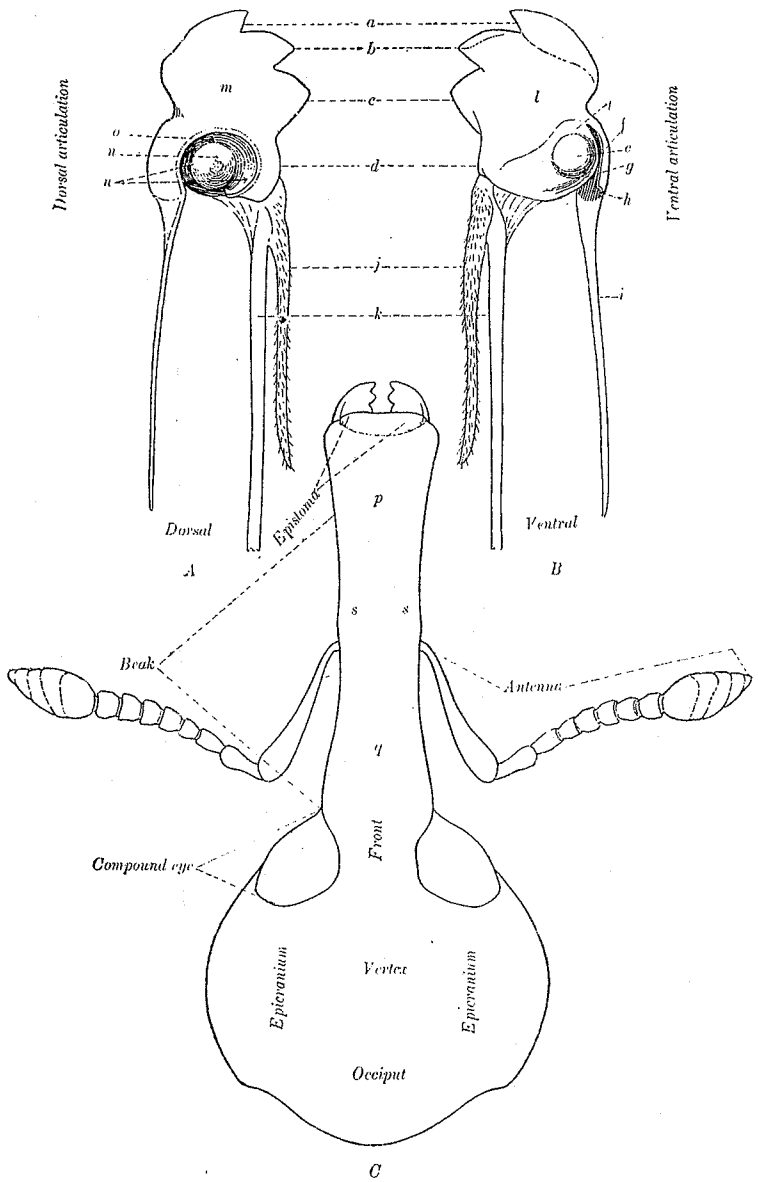

FIG. 9.—*Pissodes strobi:* Head, dorsal aspect, and mandibles. *A*, Dorsal aspect of left mandible; *B*, ventral aspect of left mandible; *C*, dorsal aspect of head; *a*, apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar; *e*, median condyle; *f*, lateral muscle process; *g*, lateral condyle; *h*, lateral fossa; *i*, extensor tendon; *j*, pharyngeal bracon; *k*, retractor tendon; *l*, ventral area; *m*, dorsal area; *n*, median condyle; *o*, anterior fossa; *p*, anterior section of beak; *q*, posterior section of beak; *s*, dorsal area; *t*, anterior condyle; *u*, lateral fossa. (Original.)

Epicranium.—The epicranium is not defined from the front or gena by sutures or lines, but the area is quite clearly indicated by the

smoother surface and by the presence of the compound eye, which is situated on the side of the head near the base of the antennæ. The anterior end of the epicranial suture defines the anterior dorsal limit of the epicranium, designated as the vertex, while the gena is represented by the ventral area between the eyes and the gular suture. The epicranial suture is more distinct in some species than in others.

Eyes.—The eyes vary from slightly oblong oval to oblong ovate and are obliquely placed in the anterior angle of the epicranial area, just posterior to the base of the antennæ. The variation in form within the genus and within the same species is shown in figures 1 to 6 and 15. There are about four hundred facets, which are small and densely placed.

Occiput (figs. 4, 5).—The occiput is not clearly defined, as it is in *Pterostichus*, but the posterior area of the cranium to the occipital foramen may be designated as the occipital region or area.

Occipital foramen (fig. 5).—The posterior opening in the head, or occipital foramen, is small as compared with the oral foramen. The invaginated wall forms a part and posterior support to the tentorium, and the dorsal apodeme is continuous with the epicranial suture.

Gula.—The gula is not represented by a space defined by two longitudinal sutures, as in most Coleoptera other than the Rhynchophora. The gular apodemes are present (fig. 5, *D*), but the gular space is invaginated, so that there is but a single gular suture.

Pregula.—In *Dendroctonus* there is a small sclerite immediately anterior to the gular suture (figs. 5, 6) which is distinctly separated from the gula and genæ by an invaginated apodeme, laterally from the pregena by an evident external line, and anteriorly from the hypostoma by a ridge which defines the anterior margin. In the rostrate beetles this is extended with the pregena and forms a more or less distinct gular space of the rostrum to a similar anterior space which supports the so-called gular peduncle, or submentum. Therefore it appears that the term pregula should serve to distinguish this important element, which is also more or less distinctly represented in Coleoptera other than the Rhynchophora. (Compare figs. 6, 7, 8.)

Gena.—The gena is not defined by lines, but it is represented by the ventral area between the gular suture and the epicranial area, as described under epicranium and gular suture.

Pregena (figs. 5, 6).—The pregena is a distinct pleural area situated between the base of the antennæ and the pregula, bounded posteriorly by the genal area and anterior angle of the epicranium, and anteriorly by the hypostoma.

Submentum (figs. 5, 6).—The submentum is represented by a bifid process or median extension of the hypostoma, and is supported by two stout braces rising from the large transverse rostral apodeme beneath the posterior angle of the pregula.

Labium proper (figs. 2, 5, *A*).—In *Dendroctonus* and other rhynchophorous beetles, the mentum, palpifer, glossæ, and paraglossa, while more or less clearly indicated, are not represented as separate elements of the labium. *Mentum:* The mentum articulates with the bifid submentum and completely surrounds the basal portion of the labrum, being subcylindrical, with the anterior ventral area strongly retuse. *Palpifer:* The palpifer is represented by the area between the ventral impression of the mentum and the row of palpiferal bristles which define the anterior limit of the mentum. *Palpi:* The labial palpi are distinct, 3-jointed, and as long as the mentum, or longer, with the first joint longer than the other two, or rarely equal. *Ligula:* The ligula is situated between the palpi, is thickly set with long lacinial teeth, and occupies the greater part of the dorsal area. It is evident that this ligular area represents the glossæ and paraglossa of other insects, and that it is homologous with the galea and lacinia of the first maxilla.

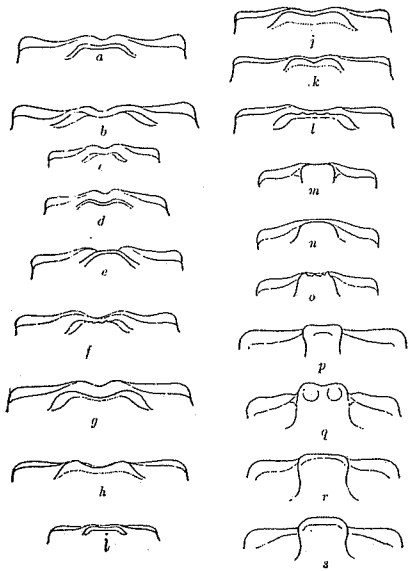

FIG. 10.—*Dendroctonus:* Epistomata. *a* to *l*, *D. valens*; *m* to *o*, *D. simplex*; *p* to *s*, *D. pseudotsugæ*. (Original.)

Maxillæ (figs. 2, 5, *B*, *C*).—The maxillæ (fig. 5, *B*) have the characteristic form of those of all other rhynchophorous beetles and are strikingly different from those of other Coleoptera. The form and relative proportions are shown in the figures. *Cardo:* The cardo is the stout basal section which articulates with a condyle on the maxillary process of the hypostomal apodeme. *Stipes:* The stipes articulates with the cardo and, while it does not appear as a separate piece, it is represented by the posterior ventro-lateral and externo-lateral part of the median section of the maxilla. *Palpifer, galea, subgalea,* and *lacinia:* The palpifer is fused with the stipes and is represented by the anterior part of the median section (fig. 5). The palpifer and stipes are also fused with the subgalea on the exto-lateral area, but on the interno-lateral area the line separating the palpifer from the subgalea is distinct, as is also the suture between the latter and the lacinia and galea, which are fused, the latter being represented by a narrow chitinous margin next to the palpus and palpifer. The lacinia is armed on the inner edge with stout lacinial teeth. The length of the base of the subgalea from the apex

to the posterior angle is usually greater than the length of the palpifer and stipes, but is sometimes equal and rarely shorter. The ventral

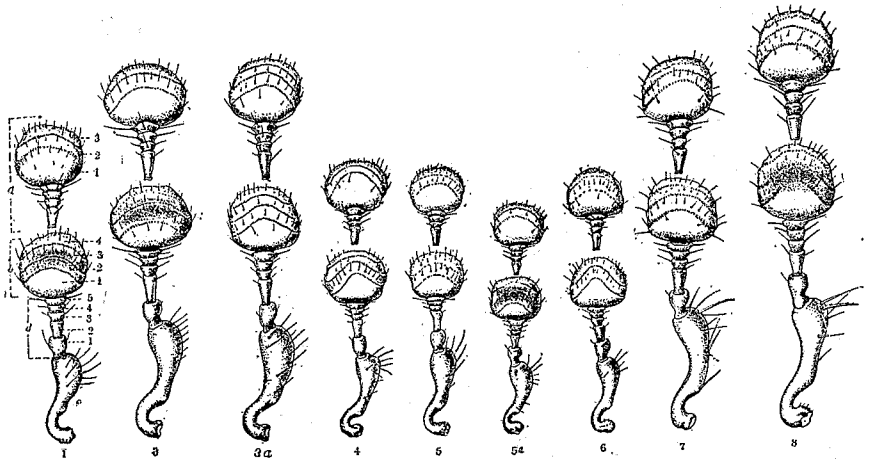

FIG. 11.—*Dendroctonus:* Antennæ. *1, brevicomis; 3, convexifrons* ♀; *3a, convexifrons* ♂; *4, frontalis* ♂; *5, arizonicus* ♂; *5a, arizonicus* ♀; *6, mexicanus; 7, parallelocollis; 8, approximatus* ♀. (Original.)
1—a, posterior face of club when antenna is extended at right angles to head, joints 1, 2, 3; *b*, anterior face, joints 1, 2, 3, 4; *d*, funiculus, joints 1, 2, 3, 4, 5; *c*, scape.

chitinous area of the palpifer and stipes together is always a third or more longer than the combined chitinous parts of the joints of

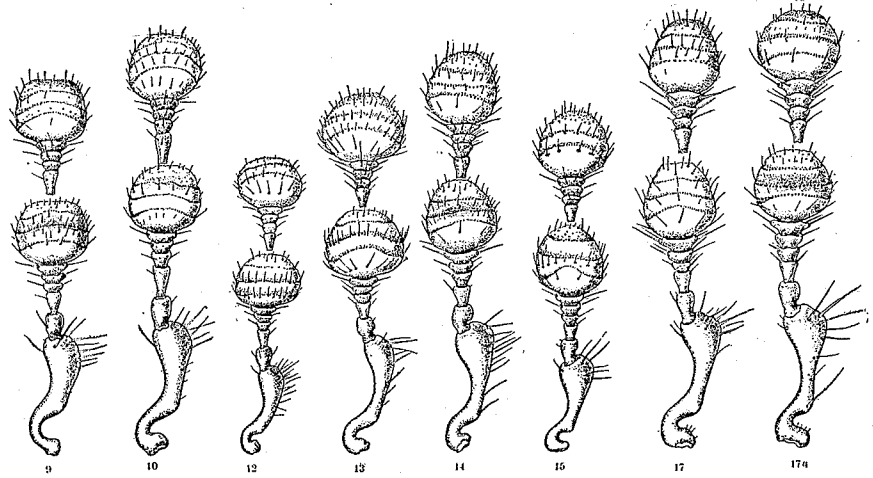

FIG. 12.—*Dendroctonus:* Antennæ. *9, monticolæ; 10, ponderosæ; 12, simplex; 13, pseudotsugæ* ♀; *14, piceaperda* ♀; *15, engelmanni; 17, obesus* ♂; *17a, obesus* ♀. (Original.)

the palpi. *Palpi:* The palpi are 3-jointed, the joints connected with each other and with the palpifer by flexible membrane which allows for a certain amount of telescoping, but not adapted for free

lateral movements as in *Pterostichus* (fig. 7). The relative lengths of the joints vary considerably in the species of the genus, and more or less in the individuals of a species. The first joint is usually longer than the other two together, but is sometimes equal or shorter; the second joint is usually longer than the third, but is sometimes shorter.

Mandibles (figs. 4, 14).—The mandibles are prominent, stout, triangular, and especially adapted for burrowing in the bark. The inner edges are acute, with a subapical and a median tooth toward the middle and a molar on the basal angle. The lateral area toward the base has a large impression and there is usually a less evident one on the dorsal area, each bearing one or two bristles. The dorsal

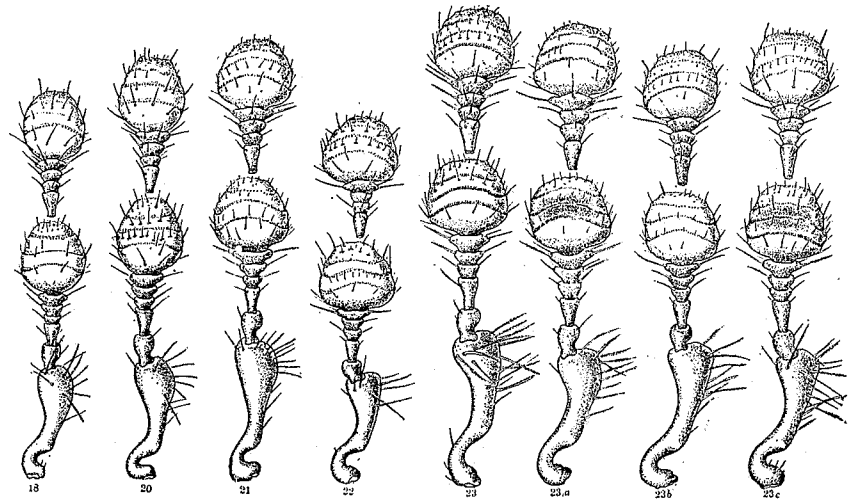

FIG. 13.—*Dendroctonus:* Antennæ. *18, rufipennis; 20, punctatus; 21, micans; 22, terebrans; 23, valens* ♂; *23a, valens* ♀; *23b, valens* ♂; *23c, valens* ♀. (Original.)

articulation with the epistoma is especially adapted to meet its several requirements. The peculiar trochlear mechanism of the articulating condyles and fossa are illustrated in figure 14; that of the dorsal condyle appears to be common to other rhynchophorous beetles, but apparently not represented in other Coleoptera, including those with similar bark and wood boring habits. The ventral articulation also appears to be different from that in other Coleoptera, but to a less degree. A detailed comparative study of the mandibles may reveal specific characters, but as a rule such characters are unsatisfactory from the fact that in comparisons the mandible must be viewed from exactly the same position to avoid error in conclusions.

THE THORAX.

The thorax, as usual, consists of three distinct segments. The prothorax freely articulates with the mesothorax, but the pleurites and sternites of the mesothorax and metathorax are rigidly connected. The combined length of the ventral areas of the three thoracic segments is slightly greater than that of the ventral area of the abdominal segments, while the combined length of the dorsal

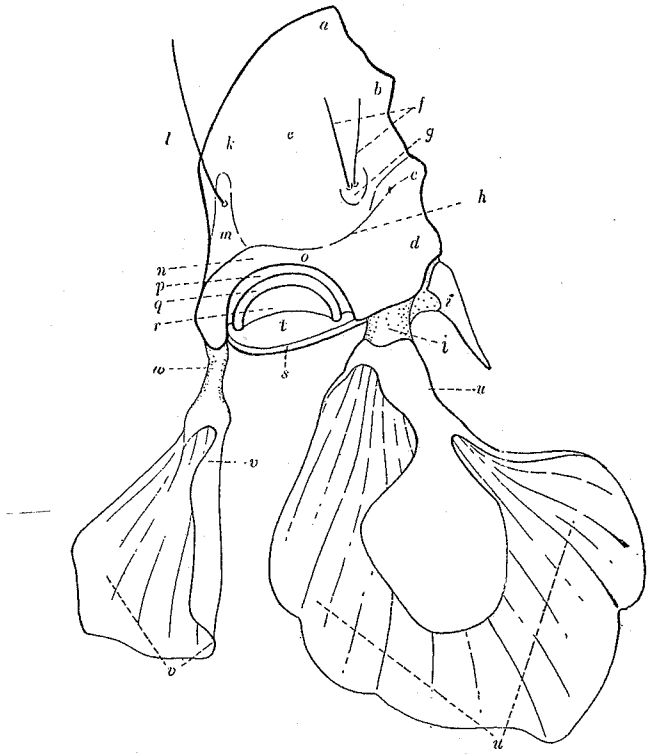

FIG. 14.—*Dendroctonus valens:* Mandible. *a*, Apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar tooth; *e*, dorsal area; *f*, dorsal bristles or setæ; *g*, dorsal impression; *h*, transverse ridge; *i*, pharyngeal process; *j*, retractor tendon; *k*, lateral area; *l*, lateral bristle; *m*, lateral impression; *n*, anterior condyle; *o*, basal ridge; *p*, median fossa; *q*, median condyle; *r*, posterior fossa; *s*, condyle of ventral articulation; *t*, basal foramen; *u*, retractor disk; *v*, extensor disk; *w*, extensor tendon. (Original.)

areas of the thoracic segments is about equal to that of the area of the abdominal segments, or slightly longer. The pronotum is as long as both the mesotergum and the metatergum together. The prosterna and mesosterna are about equal in length, and both together about equal to the metasterna, while the combined length of the thoracic pleura is slightly greater than that of the abdominal pleura. The anterior dorsal margin of the pronotum and the posterior margin of the metatergum are greatly extended anteriorly

beyond the ventral margin of the same segments, while the posterior dorsal margin of the pronotum and the anterior dorsal margin of the mesonotum are not produced beyond the corresponding sternal margin.

DIVISIONS OF THE THORACIC SEGMENT.

The divisions and other characters peculiar to the thoracic segments of a scolytid beetle are shown in figures 16, 17, 18, 19, and 20.

It will be noted that while the usual divisions or sclerites are quite clearly defined in the metathorax, corresponding divisions are less distinct in the mesothorax, and are obsolete or completely fused in the prothorax. The taxonomic significance of this wide range in the modification of similar parts or areas in the three thoracic segments of the same insect is realized when we compare these parts with corresponding segments in representative species of other families, suborders, and orders of insects. It will be seen that each segment has characters peculiar to the order or minor group to which the species belongs, and that in like manner the combined characters of any two or all three in the same insect present many features peculiar to the groups, the suborder, family, genus, or species represented.

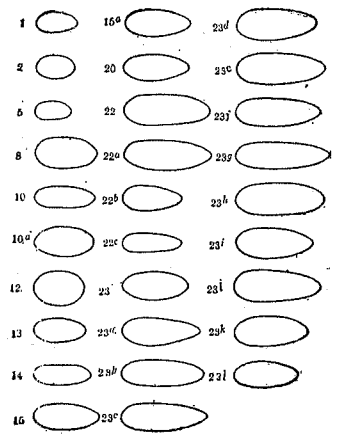

FIG. 15.—*Dendroctonus:* Eyes. *1, brevicomis; 2, barberi; 5, arizonicus; 8, approximatus; 10, 10a, ponderosæ; 12, simplex; 13, pseudotsugæ; 14, piceaperda; 15, 15a, engelmanni; 20, punctatus; 22, 22a, b, c, terebrans; 23, 23a, b, c, d, e, f, g, h, i, j, k, l, valens.* (Original.)

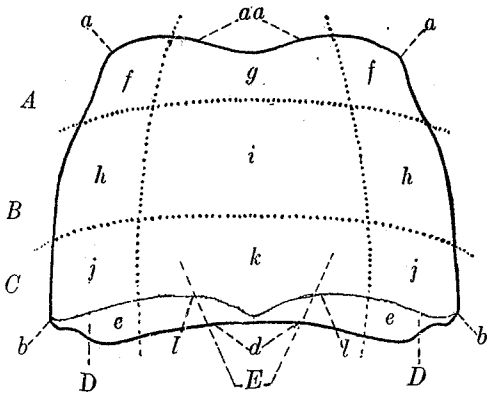

FIG. 16.—*Dendroctonus valens:* Areas of pronotum. *A*, anterior area; *B*, median area; *C*, posterior area; *D*, lateral area; *E*, dorsal area; *a*, anterior angle; *aa*, anterior margin; *b*, posterior angle; *d*, basal margin; *e*, posterior declivity; *f*, anterior section of lateral area; *g*, anterior section of dorsal area; *h*, median section of lateral area; *i*, median section of dorsal area; *j*, posterior section of lateral area; *k*, posterior section of dorsal area; *l*, posterior margin or vertex. (Original.)

It is also significant of the influence of a dominant principle or plan of structure and order of modification that one or more thoracic segments of practically any insect examined will show certain divisions more or less clearly defined, which are common to all other insects, and that when we compare the segments of different stages of insects of all orders, we find that a composite segment would represent a system of four longitudinal and four transverse divisions. The longitudinal

divisions are one dorsal, two lateral, and one ventral; the transverse divisions are one anterior, two median, and one posterior.

Audouin (1824) recognized the four longitudinal divisions and named them sternum, pleuræ, and tergum. He also recognized two divisions of the pleura and named them episternum and epimerum, and four transverse divisions of the tergum, which he named prescutum, scutum, scutellum, and postscutellum. These names have been adopted with but slight modification by most of the leading writers on insect anatomy, including McLeay, 1830; Newport, 1839; Kolbe, 1889; Amans, 1885; Comstock, 1902; and Voss, 1905. The same divisions have been recognized by many other authors, who have designated them by different names.

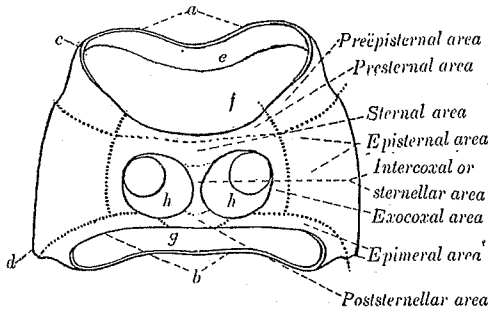

FIG. 17.—*Dendroctonus valens:* Areas of prothorax, ventral aspect. *a*, Anterior margin; *b*, posterior margin; *c*, anterior angle; *d*, posterior angle; *e*, anterior entothoracic fold for attachment of intersegmental membrane; *f*, anterior foramen; *g*, posterior foramen; *h*, coxal cavity. (Original.)

The first, second, third, and fourth transverse divisions of the ventral or sternal area were recognized by McLeay in 1830, and named, in order, presternum, sternum, sternellum, and poststernellum.

All of the divisions and subdivisions mentioned as having been recognized by Audouin and McLeay are here recognized by the writer, and, in addition, the first and fourth transverse divisions of the pleura; thus four longitudinal and four transverse divisions of each segment in the adult insect have been recognized. The writer has also recognized the same or a similar system of division in the thoracic and abdominal segments of larvæ and pupæ. While the taxonomic significance of the character and modification of these primary and secondary divisions as represented in one or more thoracic segments of the same insect, or in one or more segments in insects of different orders and minor groups, has been recognized, there has been wide difference of opinion as to the origin or homology of these divisions and in their interpretation or definition. This has naturally resulted in much confusion in the adoption and application of the nomenclature proposed by different authors, and, more than anything else

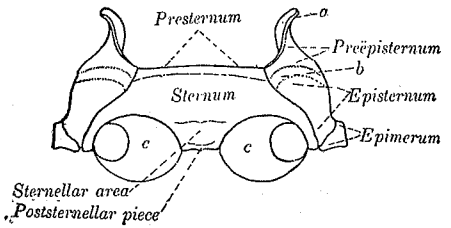

FIG. 18.—*Dendroctonus valens:* Mesothorax, ventral aspect. *a*, Preepisternal process; *b*, transverse impression; *c*, coxal cavity. (Original.)

connected with the anatomical problem, it was this state of confusion which led the writer to make a study of the subject in order to determine the facts and principles involved and to establish a basis for his future systematic and economic work on the scolytid and other beetles.

There appear to be two opposing ideas regarding the origin and evolution of the primary and secondary elements of the insect segment. One involves the principle of reduction of several primitive segments into one, on the theory that the transverse divisions represent modifications of several primitive segments. The other involves the principle of complex modification from a simple undivided primitive segment into many primary and secondary divisions, on the theory that this has been brought about more or less independently through the influence of the requirements of function to meet the demands of peculiar life activity in different forms or species, and that this plan of modification has been controlled and limited by the fundamental plan of structure in the hexapodal type of organism, and by the principle of relative proportions and correlation of parts so as to conform to the general modification of the entire body in the evolution of the species.

The writer does not deem it advisable, in this connection, to discuss the relative merits of these theories or any of the other theories advanced by different authors. He is inclined to believe that while it is important to utilize any good evidence relating to the probable origin and homology of parts, it is more important for present needs to deal with the facts as they are found in existing forms and stages and to so name and define the major and minor divisions or elements of the segment that they may be readily recognized and utilized in any comparative study of their modification and in the description and identification of species, genera, and larger groups. Therefore the writer's interpretation of the recognizable elements in the thoracic segments of *Dendroctonus* does not involve any theory of origin or evolution, but is based on the recognition of a dominant tendency in the insect segment to represent a system of four longitudinal and four transverse divisions, any one or all of which may or may not be clearly represented in one or more segments of the same insect.

With this conception of a prevailing principle as a guide to the location of the possible primary and secondary divisions of the anatomical elements as they are indicated in any given segment, and to the recognition of the possible range of modification and distinction as manifested in the different segments of the same insect or in the corresponding segment of different insects, many of the difficulties and confusing factors relating to the proper definition of parts and application of names are eliminated.

In the following discussion of the thoracic segments reference is made to the named parts as *represented* or *not represented*, as the case may be, rather than to say that they are present or not present, because in some cases where they are not defined on the external surface they may be indicated by apodemes or lines on the inner surface of the body wall, while in other cases their position or relative areas are indicated only by some character of surface sculpture or vestiture.

In the adult *Dendroctonus* there is a wide range of difference in the representation of parts in the prothorax, mesothorax, and metathorax. In the pupa there is a similar but not so marked difference between the three thoracic segments, the divisions being less evident in the mesothorax and metathorax than in the adult, but in the abdominal tergites the divisions are quite plainly indicated. In the larvæ there is not only less difference in the three thoracic segments, but these are only slightly different from the first to seventh abdominal segments. In the thoracic segments the prescutal and scutellar divisions are clearly represented, with evidence of the scutal division on the sides. The sternal and sternellar divisions are also clearly represented, with evidences of the presternal and poststernellar divisions in the prosternum, and the latter clearly defined in the mesosternum and metasternum. The pleurites are also represented by pleural lobes. In the abdominal tergites 1 to 6 the prescutal, scutal, and scutellar divisions are clearly represented and the sternal, sternellar, and poststernellar divisions are in like manner represented in abdominal sternites 1 to 8, inclusive. Whether or not these divisions or lobes are homologous with divisions occupying relatively the same positions in the pupa and adult may be a subject for difference of opinion, but the names here applied to what appear to be corresponding parts should serve as a reliable guide to their recognition and accurate definition and description in comparative studies and identification of species.

Elements of the Adult Thorax.

The primary and secondary elements as represented in the thoracic segments of an adult *Dendroctonus* beetle are shown in the figures and are interpreted, named, and described as follows:[a]

THE PROTHORAX.

In this genus, as in rhynchophorous beetles generally, the tergal, pleural, and sternal areas are fused into a continuous band. The primary and secondary divisions are not indicated by lines or sutures, but the corresponding areas are suggested by peculiar characters of sculpture and vestiture, which are of more or less taxonomic importance, and thus may be arbitrarily indicated, as in figures 16 and 17, to serve as guides to the location of characters in comparative study and description.

[a] *Notum and tergum.*—While the names notum and tergum are synonymous, the former has been applied more specifically to the dorsal division of the prothorax, especially in beetles, and is here utilized in that sense. The name tergum is here used to designate the dorsal areas of the mesothorax, metathorax, and abdomen, on account of the use of the term tergite to designate a subdivision.

Pronotum.—The pronotum is the dorsal or tergal area of the prothorax, as defined by the anterior, posterior, and lateral margins. There is considerable specific variation in its structure, sculpture, and relative proportions. It ranges from about one-fourth to about one-third broader than long, with about the same range of difference in the width of the posterior and anterior areas. In some species the lateral margins are nearly parallel, while in others they are distinctly convergent and constricted anteriorly. The anterior margin is broadly sinuate, while the vertex or dorsal margin of the posterior declivity is bisinuate. The anterior area is broadly transversely impressed, except in the females of some species, where the median section of the area is transversely elevated. The posterior declivity, which perhaps represents the postscutellum, is more distinctly exposed and defined in this genus than it is in allied genera and is therefore an important character of generic distinction. The pleural and sternal areas are indicated in figure 17.

Episternal area.—The episternal area is limited dorsally by the lateral margins of the notum, ventrally by the smooth exocoxal area, posteriorly by the epimeral area, and anteriorly by a preepisternal impression or in some species by a ridge. The sculpture of this area is quite variable and in some species furnishes characters of considerable value.

Epimeral area.—The epimeral area is represented by a flattened, smooth space situated between the roughened episternal area and the posterior margin of the prothorax and between the coxæ and the basal angle of the notal area.

Sternal area.—The entire sternal area between the anterior and basal margins is largely occupied by the coxal cavities, which are separated by the very narrow intercoxal or sternellar piece. The elevated anterior margin evidently represents the *presternum*, while the *sternum* is quite clearly defined by a nearly vertical flat to concave space between the presternum and the coxæ, the lateral limit being indicated by the smooth, shiny exocoxal area between the coxæ and the episternal area. The sternum proper is quite variable, ranging from concave, smooth, and shiny, without trace of a median longitudinal line to nearly flat, roughened, or with a median subcarinate line; but apparently none of these minor characters is sufficiently constant, even within the same species, to be of much taxonomic value.

Poststernellar area—The poststernellar area is well defined and serves to completely inclose the coxal cavity. It has been referred to as the epimeron, but since the epimeral is so clearly defined as a lateral area, it appears to more correctly represent the poststernellum, which in the mesosternum and metasternum is not evident, or is modified to accommodate the large coxal cavities.

THE MESOTHORAX.

The mesothorax (figs. 18, 19) is short and partially hidden from view by the prothorax, which covers the anterior third of the sterna, pleurites, and tergites, while the base of the elytra covers

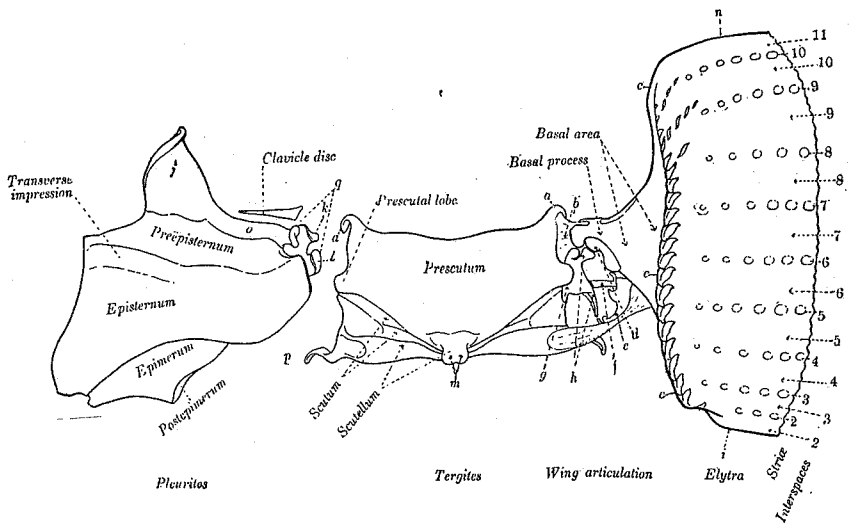

FIG. 19.—*Dendroctonus valens:* Mesotergum and mesopleurum. *a*, Lateral arm of prephragma and prescutum; *b*, wing root or connecting membrane; *c*, basal margin of elytra; *d*, radial plate; *e*, flexor plate; *f*, median plate; *g*, scapular plate; *h*, subscapular plate; *i*, sutural or anal margin; *j*, preepisternal process; *k*, clavicle condyle; *l*, coracoidal condyle; *m*, scutellum; *n*, lateral margin of elytra; *o*, arm of preepisternal process; striæ 2–10; interspaces 2–11; *p*, lateral arm of postphragma; *q*, pleural claviculus. (Original.)

the posterior third and dorsal area of the tergum, leaving but a small triangular area exposed between the thorax and inner angles of the elytra. Upon removing the prothorax and elytra this segment is found to represent most of the primary and secondary divisions of the normal segment.

MESOTERGUM.

The mesotergum (fig. 19) is rectangular in form, with the prescutum occupying two-thirds of the area, while the scutum, scutellum, and postscutellum are less clearly defined or rudimentary.

Prescutum.—It is evident that the large subtriangular dorsal section represents the prescutum, as indicated by the evident prescutal lobe and prescutal process, attachment of wing accessories, etc.

Prephragma.—The prephragma is strongly flexed beneath the median area, but the anterior arms, in conjunction with the anterior angles of the prescutum, are prominent and strongly produced.

Scutum.—The oblique, impressed, triangular section situated beneath the posterior margin of the prescutum evidently represents the scutum.

Scutellum.—The hornlike process situated at the apical angle of the prescutum apparently belongs to the scutellum and corresponds, perhaps, to the structure which forms the scutellar groove of the metathorax. This, with the posterior lateral section, represents the median and lateral sections of the scutellum.

Postscutellum.—The postscutellum apparently is not represented by an external piece, but by an evaginated fold beneath the scutellum and by the lateral arms of the postphragma (fig. 19).

Postphragma.—The postphragma is represented by the posterior invagination or fold beneath the scutellum and by the lateral arms, as evidenced by the attachment of the scutal muscle to the arm and the connection of the arm with the invaginated phragma.

MESOPLEURA.

The episternum, preepisternum, epimerum, and postepimerum are all represented and together occupy an area greater than that of the sternal and slightly greater than that of the tergal.

Preepisternum.—The preepisternum occupies the area in front of a transverse impression and is quite prominent. The anterior margin bears the preepisternal process (fig. 19, *j*), which is common to most of the Rhynchophora, and is more or less represented in certain other Coleoptera, such as Carabidæ, Cicindelidæ, Scarabæidæ, etc., but it is surprising to find that it is not represented in *Ips* (*Tomicus*) and allied genera of the Scolytidæ. It is peculiar to the mesothorax and is progressively modified in character and function through various groups of Coleoptera from an obscure accessory of the clavicle disk to a prominent process. In *Dendroctonus* it is fused with the anterior margin of the preepisternum and has an arm extending to the dorsal angle to form an accessory to the wing process. It bears a set of powerful muscles, which are attached to the inner wall of the postscutellar and scutellar areas of the pronotum, thus forming a powerful muscle connection between the two segments. The mesothoracic spiracle is situated in the angle between this process and the sternal area and is covered by the epicranial area of the prothorax.

Clavicle disk.—The slender plate situated in front of the arm of the preepisternal process appears to correspond with the clavicle disk of the metapleurum. It is connected by a ligament to the head of the elytra, and its muscle is attached to the rudimentary antecoxal piece. Both the preepisternal process and the clavicle plate,

as here defined, are probably modifications of the episternal paraptera of Audouin.

Episternum.—The episternum is the clearly defined, large, exposed triangular pleurite situated between the posterior margin of the preepisternum and the epimerum, with the dorsal angle dilated, produced, and flexed ventrally at the apex and with the apex of the epimerum and preepisternal process forming the pleural claviculus with its clavicle and coracoidal condyle for the articulation of the elytra. The posterior angle of the episternum is acute, and the suture between it and the sternum is obliquely sinuate. The episternal impression is clearly defined by the elevated posterior margin of the preepisternum, and is usually covered by the posterior margin of the prothorax.

Epimerum.—The epimerum is exposed at its posterior ventral half and has its posterior margin fused with the metasternum and metepisternum and the produced anterior dorsal angle with its coracoidal condyle is covered by the episternum.

Postepimerum.—The postepimerum is represented by a small declivous area beneath the posterior dorsal angle, where it covers the metathoracic spiracle.

MESOSTERNA.

Presternum (fig. 18).—The presternum is quite clearly represented by the narrow, slightly elevated, anterior margin joined directly with the anterior ventral angle of the preepisternum.

Sternum.—The sternum is short, flat, and subdeclivous, with the posterior angle (exocoxal piece) extending around the coxal cavity to its junction with the anterior angle of the metasternum.

Sternellar area.—The sternellar area appears to be represented by the elevated and rather broad intercoxal piece, while the poststernellum is apparently represented by a poststernellar piece.

THE METATHORAX.

METATERGUM.

From a systematic and taxonomic point of view, the metatergum is by far the most important and interesting part of the thorax of beetles. We find in it not only evidence of the four transverse divisions, but examples of the possible extremes in modification to meet the requirements of wing articulation and wing motion.

Transverse sutures.—By a comparison of the metatergum of representatives of different orders of insects and of the larvæ, pupæ, and adults of some insects, as in *Dendroctonus*, we find that the prevailing principle of division involves three transverse external lines, sutures, or impressions, and three corresponding entothoracic ridges, apodemes, or invaginated ectoderm, which define more or less clearly the four divisions, viz, prescutum, scutum, scutellum, and postscutellum. We also find that these transverse sutures are subject to great variation in position, contour, character of surface, manifesta-

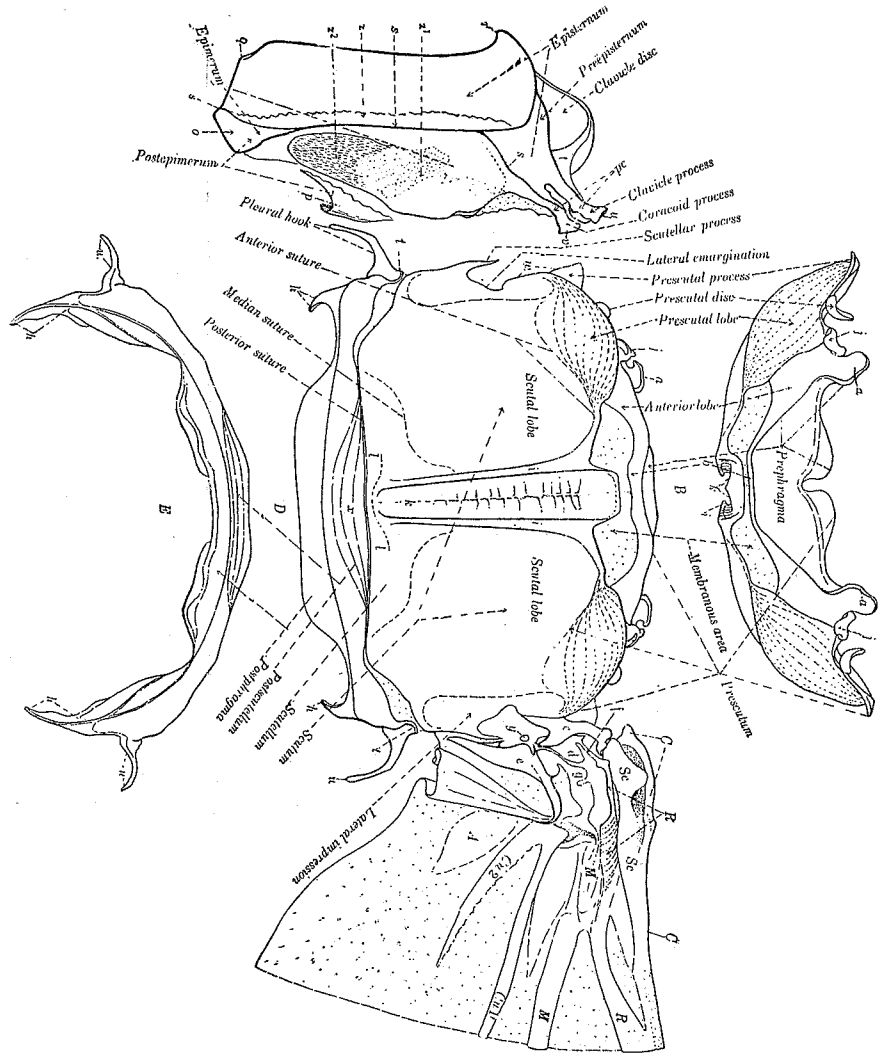

FIG. 20.—*Dendroctonus valens:* Metatergum and metapleurum. *B*, Anterior aspect of prephragma and prescutum; *D*, metatergum and metapleurum; *E*, posterior aspect of postphragma and postscutellum; *a*, lateral arm of prephragma; *b*, dorsal band; *c*, scapular plate; *d*, subscapular plate; *e*, flexor plate; *f*, radial plate; *g*, medial plate; *h*, lateral arm of postphragma; *i–i*, metatergal costæ; *j*, anterior disk; *k*, scutellar groove; *l*, posterior ridge; *o*, exposed triangular plate of postepimeron; *p*, pleural hinge; *pc*, pleural clavicula; *q*, posterior ventral angle of episternum; *r*, anterior ventral angle of episternum; *s*, pleural suture; *t*, postscutellar process; *u*, clavicle condyle; *v*, coracoidal condyle; *w*, attachment and articulation of scapular plate; *x*, dorsal area of postscutellum; *y*, pleural disk; *z*, elevated acute margin; *z 1*, membranous area; *z 2*, villous area. Wing veins: *C*, costa; *Sc*, subcosta; *R*, radius; *M*, media; *Cu 1*, cubitus 1; *Cu 2*, cubitus 2; *A*, anal. (Original.)

tions, etc., to correspond with the enormous range of modification to which one or all four of the transverse divisions are subject. These external evidences of separation of parts are here referred to as sutures,

although in some cases they may be but faintly or obscurely indicated. The lateral and median sections of the anterior suture separating the prescutum from the scutum have a tendency to curve posteriorly, and especially the median section, which has a very strong tendency in this direction, and is often manifested to such an extent as to separate the scutum into two lateral sections, as shown in figure 20. The median suture has a reverse tendency, the lateral sections extending anteriorly, the submedian section posteriorly, and the median strongly anteriorly. Thus we often find, as shown in figures 20 and 21, that the two sutures overlap and form external longitudinal ridges and internal oblique apodemes, with an external median longitudinal impressed area. It appears that the dorsal groove may belong to either the scutellum or prescutum or represent a combination of the two, but for the sake of uniformity in its definition the name scutellar groove is here adopted. The posterior suture is usually distinct in the metatergum, especially in that of Coleoptera, and is much less subject to striking modifications in contour, etc., than the two preceding. Thus, it clearly defines the postscutellum, as in figure 20.

Transverse divisions.—The writer's interpretations of the modifications and position of the four transverse divisions as represented in *Dendroctonus* are demonstrated in figure 20.

Prescutum (fig. 20).—The area designated as the prescutum is that involving the attachments of the principal sternotergal muscles and the anterior lateral process for the attachment and articulation of the scapular plate. The anterior limit is defined by the prephragma, its posterior limits by the anterior suture and apodeme and the posterior limit of the prescutal lobes, and laterally by the anterior angle or limit of the lateral emargination. The most important features are the prominent prescutal lobes and anterior lobes for the attachment of the depressor muscles, the prescutal disk for the small muscle connecting it with the pleural clavicula, and the triangular prescutal process for the attachment and articulation of the scapular plate. (See, also, figure 21 for the entotergal characters and anterior apodeme.)

Prephragma (fig. 20, *B*).—The prephragma is the median section of the anterior vertical area of the prescutum. Its dorsal and lateral limits are defined by the line of attachment of the intersegmental membrane. The lateral arms in conjunction with the anterior process of the anterior lobe of the presternum are greatly extended ventrally.

Scutum.—The scutum is represented by the large scutal lobes situated each side of the scutellar groove. These lobes are for the anterior attachment of the large scutal muscles with the posterior attachment to the lateral arms of the postphragma. The lateral margin of the scutum is defined by the lateral emargination and elevated scutellar ridge which terminates in the scutellar process, and posteriorly by the oblique sinuated line of the median suture and the lateral section of the posterior ridge.

Scutellum.—The scutellum is represented externally by the area posterior to the oblique line of the median suture and by the sublateral and lateral ridge which terminates in the scutellar process, as is indicated by the character of the entotergum and by comparison with the less modified scutellar division in other insects. The median longitudinal groove appears to represent the median produced section of the scutellum rather than a part of the scutum or prescutum, as indicated by the character of the entotergum and the widely-separated apodemes of the median suture which extend to and join

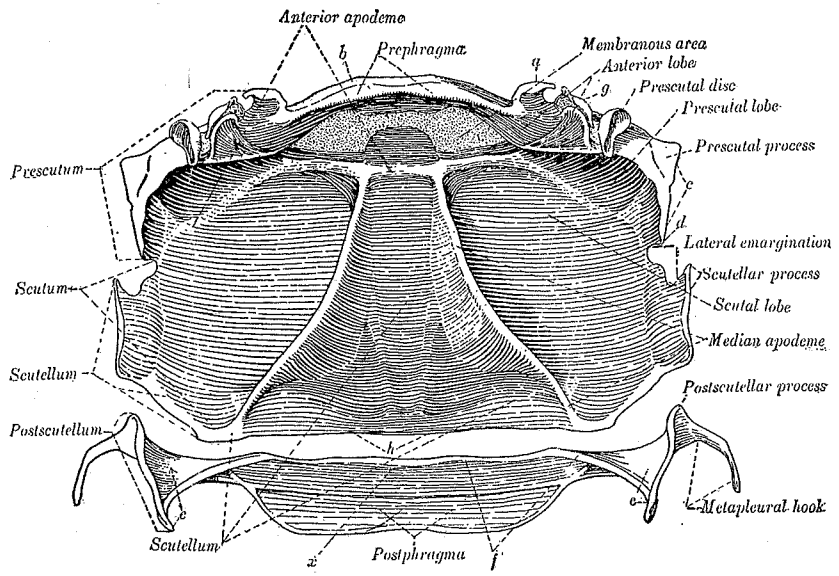

FIG. 21.—*Dendroctonus valens:* Metatergum, inner aspect. *a*, Lateral arm of prephragma; *b*, dorsal band; *c*, scapular articulation; *d*, posterior angle of prescutum; *e*, posterior arm of postphragma; *f*, posterior apodeme; *g*, anterior disk; *h*, posterior margin of scutellum; *x*, ventral wall of postscutellum. (Original.)

with the anterior apodeme (fig. 21), thus defining a large median triangular area which is evidently scutellar.

Postscutellum.—The postscutellum is the exposed dorsal and lateral area between the clearly defined posterior suture and the line of attachment of the first abdominal tergite. It is firmly connected with the scutellum toward each side at a point near the base of the oblique apodeme of the middle suture, otherwise the connection is membranous. The anterior angles support the metapleural hooks (fig. 20, *E*, *u*), which fit into a fold in the dorsal margin of the postepimerum (fig. 20, *p*).

Postphragma.—The postphragma is an invagination of the posterior section of the postscutellum and, with the produced posterior disks and arms, serves as important posterior attachments for the longitudinal, tergal, and oblique scutal muscles.

METAPLEURA.

The metapleurum is well developed and distinctly represented by the two longitudinal sclerites, episternum and epimerum (figs. 3, 20), with their anterior dorsal angles greatly produced to form the pleural clavicula with its clavicle and coracoidal processes.

Pleural suture and apodeme.—The pleural suture marks the line of division between the episternum and epimerum, and extends from the dorsal angle of the coxæ to the apex of the pleural clavicula and between the clavicle and coracoidal process. That this is the true pleural suture is indicated by the corresponding prominent pleural apodeme. It is also quite evident that the episternum corresponds to the hypopleurites and the epimerum to the epipleurites of the abdominal segments (figs. 3, 22).

Episternum.—The episternum is exposed when the elytra are closed (fig. 2). The suture between it and the sternum is distinct and nearly straight, with the anterior end curved toward the coxa. The posterior ventral angle is oblique and joins the posterior dorsal angle of the sternum; from here the posterior margin is oblique to its acute junction with the epimerum and the dorsal angle of the coxal cavity. From here the dorsal margin is acutely elevated to fit into the anterior lateral groove of the elytron, and is nearly parallel with the ventral margin to the preepisternum.

Preepisternum.—The preepisternum appears to be represented by the narrow declivous anterior section of the episternum connected with the anterior basal area of the pleural clavicula and is apparently involved in the formation of the clavicle process. The clavicle disk evidently represents one or both of the paraptera of certain other insects and belongs to the prepleura. It is situated immediately anterior to the preepisternum. It is large, prominent, and partially exposed, and is connected by a chitinous tendon to the side of the clavicle process. This disk supports the set of large clavicular or sterno-pleural muscles, the opposite ends of which are attached to the sternum and sternellum.

Epimerum.—The epimerum is situated between the pleural suture and the tergum. With the exception of the extreme posterior ventral angle of the postepimerum it is covered by the elytra. The anterior dorsal angle is strongly produced to form the coracoid process. The ventral area is chitinous and is joined to the episternum by the pleural suture, while the dorsal area is submembranous to membranous to its junction with the base of the wing membrane.

Postepimerum.—The posterior ventral angle and posterior lateral section represent the postepimerum, as is indicated by its articulatory junction with the poststernellum (fig. 20, *p*). The posterior ventral angle or ventral section of the postepimerum, which might be mistaken for a postepisternum, is indicated by the pleural apodeme and pleural suture which here join the dorsal angle of the coxa. It is not impossible, however, that this plate may represent a combined postepisternum and postepimerum.

METASTERNA.

The metasterna (figs. 2, 3) form a broad rectangular plate separated into two lateral sections by a median longitudinal line. The presternum and poststernellum are not represented by external parts.

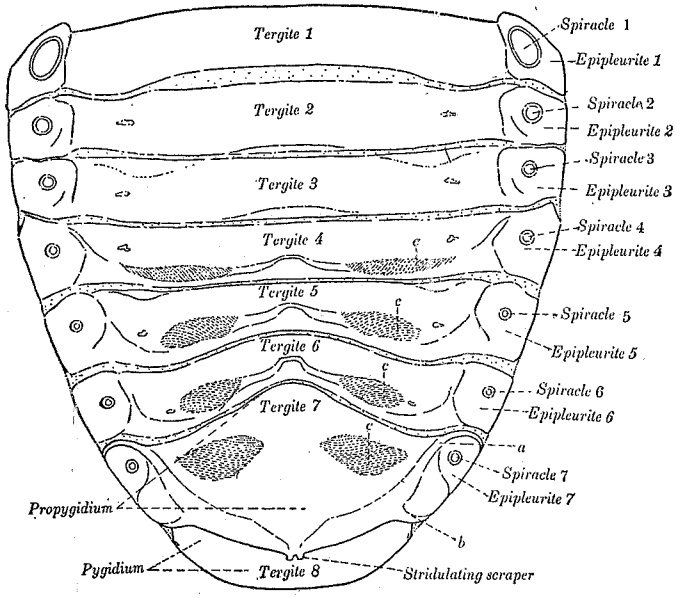

FIG. 22.—*Dendroctonus valens:* Abdominal tergites. *a*, Anterior arm of epipleurite 7; *b*, posterior arm of epipleurite 7; *c*, membranous lobes. (Original.)

Sternum.—The sternum is evidently represented by the large continuous area between the mesocoxæ and the small median plate and the slightly acclivous area anterior to the metacoxa.

Sternellum.—The sternellum is evidently represented by the posterior median plate and the posterior acclivous areas (fig. 2, *a*). The relation of the latter to the sternellar area is indicated by the attachment of the posterior pair of clavicular muscles.

THE ABDOMEN.

The abdominal terga, pleura, and sterna, and their relative proportions, are shown in figures 1–3 and 22–25.

Abdominal Tergites.

The eight abdominal tergites are normally covered by the elytra. The apparent difference in the relative proportions, as indicated by figures 3 and 22, is due to the flexible intersegmental membrane and the fact that figure 20 is from a balsam mount. The integument of 1 to 6, inclusive, is more or less membranous, while that of 7 and 8, with the exception of the finely sulcate membranous lobes of 7, is chitinous. In the female, 8 is covered by 7, and forms the so-called

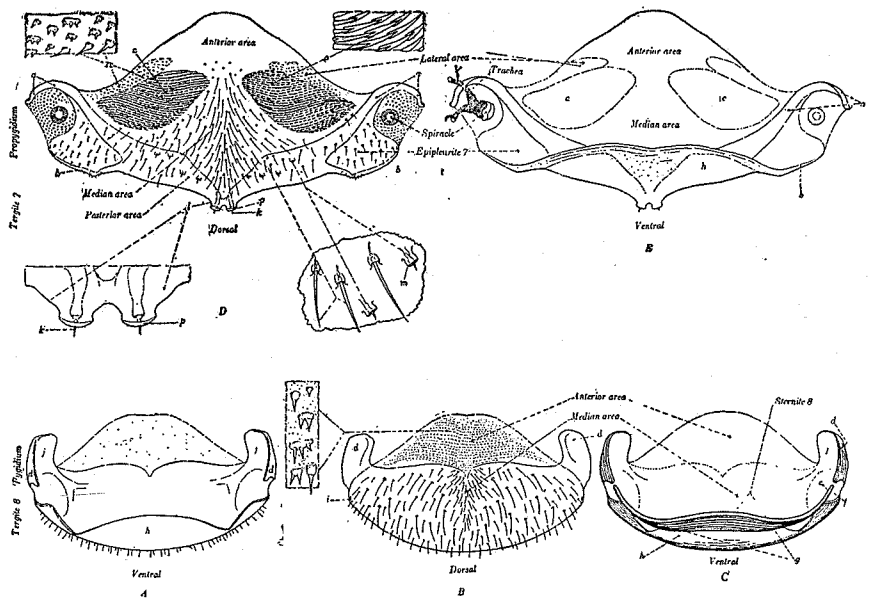

FIG. 23.—*Dendroctonus valens:* Male, abdominal tergites 7 and 8. *A*, Tergite 8 (pygidium), ventral; *B*, same, dorsal; *C*, same, ventral, showing position of sternite 8; *D*, tergite 7 (propygidium), dorsal; *E*, same, ventral; *a*, anterior arm of epipleurite 7; *b*, posterior arm of epipleurite 7; *c*, membranous lobe; *d*, epipleural process; *e*, hypopleural arm of sternite 8; *f*, pleural opening; *g*, anal space; *h*, ventral fold; *i*, rudimentary spiracle 8; *j*, epipleural disk; *k*, apical spine; *l*, stridulating process; *m*, sensory bristles; *n*, enlarged section of lateral area; *o*, enlarged section of membranous lobe; *p*, stridulating scraper. (Original.)

"pygidium," while in the male 8 is distinct and together with 7 forms the so-called "divided pygidium."

Pygal tergites of the male.—The pygal tergites of the male are shown in figure 23, *A*, *B*, *C*, *D*, *E*. Tergite 7 is the propygidium and as a bearer of generic and sexual characters is the most important of the entire series. In the male the posterior margins between the epipleurites converge toward the apex, which is produced into a bifid process and supports the stridulating scrapers. The posterior area of the tergite is thickened and strengthened to meet the requirements of stridulation. There is a broad ventral fold (fig. 23 *E*, *h*) of the integument which may serve a similar function to that of a sounding board.

The median area is triangular in form and covered with bristles and hairs rising from variously formed bases. On its face and sometimes on the posterior area there are a few irregularly arranged truncate tubercles (*D*, *m*), each bearing a short, stiff bristle. These may possibly function as sense organs.

The membranous lobes are subovate, finely sulcate, and thickly clothed with reclining microscopic spines (*o*). The exact function of these lobes is not known to the writer. Tergites 4, 5, and 6 have similar lobes. The other dorsal and ventral characters are made sufficiently clear in *D* and *E*.

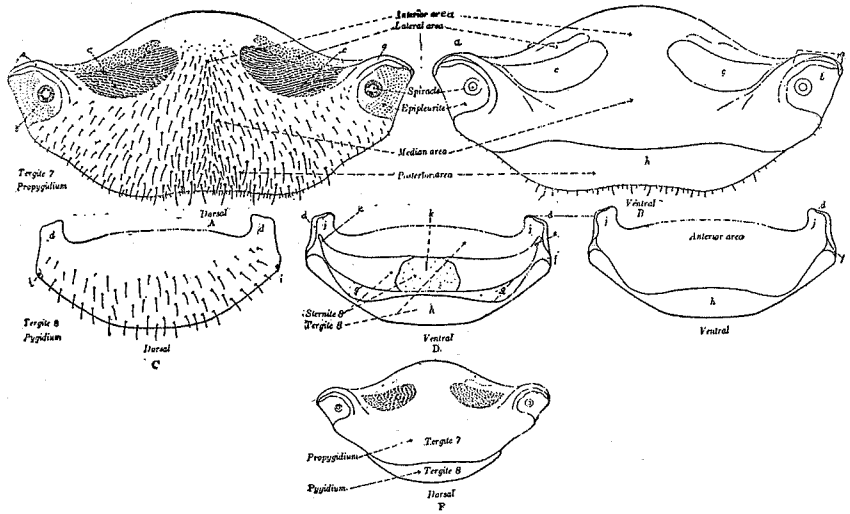

FIG. 24.—*Dendroctonus valens:* Female, abdominal tergites 7 and 8. *a*, Anterior arm of epipleurite 7; *b*, membranous area surrounding spiracle; *c*, membranous lobe; *d*, epipleural process; *e*, hypopleural process of sternite 8; *f*, pleural opening; *g*, anal space; *h*, ventral fold; *i*, rudimentary spiracle; *j*, epipleural disk; *k*, median membranous connection of the lateral sections of sternite 8. (Original.)

Tergite 8 (*A*, *B*) is the pygidium. This, in the male, is always larger and more exposed beyond the margin of tergite 7 than in the female. The relative proportions, as compared with 7, and the dorsal and ventral characters are clearly shown in *A* and *B*. The lateral arms serve as attachments for pleural muscles and articulating membrane and ligaments. In *C* the abdominal sternite is added to show its relative position and proportions.

Pygal tergites of the female.—The pygal tergites of the female are shown in figure 24, *A*, *B*, *C*, *D*, *E*, *F*.

Tergite 7 (propygidium) is much more simple in structural details in the female than in the male, and tergite 8 (pygidium) is also more simple and shorter, being almost or entirely covered by 7 when in normal position.

The characters of sternite 8 are shown in *D*, the most important of which is the median membranous area.

Abdominal Pleurites.

At the lateral ends of the abdominal tergites and sternites there are well-defined areas (figs. 3, 22, 25), which may be designated as pleurites. Those situated immediately above the pleural suture and bearing the spiracles may be referred to as *epipleurites*, while those of the sternites which are immediately below the pleural suture may be designated as *hypopleurites;* both series are well defined in *Dendroctonus*.

In a lateral view (fig. 3) seven epipleurites and five hypopleurites are clearly defined, with the eighth epipleurite and the second hypopleurite indicated, and when the abdomen is removed both the first and second of the latter series are quite distinct.

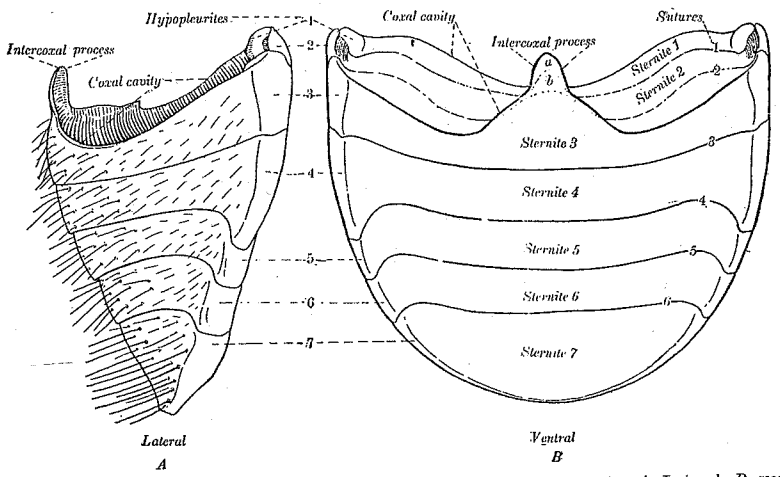

Fig. 25.—*Dendroctonus valens:* Abdominal sternites, ventral and lateral aspects. *A*, Lateral; *B*, ventral; *a*, sternite *1*, faintly indicated; *b*, sternite *2*, faintly indicated. (Original.)

Abdominal Sternites.

The characters of the abdominal sternites are shown in figures 2, 3, and 25. There are eight, corresponding to the eight tergites, but only five are exposed, viz. 3 to 7, which are densely chitinized and clearly defined by four sutures.

Sternites 1 and 2 and the anterior portion of 3 are covered and obscured by the large metacoxa and form the posterior wall of the coxal cavity. They are fused, but the sutures are indicated by faint lines. Sternite 3 (first ventral segment of some writers) has the median area produced anteriorly, and with faintly indicated median portions of sternites 2 and 1 it forms the intercoxal process, the apex of which forms a junction with the metasternellar piece. The anterior exposed margin forms the posterior margin of the coxal cavity, but the junction with the preceding segment is but faintly

indicated in the wall of the coxal cavity. Sternites 4, 5, and 6 are nearly of equal length, while sternite 7 is nearly as long as 5 and 6 together, with the posterior margin broadly curved and forming the apex of the exposed series. Sternite 8 (figs. 23, *C*, and 24, *D*) is entirely covered by 7, and is represented in the male by a narrow chitinous rim below the anal opening, while in the female the median section of this sternite is membranous.

Suture 3, between sternites 3 and 4, is the first visible suture, and is rigid and straight throughout, while sutures 4, 5, and 6 are slightly flexible and are strongly recurved toward and between the hypopleurites, thus presenting an important generic character.

Spiracles.

There are 9 well-developed spiracles, 2 thoracic and 7 abdominal, with the rudiments of a tenth. The large mesothoracic spiracle is located in the intersegmental membrane between the prothorax and mesothorax, and lies between the preepisternal process and the anterior ventral angle of the preepisternum. It overlaps the anterior margin of the latter for half its length, but is completely covered and obscured by the epimeral area of the prothorax. The metathoracic spiracle is situated in the intersegmental membrane between the metathorax and mesothorax, and concealed beneath the dorsal margin of the mesepimerum. The abdominal spiracles 1–7 are conspicuous; 1 is very large and situated in the epipleurite just posterior to the pleural hook of the metapostscutellum; 2–7 are situated in their respective epipleurites, as shown in figures 3, 22, 23, and 24, while 8 is evident, but rudimentary.

The Legs.

The structures and characters of the parts of the legs are so well illustrated in the figures (figs. 3, 26–29) that they do not require detailed description. The procoxæ and mesocoxæ are large, globose, and prominent, the former subcontiguous and the latter widely separated by the elevated intercoxal or sternellar piece, while the metacoxæ are oblong, oval, and separated by the process of the third abdominal sternite. There is no striking difference in the anterior, middle, and posterior trochanters, femora, tibiæ, and tarsi. The trochanters are small; the femora are moderately stout, and each is as long as its tibia, which is dilated toward the apex and armed on its outer lateral margin with stout teeth. The anterior dorsal area has a distinct tarsal groove for the retractile tarsus, as shown in figures 26 to 29. The tarsi are each more than half as long as their tibiæ, and have five joints; joint 1 is always longer than 2, but never as long as 2 and 3 together; 3 is distinctly bilobed, the

lobes slightly longer than joint 4; joint 5 from tip of lobes of 3 is never as long as the others (1 to 3) together, but sometimes shorter than 1 and rarely equal to 2 and 3. In the males this joint is often longer than in the female.

The trochlear articulation of the tibia with the tarsus is shown in figure 26, in which the other more important characters are shown and named.

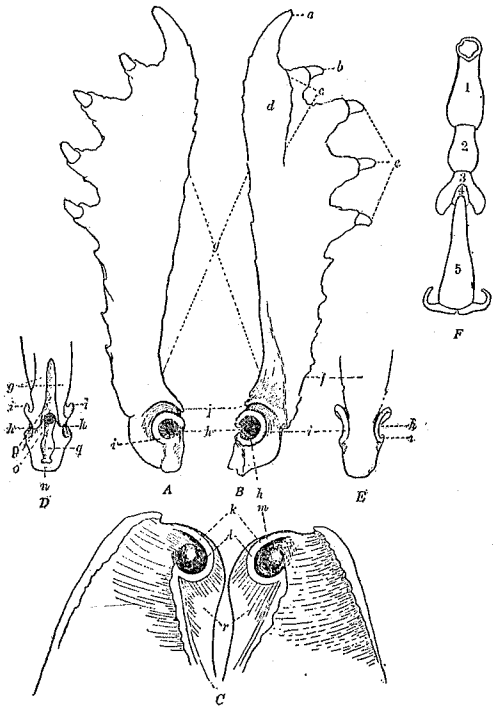

FIG. 26.—*Dendroctonus valens:* Tibia and tarsus, articulation, etc. *A*, Left tibia, ventral view; *B*, left tibia, dorsal view; *C*, left femora, ental view; *D*, left tibia, dextral view of base; *E*, left tibia, sinistral view of base; *F*, tarsus; *a*, apical tooth; *b*, subapical tooth; *c*, tarsal groove; *d*, subapical ridge; *e*, marginal teeth; *f*, sinistral margin; *g*, dextral margin; *h*, median fossa; *i*, lateral condyle of tibia; *j*, anterior fossa; *k*, lateral condyle of femur; *l*, lateral fossa of femur; *m*, median condyle of femur; *n*, attachment of extensor muscle; *o*, basal foramen; *p*, attachment of flexor muscle; *q*, basal groove; *r*, tibial groove. (Original.)

THE WINGS.

Notwithstanding the vast amount of published data on the wings of insects, there is yet much difference of opinion among the leading authors in regard to some of the details, and much confusion exists, due to different interpretations of the homologies of the elements of the wing and its articulatory accessories. A detailed investigation has been made of the basal areas of the wings of representatives of different orders of insects, to determine facts relating to the fundamental plan of development and modification, and the system of organization of the elements as represented in *Dendroctonus*.

Nomenclature.—While the more generally accepted nomenclature has been adopted, it has seemed necessary to revise and more definitely define the application of some of the old names and to introduce some new ones to designate the elements heretofore obscurely defined.

Attachments and articulations.—There are certain elements in the structure, mechanism, attachments, and articulation common to the wings of all insects, but within defined limits and according to a definite system modifications, additions, and reductions occur. Therefore the presence or absence of a given element should be detected in any form of wing.

Primary elements of the Dendroctonus wing.—The primary wing elements and their relations to each other as represented in *Dendroctonus* may be summarized as follows: *The structure* consists of a dorsal and ventral membrane or chitinous integument. *The primary tracheæ* are costal, subcostal, radial, cubital, and anal. *The primary veins* are costa, subcosta, radius, media, cubitus, and anal. *The wing plates* are scapular, subscapular, flexor, subflexor, radial, and medial. *The wings are attached* by membrane to the tergum and

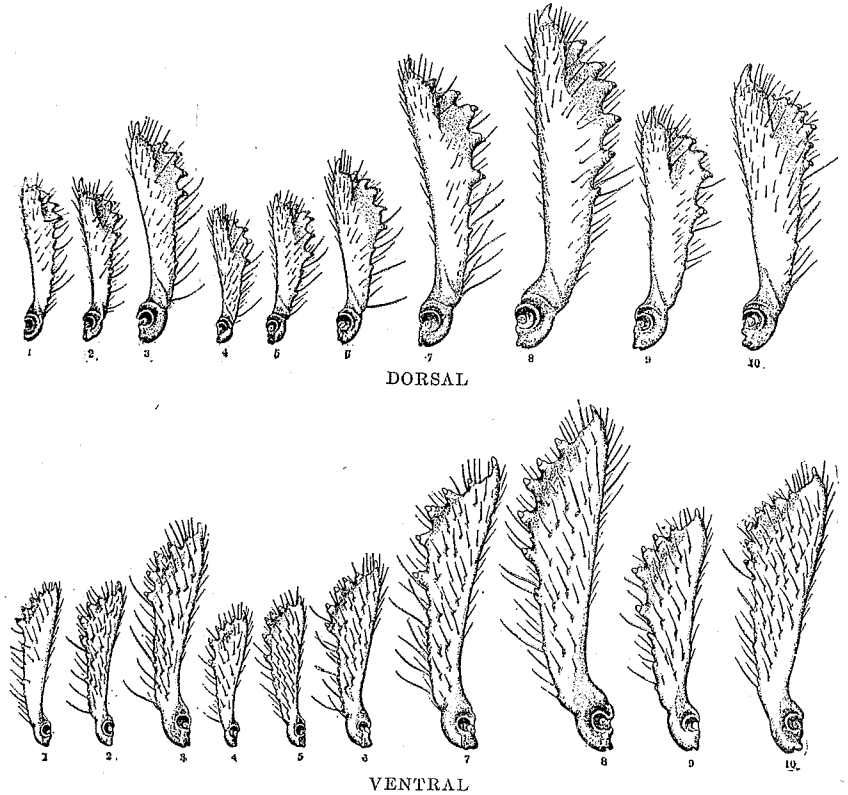

FIG. 27.—*Dendroctonus:* Left tibiæ, dorsal and ventral aspects. *1, brevicomis; 2, barberi; 3, convexifrons, 4, frontalis; 5, arizonicus; 6, mexicanus; 7, parallelocollis; 8, approximatus; 9, monticolæ; 10, ponderosæ.* (Original.)

pleurum, and by ligaments and tendons to tergal and pleural processes and muscle disks. *The pleural processes* are the clavicle and coracoid processes, which together form the pleural clavicula. *The tergal processes* are the prescutal, scutellar, and postscutellar.

Elements of wing motion.—The elements of wing motion are the clavicular disk and clavicular muscle, pleural disk and pleural muscle, flexor and flexor muscles, prescutal disk and muscles, anterior prescutal lobe and anterior sternotergal muscles, posterior prescutal lobe and posterior sternotergal muscles, scutal lobe and scutal muscles,

scutellar lobe, postscutellar processes, prephragma, and postphragma; also the pleural clavicula, clavicle, coracoidal, tergal, prescutal, scutellar, and postscutellar processes, and connecting ligaments.

Mesothoracic and Metathoracic Wings.

While there is a wide difference in the appearance and structural details of the elytra and the hind wings of beetles, they are evidently homologous and differ only in their modification in structure and function.

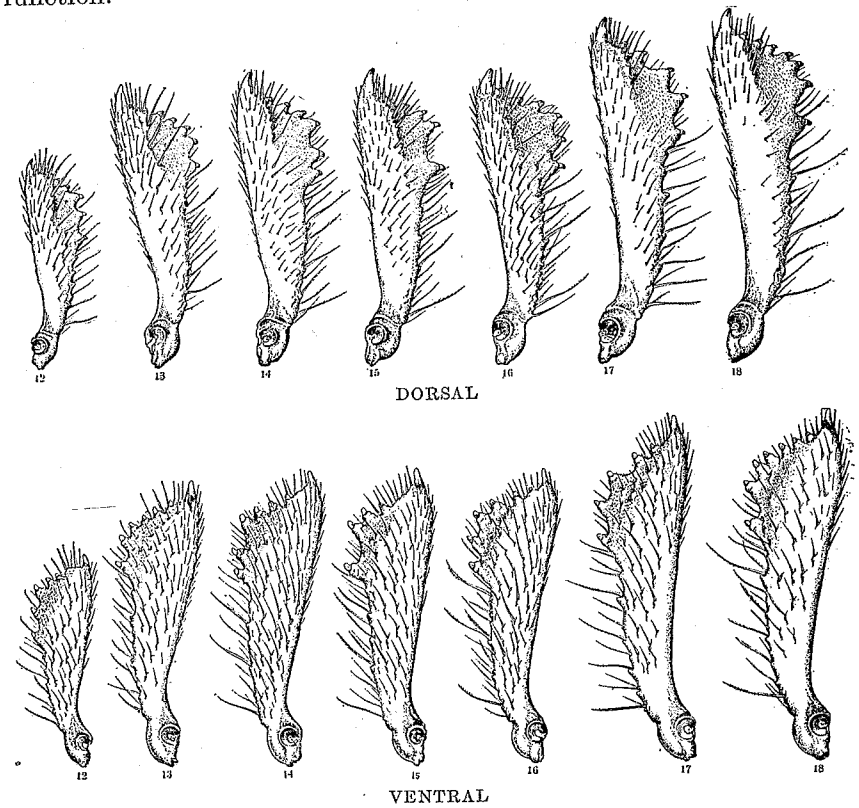

Fig. 28.—*Dendroctonus:* Left tibiæ, dorsal and ventral aspects. *12, simplex; 13, pseudotsugæ; 14, piceaperda; 15, engelmanni; 16, borealis; 17, obesus; 18, rufipennis.* (Original.)

Structure.—The wing consists of two layers of integument, the dorsal evidently rising from the tergites and the ventral from the epipleurum (epimerum). Between these layers there is a system of tracheation and circulation. The integument of the mesothoracic wing or elytron is chitinous throughout, while that of the metathoracic or hind wing, with the exception of the veins and basal pieces, is membranous.

Tracheation.—The same system of primary tracheæ prevails in both the elytra and the hind wings. In the former it corresponds in

general position to that of the primary veins in the latter, thus conforming to the prevailing system in fully developed wings of all insects. The primary tracheæ are costal, subcostal, radial, medial, cubital, and anal. In the elytron these occupy the marginal and alternating interspaces between the longitudinal striæ or rows of

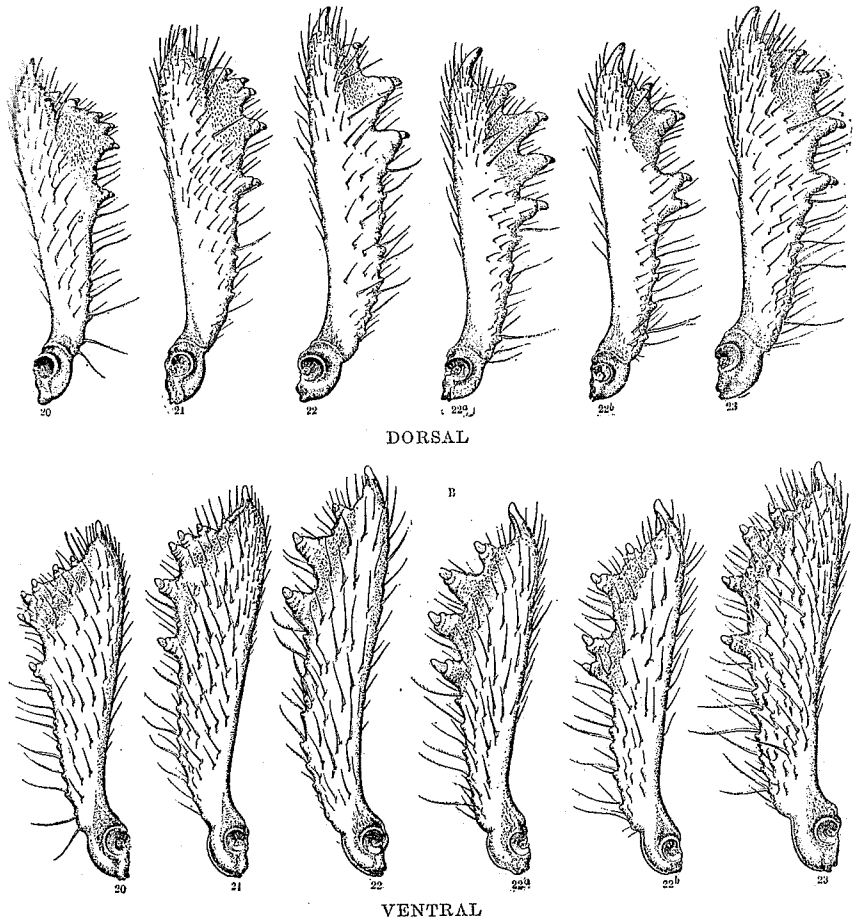

Fig. 29.—*Dendroctonus:* Left tibiæ, dorsal and ventral aspects. *20, punctatus; 21, micans; 22a, 22b, terebrans; 23, valens.* (Original.)

punctures, while in the hind wing they follow approximately the primary veins.

Metathoracic or Hind Wings.

The hind or metathoracic wings (figs. 1, 20, and 30) are a third longer than the elytra or mesothoracic wings, under which they are folded when at rest. In consequence the veins toward the middle of the wings are flexible and adapted to the requirements of folding and unfolding.

Basal area (fig. 30).—The basal area is that in which the basal plates and head of the veins occur. In this area there are four axillary plates, which are more or less common to insect wings in general. These appear to belong to the wing rather than to the body structures, and are here designated as scapular, subscapular, flexor, radial, and medial plates. They are discussed in greater detail under wing articulation.

Veins.—The six primary veins represented in the hind wing are costa, subcosta, radius 1 and 2, media 1 and 2, cubitus 1 and 2, and anal, which last is rudimentary.

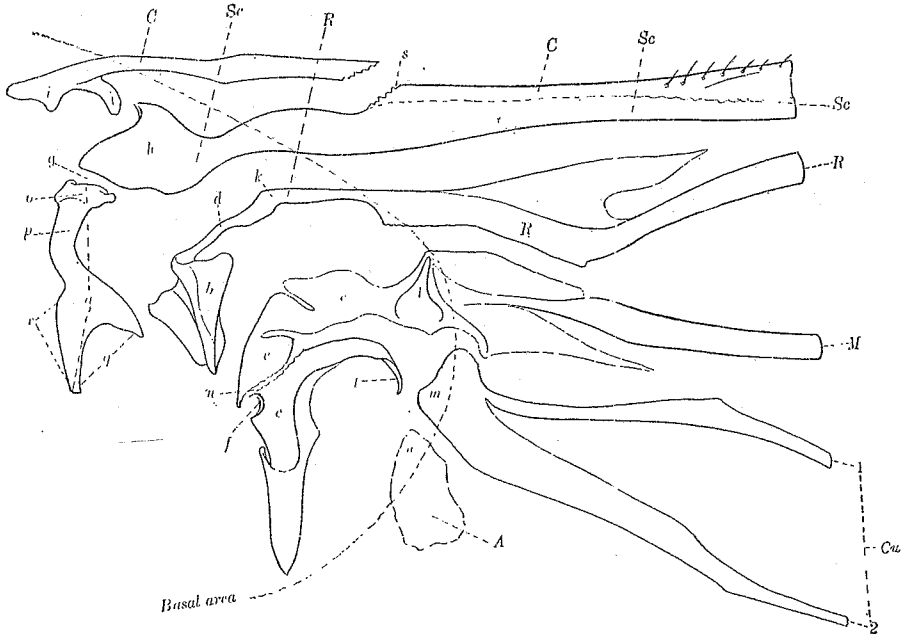

FIG. 30.—*Dendroctonus valens:* Diagram of basal area of hind wing. *a*, Scapular plate; *b*, subscapular plate; *c*, flexor plate; *d*, radial plate; *e*, medial plate; *f*, tendon attachment; *g*, articulation; *h*, subcostal head; *i*, costal head; *j*, costal tongue; *k*, radial head; *l*, medial head; *m*, cubital head; *n*, anal head; *o*, scapular condyle; *p*, scapular arm; *q*, scapular base; *r*, articulatory margin; *s*, connection of costa with subcosta; *t*, flexor arm; *u*, connection of medial plate with flexor; *C*, costa; *Sc*, subcosta; *R*, radius; *M*, media; *Cu*, *1*, *2*, cubitus 1 and 2; *A*, anal. (Original.)

Costa.—In *Dendroctonus* and most beetles the vein which corresponds to the costal trachea is confined to the basal area, and forms the anterior basal angle. The head is produced beyond the head of the subcosta, with which it is fused to form the articulating fossa. The produced head of this vein appears to function as an important accessory of the clavicle muscles in extending and depressing the wing, since it is connected with the clavicle condyle and clavicle disk by tendons. The vein proper extends outward but a short distance to its submembranous connection with the subcosta, and from that point the costal margin is occupied by it and the subcosta to its

junction with the radius, which appears to form the broad chitinous costal area to near the apex, with branch 2 as a distinct vein.

Subcosta.—The subcosta is the principal vein of the wing. It gives rigidity to the base, and with the head of the costa forms the articu-

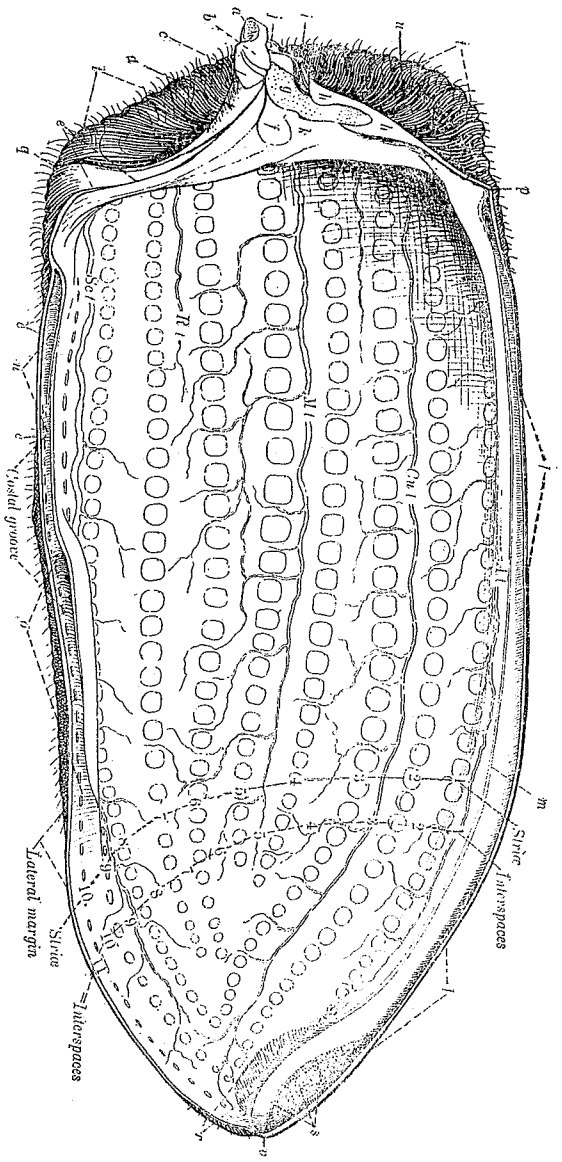

FIG. 31.—*Dendroctonus valens:* Right elytron, ventral aspect. *a*, Foramen of articulatory head; *b*, subcostal head; *c*, costal head; *d*, costal fold; *e*, costal margin; *f*, callus; *g*, basal foramen; *h*, anal fold; *i*, muscle disk; *j*, radial plate; *k*, ventral area; *l*, anal margin, dorsal, or sutural margin; *m*, ventral shoulder; *n*, anterior, and *o*, posterior section of costal groove; *p*, dorsal angle; *q*, lateral angle; *r*, stridulating rasp; *s*, rugose surface of apical lock; *t*, basal margin; *u*, basal declivity; *v*, apex; interspaces 1–11; striæ 1–10. Tracheæ: *At*, anal; *Cut*, cubital; *Mt*, medial; *Rt*, radial; *Sct*, subcostal. (Original.)

lating head. It is broadest where it is joined by the costa, and is strongly narrowed to its junction with the radius.

Radius.—The radius is an important vein in giving additional rigidity to the median, distal, and costal areas and in forming the folding

hinge. It arises through the radial plate from the subscapula, and joins and fuses with the head and posterior edge of the subcosta to

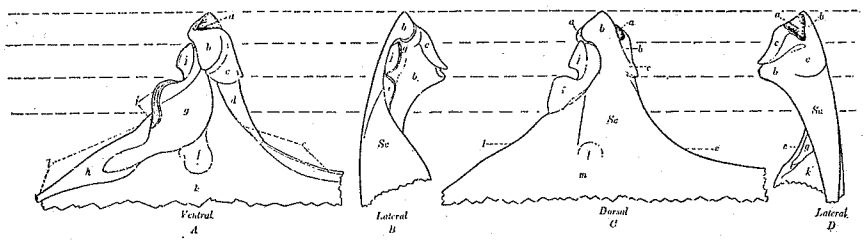

FIG. 32.—*Dendroctonus valens:* Basal process of right elytron. *A*, Ventral; *B*, latero-sinistral; *C*, dorsal; *D*, latero-dextral; *a*, foramen of articulatory head; *b*, subcostal head; *c*, costal head; *d*, costal fold; *e*, costal margin; *f*, callus; *g*, basal foramen; *h*, anal fold; *i*, muscle disk; *j*, radial plate; *k*, posterior ventral area; *l*, anal margin; *m*, posterior dorsal area; *Sc*, subcostal area. (Original.)

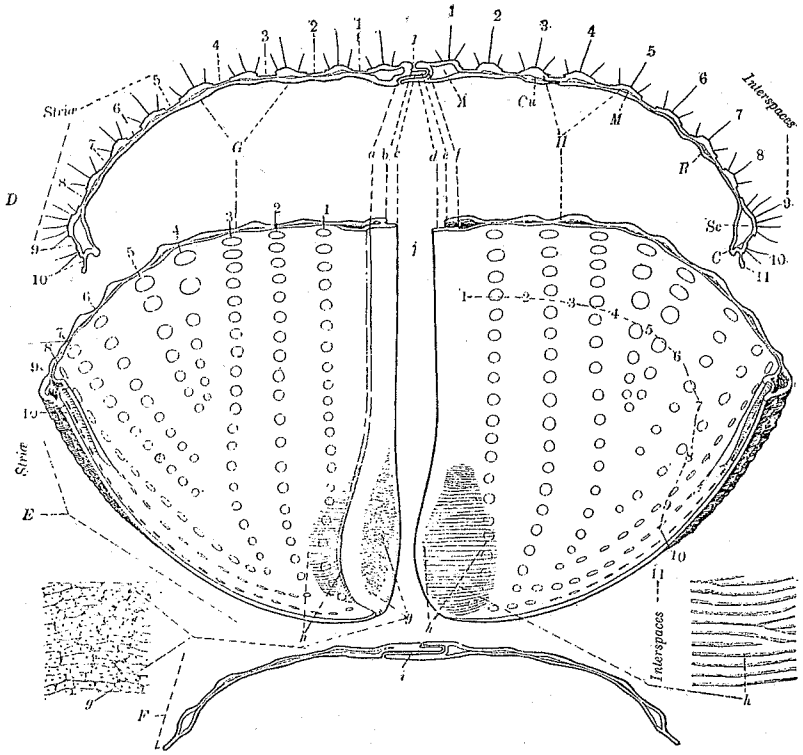

FIG. 33.—*Dendroctonus valens:* Declivital section of elytra. *a*, Ventral shoulder; *b*, dorsal shoulder; *c*, sutural tongue; *d*, ventral lip; *e*, dorsal lip; *f*, sutural groove; *g*, rugose surface of apical wing-lock; *h*, stridulating rasp; *i*, apical wing-lock; *j*, suture; *A*, anal canal; *Cu*, cubital canal; *M*, medial canal; *R* radial canal; *Sc*, subcostal canal; *C*, costal canal; *D*, transverse section; *E*, ventral aspect; *F*, transverse section through stridulating rasp; *G*, right elytron; *H*, left elytron. (Original.)

the point where it becomes broadened and obliquely rugose. Here it separates from the subcosta and joins the media by a short cross-vein, and thence proceeds, as shown in the figure.

Media.—The media is distinctly connected with a basal, irregular, ...ible medial plate, which is joined to the flexor, radial, and sub-...ular plates by membrane and flexible chitin. Near the distal ... of the basal area there is an evident fold or cross vein connecting ... base of the media with the base of the cubitus, from which it ...eeds outward to the hinge, and ... this point two branches ex-... to the anal margin.

Cubitus.—The cubitus rises from ... outer border of the basal area ... apex of the flexor and has two ...nches. Branch 1 extends to the ...rgin. Branch 2 is short and ...re or less rudimentary.

Anal.—The anal vein is evidently ...presented by the broad, short spur ...sing from the base of the cubitus, ... does not extend to the margin.

Wing attachment.—The wing is ...ached to the body by chitinous ...rsal and ventral integument, the ...ter arising from the dorsal mar-... of the epimerum, and the for-...r from the lateral margins of the ...escutum, scutum, and scutellum, ... indicated in the pupa. The heads ... roots of the veins are attached ... a system of connecting chitinous ...ndons and ligaments to the pleural ... tergal processes and disks.

Wing articulation.—The principal ...ticulation of the wing is between ...e wing head formed by the costa ...d subcosta and the condyles of ...e clavicle and coracoid processes ...gether with the scapular plate. The scapular plate is also con-...ected with the prescutal process by articulating membrane and ...gaments.

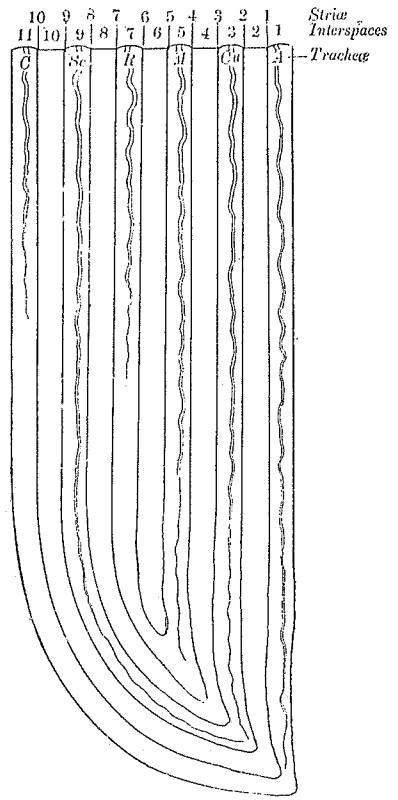

FIG. 34.—*Dendroctonus valens:* Diagram of elytron, showing striæ, interspaces, and tracheæ. Striæ 1–10; interspaces 1–11. Tracheæ: *C*, costal; *Sc*, subcostal; *R*, radial; *M*, medial; *Cu*, cubital; *A*, anal. (Original.)

Pleural clavicula ("clavicula thoracique," Chabrier, 1820).—The ...sition and function of the articular processes of the episternum ...d epimerum (fig. 20, *pc*), as represented more or less distinctly in all ...sects, are in *Dendroctonus* so strikingly analogous with that of the *...vicle* and *coracoid* in winged vertebrates as to suggest to the writer ...e same names. The giving of these names conforms with the prac-...ice of adopting for insect anatomy such of the nomenclature of ver-

tebrate anatomy as is applicable to parts in insects having the same or similar functions. Subsequently the writer's attention was called to the fact that the same idea was suggested to Chabrier.

In *Dendroctonus* the clavicle and coracoid processes are prominent and clearly defined, the condyle of the former being definitely connected with that of the head of the subcostal vein, which articulates between the condyles of the clavicle process and scapular plate. Chabrier's name *clavicula* has been adopted for the combined clavicle and coracoid processes.

Tergal processes (fig. 20).—The processes of the tergal area, which have more or less important functions as articulatory accessories, may be designated as prescutal, scutellar, and postscutellar.

Prescutal process.—The prescutal process is represented by a triangular extension of the posterior angle of the prescutum, and is of primary importance as an accessory to the scapular plate.

Scutellar process.—The scutellar process is represented by the thickened lateral margin of the lateral impression and by the produced, acute, anterior angle. It is attached along its lateral margin to a pleural tendon connecting the pleural disk to the flexor and subscapula. This process is also accessory to the flexor.

Postscutellar process.—The postscutellar process is an extension or arm of the anterior angle of the postscutellum, and has its apex attached to the pleural disk and to the pleural hook.

Lateral emargination.—What is termed the lateral emargination is the emargination in the side of the scutum between the posterior angle of the prescutum and the scutellar process. It is present in most of the insects and appears to facilitate the functions of the flexor muscle.

Lateral impression.—The lateral impression is an impression to accommodate the flexor plate when the wing is at rest.

Basal elements.—The basal elements of the wing which function as articulatory accessories are here referred to as head of costal vein, scapular, subscapular, radial, medial, and flexor plates (fig. 30).

Head of costal vein (*i*).—The head of the costal vein is produced beyond its fused connection with the head of the subcosta. It is connected to the head of the clavicle by a ligament, and evidently functions in extending the wing forward as well as in contributing to other motions.

Scapular plate (*a*).—In form and function the fundamental basal plate, which we here call scapular plate, is very suggestive of the scapula of vertebrates, but its peculiar functions require quite different tergal connections. It is joined by ligaments to the prescutal process and lateral margin of the prescutal lobe in such a manner as to facilitate part of its functions—that of unfolding, elevating, and depressing the wing. Its condyle articulates directly with the

dorsal or inner edge of the head of the subcosta and with the clavicle condyle.

Subscapular plate (*b*).—The subscapular plate is more complicated in its structure than the scapular plate, to which it is a direct accessory, the two being closely joined by articulating ligament. It functions as an intermediate patella-like connection of the system of tendons which connect the pleural disk at the head of the pleural muscle with the flexor, head of scapular plate, head of coracoidal process, head of subcosta, etc. Therefore it must be of fundamental importance in wing motion.

Radial plate (*d*).—The radial plate is represented by a thin chitinous piece connecting the radius with the subscapula.

Medial plate (*e*).—The medial plate is of flexible chitin connecting the media with the flexor and subscapula.

Both the radial plate and flexor plate evidently function as articulating accessories.

Flexor plate (*c*).—The flexor plate comes next to the scapular plate in its fundamental importance in wing connection and articulation, and is especially fitted in structure and muscular connection for its primary function of flexing and longitudinally folding the wing, as well as in the reverse action of contributing to its outward extension and rigidity during flight.

Mesothoracic Wings or Elytra.

The form and general structure of the elytra are shown in figures 1 and 31. They are oblong, rigid shields, with a subacute apex and a truncate declivous base and a produced articulating head. The structure, like that of the metathoracic wing, consists of two layers of integument inclosing the tracheal and circulatory system, but instead of the dorsal and ventral layers being partially composed of flexible membrane, they are chitinous throughout. The ventral layer is thin and smooth, while the dorsal one is thick and deeply sculptured.

Tracheation.—The six primary tracheæ (figs. 31, 34) occupy the marginal and the alternating longitudinal spaces between the rows of punctures. Each has numerous fine lateral branches passing between the punctures into the intervening interspaces, producing a network of fine tracheæ, with the punctures representing the mesh. Thus we have a probable explanation of the primary cause of the system of punctures in the elytra and the longitudinal and tranverse thickened spaces between them. The thickened and elevated areas are due to a concentration of chitin over the tracheal and circulatory canals, while the punctures and grooves are the points of adhesion or junction of the two layers to form the walls between the canals.

Sculpture.—The dorsal chitinous layer presents many and varied characters of sculpture, the principal elements of which are the striæ, including the longitudinal impression and rows of punctures. The interspaces are longitudinal spaces between the striæ. The rugosities of the interspaces and striæ and the elevated rugose basal margin are all characteristic elements of sculpture. There are ten striæ and eleven interspaces. For convenience in referring to the variable characters, these are numbered, beginning with those next to the dorsal suture, when the elytra are closed, or with the posterior or anal margin when the elytra are open. Thus we have interspaces 1 to 11, and striæ 1 to 10 (figs. 31, 33).

Interspaces.—In an ideal system (fig. 34) interspaces 1 to 5 are continuous toward the apex with 11 to 7, leaving 6 independent between 5 and 7. The primary tracheæ occupy interspaces 1, 3, 5, 7, 9, and 11. There is, however, more or less variation and modification in the elytra of beetles from this ideal arrangement and especially upon the distal ends and their junctions with each other on the declivital area. In *Dendroctonus* interspace 1 is usually more elevated and continuous to apex, where it joins the very narrow marginal 11; 2 is less elevated to flat, narrowed toward apex, and joins the very narrow and obscure submarginal 10, which becomes broader and distinct toward the base; 3 joins the distinct 9; 4 joins 6 around the apex of 5, and also joins 8 around the apex of 7.

Striæ.—In the ideal arrangement (figs. 1, 31, 34), striæ 1 to 5 are continuous with striæ 10 to 6, but the usual arrangement on the declivity in this genus is 1 to 3 continuous with 10 to 8, while 4 is continuous with 5, and 6 with 7. The strial punctures range from small to coarse and from very distinct to obscure, and are sometimes variable in size and appearance in the same species. The prevailing condition, however, of relative obscurity or distinctness in different species is of considerable specific importance. The strial impressions also vary within the genus from scarcely to distinctly or deeply impressed, and the prevailing condition within the species is of considerable value. The elytral declivity, as is usual in the scolytid beetles, bears some of the more important specific and secondary sexual characters.

The other character-bearing areas of the elytra are the lateral, median, and the dorsal toward the vertex and base.

Vestiture.—The elytra are more or less distinctly clothed with short or long hairs. The length, size, arrangement, and areas occupied furnish important taxonomic characters in distinguishing the major and some of the minor divisions, as shown in the synoptic table. A progressive modification in vestiture is from very short hairs over the entire surface to longer hairs and sparsely arranged

bristles toward the vertex of the declivity and on the declivity itself, or to fine and coarse long hairs over the entire surface.

Lateral fold or costal groove (fig. 31, *n*, *o*).—In the costal edge of the elytron, from near the base to the median section, there is a lateral or costal groove for the reception, when the elytra is closed, of the corresponding produced and acute dorsal edge of the episternum. There is also a deeper and broader groove in the median section of the costal area, for the reception of the produced dorsal edges of hypopleurites 3 and 4. According to LeConte and other writers, this lateral groove is an important subordinal character.

Sutural tongue and groove (fig. 33, *a–f*).—In the sutural edge of the left elytron there is a deep lateral groove and produced ventral edge for the reception of the corresponding produced lateral edge or tongue of the right elytron, thus forming a tongue and groove suture. Toward the apex both the ventral edge of the left and the tongue of the right are dilated to facilitate the locking of the elytra when they are closed.

Stridulating accessories.—In the male there is a transversely and microscopically sulcated area on the ventral surface toward the suture and apex of each elytron (fig. 33). When the elytra are closed this forms a continuous filelike surface situated directly above the stridulating scraper of the seventh abdominal tergite or propygidium. A peculiar, independent, upward and backward motion of the propygidium brings the scraper in contact with the file, and thus produces a peculiar chirping sound which is quite audible to the human ear.

The exact location of the organs of hearing in these beetles has not been determined.

Basal and pleural elements.—The basal process, or articulatory arm (fig. 32) of the elytron appears to represent the fused heads of the costa, subcosta, and radial veins. The usual scapular, subscapular, flexor, and medial plates are quite definitely represented, and occupy the same relative positions as in the metathoracic wing. The pleural clavicula are represented in the mesothorax by the clavicle and coracoidal processes, which are fused beneath the anterior dorsal angle of the episternum to form the condyles (fig. 19). The clavicle disk is not represented, unless it is by a narrow free piece attached to the costal angle of the elytral process, and represents the parapterum or extensor plate, to which the extensor muscle is attached.

INTERNAL ANATOMY.

While some study has been made of the internal anatomy of these beetles it has not been sufficient to warrant a detailed discussion in this connection.

DIGESTIVE SYSTEM.

The general character of the digestive system is shown in figure 35, and no further explanation is necessary in this connection than that given in the legend under figures 35 and 36. In figure 36 some of the details of the internal anatomy of the fore intestine are shown, and especially the structures and elements of the proventriculus and hypopharynx.

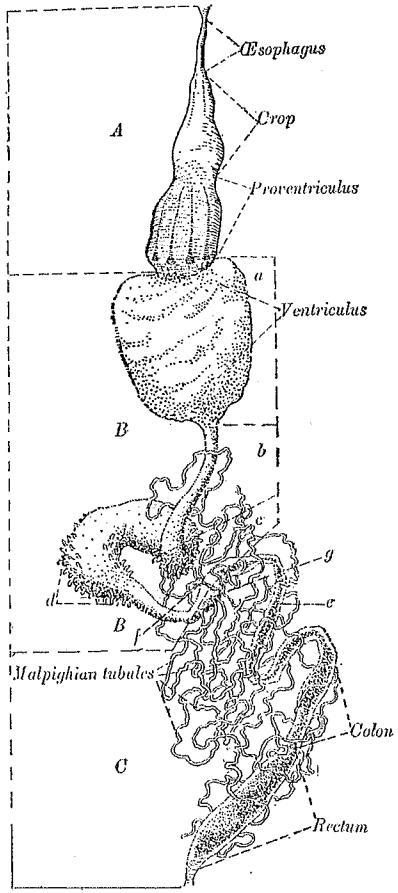

FIG. 35.—*Dendroctonus valens:* Digestive organs of adult. *A*, Fore intestine; *B*, mid intestine; *C*, hind intestine; *a*, anterior section of mid intestine; *b*, median section of mid intestine; *c*, posterior section of mid intestine; *d*, cœcal glands; *e*, ileum or small intestine; *f*, base of 4 malpighian tubes; *g*, base of 2 malpighian tubes. (Original.)

SECONDARY SEXUAL CHARACTERS.

While there are certain clearly defined secondary sexual characters in these beetles, they have not been recognized by other writers, and they were not found by the present writer until after much detailed study of the genus. When they were determined it was surprising how such prominent characters could have been overlooked. Thus we have another example of how thoroughly familiar one must be with a given group in order to recognize and properly interpret the significance of characters in structure, sculpture, vestiture, etc. In the first subdivision of the genus the females are distinguished by a transverse ridge across the anterior area of the pronotum, while the males are distinguished by the absence of this ridge and by more prominent frontal tubercles which are separated by a deeper frontal groove.

In the second subdivision the females are distinguished by the smoother and more shining elytral declivity. In the third subdivision the females have the elytral declivity distinctly more rugose, while that of the males is smooth and shining. Thus we have a reversal of the secondary sexual characters within the same genus, which is an unusual occurrence.

In the fourth subdivision the sexes are more difficult to recognize, but the males are distinguished by stouter, more opaque mandibles, broader front, and by a narrower and more elongate antennal club. Whenever there is doubt as to the sex of an individual it can be settled by examining the pygal segments for the characters shown in figures 23 and 24.

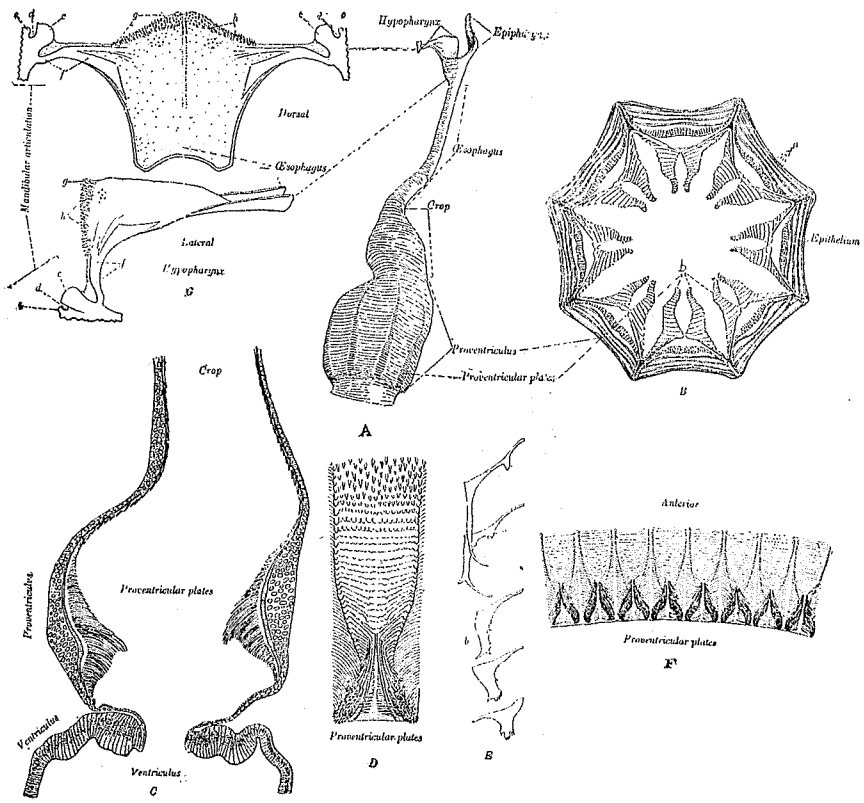

FIG. 36.—*Dendroctonus valens:* Fore intestine, showing details. *A*, Fore intestine; *B*, transverse section of proventriculus; *C*, longitudinal section of same; *D*, single plate; *E*, teeth; *F*, plates; *G*, hypopharynx; *a*, muscles; *b*, proventricular teeth; *c*, posterior condyle of mandibular articulation; *d*, median fossa of same; *e*, anterior condyle of same; *f*, hypopharyngeal bracon; *g*, anterior margin; *h*, hypopharyngeal papilli. (Original.)

PUPA.

The general structure, proportions, and anatomical details of the *Dendroctonus* pupa are shown in figures 37 and 38.

Among the distinctive generic characters are the large prominent head and broad pronotum, while among the divisional and specific characters are the sculpture, armatures, etc., of the head, pronotum, elytra, and abdominal segments, as shown in the figures and defined in the synoptic tables and descriptions.

Head.—The elements of the adult head recognizable in the young pupa are the antennæ, mandibles, maxillæ, labium, and what appears to be a well-developed labrum, which extends to the middle of the mandibles. Evidently, however, this does not represent the labrum or even the clypeus, but is a pad to accommodate the development of

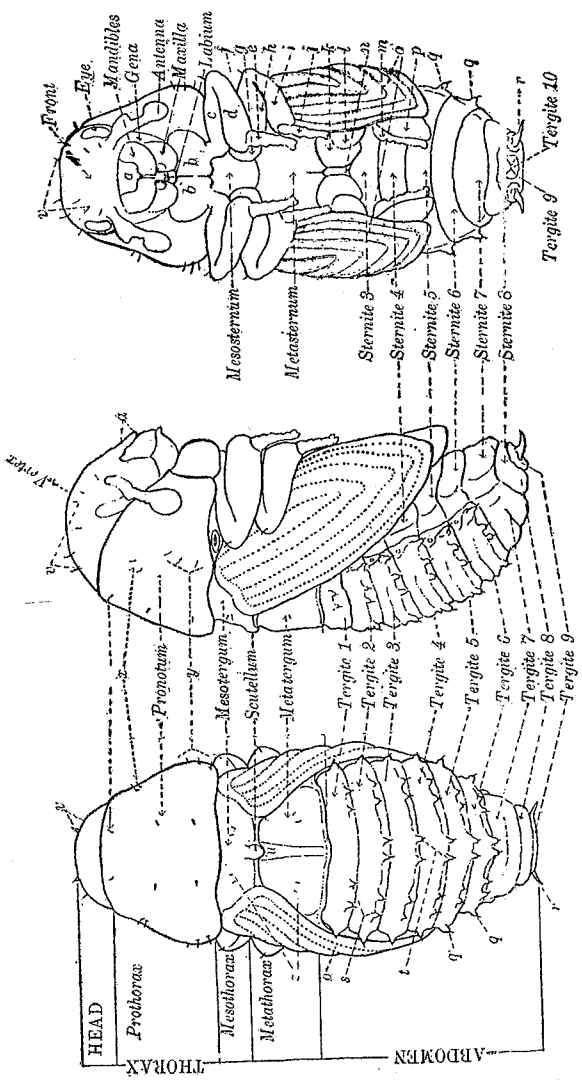

FIG. 37.—*Dendroctonus valens:* Pupa. *a*, Epistomal bristle-pad or pseudo-labrum. Anterior leg: *b*, Coxæ; *c*, femur; *d*, tibia; *e*, tarsus; *f*, apical spines of femur. Middle leg: *g*, Coxa; *h*, femur; *i*, tibia; *j*, tarsus. Posterior leg: *k*, Coxa; *l*, femur; *m*, tarsus. *n*, Sternellar or intercoxal area; *o*, elytral pad; *p*, wing-pad; *q*, pleural spines; *r*, caudal spine or 9th pleural; *s*, lateral spines; *t*, dorsal spines; *u*, scutellar groove; *v*, frontal spines; *w*, dorsal spines of pronotum; *x*, lateral spines of pronotum; *y*, pleural spines of pronotum; *z*, mesotergal and metatergal spines. (Original.)

the long epistomal bristles. The frontal spines in examples representing different divisions and species are variable in size and position and are of considerable taxonomic importance. The antennæ do not extend to the base of the pronotum or scarcely beyond the mouth parts, and the club does not extend beyond the lateral margins of the pronotum.

Prothorax.—The form of the pronotum corresponds to that of the adult and its relative proportions are of some value in distinguishing the species. The number and position of the frontal spines are fairly constant in a species, although they vary in prominence with

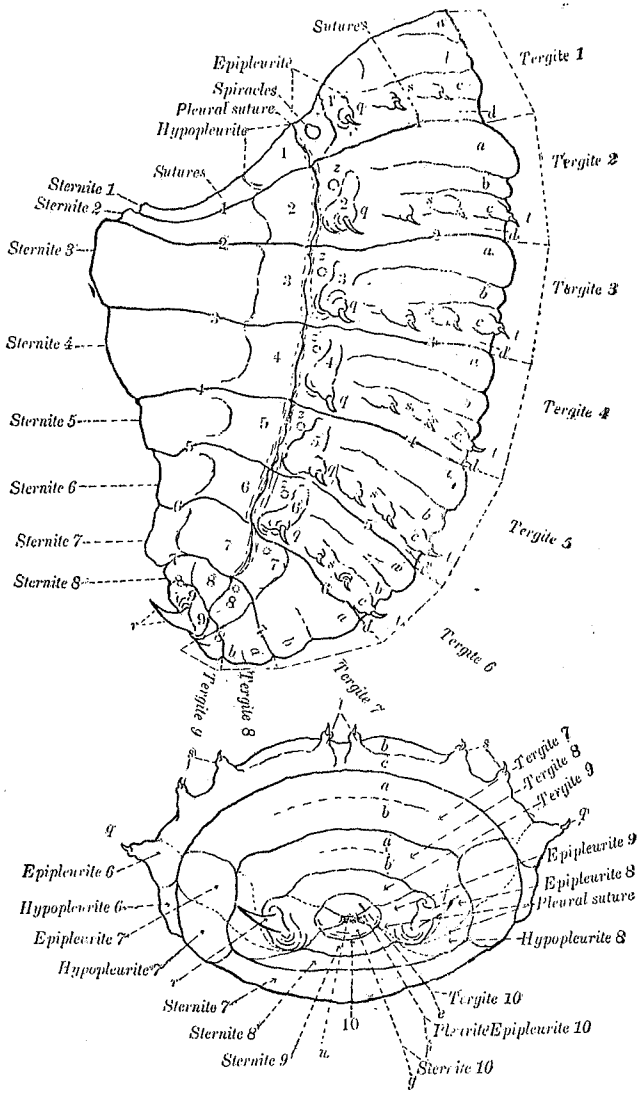

FIG. 38.—*Dendroctonus valens:* Abdomen of pupa, lateral and anal aspects. *a*, Presental lobe; *b*, scutal lobe; *c*, scutellar lobe; *d*, postscutellar area; *e*, supraanal lobe; *f*, paraanal lobe; *g*, infraanal lobe; *q*, pleural spines; *r*, caudal spine or epipleural spine of the 9th segment; *s*, lateral spines; *t*, dorsal spines; *u*, anal opening; *10*, tenth segment. (Original.)

the age of the individual, as do other spines of the body, being much less prominent in the older or preimaginal stage.

Mesothorax.—The mesotergum is subrectangular and without special characters, except, perhaps, in the number and arrangement

of the spines. The median process of the scutellum is prominent and the posterior or scutellar ridge is distinct. The base of the elytra is oblique and elevated, and its integument continuous with that of the tergum and scutellar ridge. The sternum is situated between the mesocoxæ and the trochantins of the prothoracic leg.

Metathorax.—The metatergum is prominent and has the usual dorsal or scutellar groove. The transverse posterior or scutellar ridge is distinct and joined at its ends with the basal angle of the wing pads. Each of the scutal lobes bears a pair of spines. It differs from the metatergum of the adult mainly in the absence of the prescutum and postscutellum, as defined by external elements.

Abdominal tergites (fig. 38).—There are nine tergites visible dorsally and a very small tenth visible ventrally. Tergites 3 to 6 are armed more or less distinctly with dorsal, lateral, and pleural spines. The dorsal spines are located each side of a narrow dorsal groove; the pleural spines on the epipleura posterior to the spiracles, and the lateral spines are situated between the dorsal and pleural. The size of the pleural spines and the size and number of the dorsal and lateral ones are quite variable and of considerable importance in defining the minor divisions. Tergites 7 and 8 are usually unarmed, but, as in the adults, show sexual differences in their relative prominence; 9 has the median lobe short, but the pleurites are greatly enlarged and each is armed with a prominent caudal spine.

The four transverse divisions of the segments are quite clearly indicated in tergites 1 to 6. Tergites 7 and 8 show two divisions, the first representing prescutal and the second the scutal and scutellar combined, while tergites 9 and 10 are undivided. It is interesting to note that the dorsal and pleural armatures are borne by what is evidently the scutellar division, and that the spiracles are in the prescutal division, thus indicating that the prescutal represents the first primary division and the combined scutal, scutellar, and postscutellar represent the second primary division.

Abdominal sternites.—There are eight exposed abdominal sternites. These are sternites 3 to 10, 1 and 2 being concealed beneath the metacoxæ, as shown in figure 38.

Abdominal pleurites.—Epipleurites and hypopleurites 1 to 8 are clearly defined in the removed abdomen (fig. 38), but in 9 and 10 only the epipleurites are represented, as indicated by the pleural suture. The pleural suture is distinct to the ninth segment, where it joins the lines marking the dorsal and ventral limits of the pleural division.

Spiracles.—There are nine spiracles in each side of the body, one large mesothoracic spiracle situated between the posterior lateral margin of the prothorax and the anterior ventral angle of the elytral pad, and eight abdominal ones, each in its respective epipleurite.

The metathoracic spiracle is not represented. Spiracles 3 to 8 are exposed when the elytral pad is in normal position, but spiracles 7 and 8 are very small and obscure. Thus the pupa has the same number of spiracles as the larva, while in the adult there is an additional one, although that of the eighth abdominal tergite is apparently rudimentary. The larva has one thoracic spiracle, apparently in the prothoracic segment. The pupa has one in the mesothoracic, and the adult has one in the mesothorax and one in the metathorax.

Legs.—The front and middle legs are exposed, while the hind legs are partially concealed beneath the elytra and wing pads. The front coxæ are large and contiguous, the anterior fourth covered by the maxillæ and labium, and the posterior margin extends over the anterior margin of the mesosternum. The middle coxæ are partially hidden by the apex of the front tibia and its tarsus. The hind coxæ are for the most part exposed, and distinctly separated by an intercoxal area. The positions of the different parts of the legs in their relation to the exposed structures are shown in figure 37, and are of considerable taxonomic importance. The apical and subapical spines of the femora are also of considerable importance as distinctive characters.

LARVA.

The structure and general characters of the larva are shown in figure 39. It is of the subcylindrical, wrinkled, legless type common to all of the true Rhynchophora, and also has the form of mouth parts characteristic of the larvæ of this suborder. There are three thoracic and ten abdominal segments, the tenth being represented by the anal lobes. The four longitudinal divisions, viz, one sternal, two pleural, and one tergal, are clearly represented in all of the segments. The tergal division occupies nearly one-half of the circumference, the two pleural divisions together about one-fourth, and the sternal division slightly more than one-fourth. The head is much narrower than the first thoracic segment and but slightly longer. The three thoracic segments together, or the thorax, is about one-third as long as the abdomen. With the exceptions of the scattering hairs on the head and on the scutellar lobes of the thoracic and abdominal segments, the body is without distinguishing vestiture.

EXTERNAL CHARACTERS.

Head (figs. 40, 41).—The head is by far the most important part of the body as a bearer of taxonomic characters in the larva. The general structure is shown in figure 40, and the anatomical details in figures 41 and 42. All of the primary elements of the adult head are represented, but they are much more simple in their structural details. The more striking differences in the larval head are found in the

presence of clearly defined front, clypeus, and laorum, in the articulation of the mandibles, and in their rudimentary hypostoma.

Labrum (figs. 40, 41).—The labrum is prominent, the dorsal area twice as broad as long, about one-third narrower than the clypeus, but nearly as long, with the apical margin broadly rounded, truncate

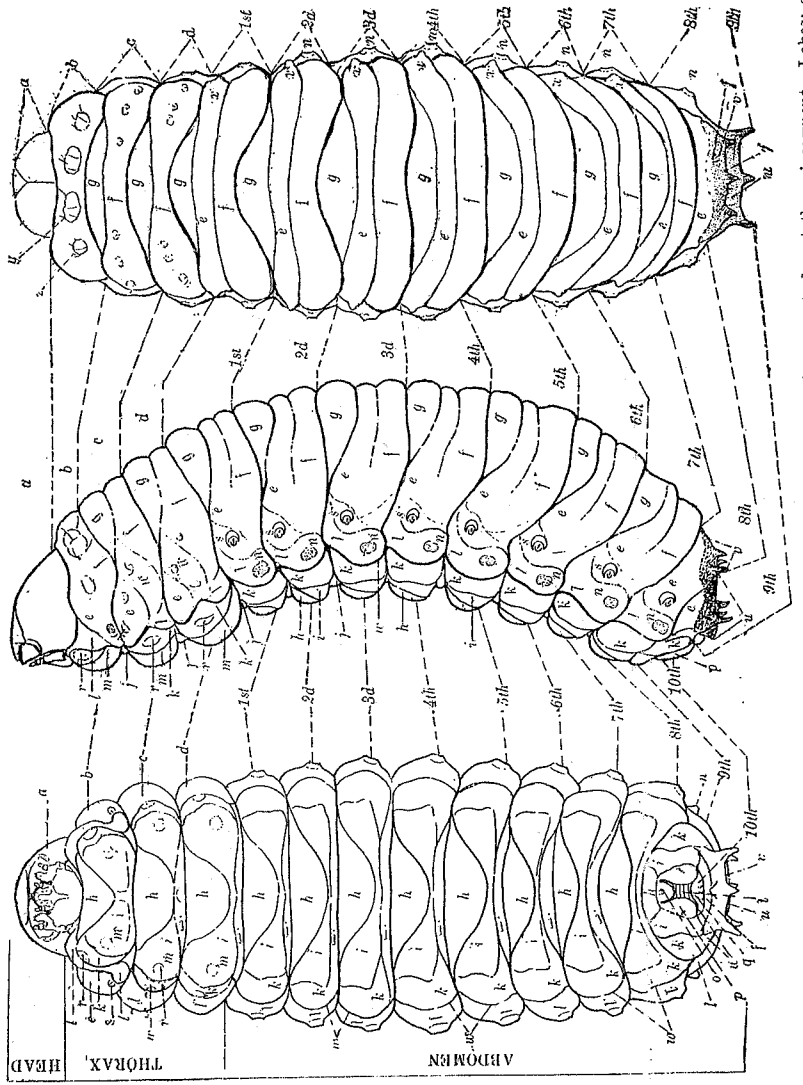

FIG. 39.—*Dendroctonus valens:* Larva. *a*, Head; *b*, prothoracic segment; *c*, mesothoracic segment; *d*, metathoracic segment. Lobes: *e*, Scutal; *f*, scutellar; *g*, prescutal; *h*, sternal; *i*, sternellar; *j*, poststernellar; *k*, hypopleural; *l*, epipleural. *m*, *m*, Foot calli; *n*, *n*, epipleural calli and tubercles; *o*, infraanal lobe or sternite of the 10th segment; *p*, paranal lobe or 10th pleurite; *q*, supraanal lobe or 10tL tergal lobe; *r*, hypopleural callus; *s*, spiracle; *t*, anal opening; *u*, dorsal plate of 9th segment with scutellar spines; *v*, dorsal plate of 8th segment with scutellar spines; *w*, pleural suture; *x*, spiracular tubercles; *y*, prothoracic dorsal plate (scutellar?); *z*, prothoracic lateral plate (scutellar?). (Original.) (See also Pl. VIII.)

or faintly emarginate, and with several apical papillæ. The median dorsal area bears several long hairs and two slightly elevated dark spots where the epipharyngeal bracons are attached. The latter somewhat resemble the mandibular hooks of dipterous larvæ, and may or may not represent paired elements of the head of a primitive arthropod.

Whatever their origin may have been, the present function is to support the epipharynx and also serve as chitinous attachments for the depressor muscles of the labrum. They are covered by the epipharynx and extend down and back to the œsophagus and to a point beneath the base of the clypeal area.

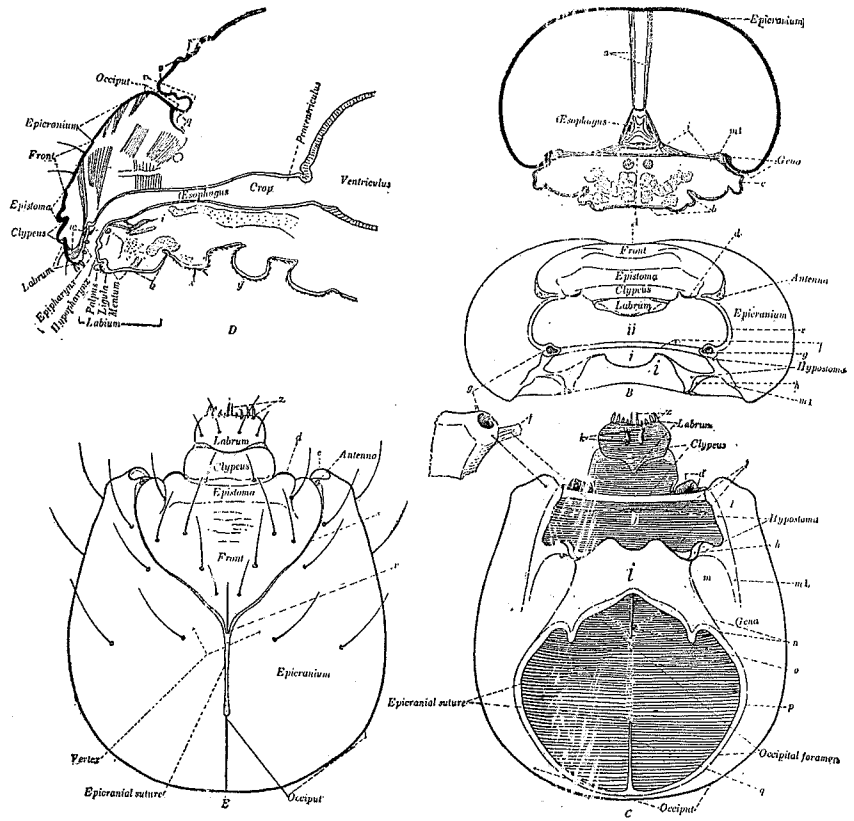

FIG. 40.—*Dendroctonus valens:* Head of larva. *A*, Transverse section; *B*, oral aspect; *C*, ventral aspect; *D*, longitudinal section; *E*, dorsal aspect; *a*, muscles; *b*, submental lobe; *c*, maxilla; *d*, condyle of dorsal articulation of mandible; *e*, pleurostoma; *f*, hypopharyngeal bracon; *g*, fossa of ventral articulation of mandible; *h*, maxillary condyle; *i*, gular plate; *j*, maxillary foramen; *jj*, oral foramen; *k*, attachment of epipharyngeal bracons (labral hooks); *l*, pregenal area; *m*, gular area; *m1*, gular apodeme; *n*, attachment of labial muscle; *o*, frontal apodeme; *p*, integumental attachment; *q*, occipital apodeme; *r*, frontal apex; *s*, frontal suture; *t*, prescutal lobe of mesothoracic segment; *u*, scutellar lobe of prothoracic segment; *v*, prescutal lobe; *w*, hypopharyngeal bracon; *x*, sternal section of prothoracic segment; *y*, sternellar section of mesothoracic segment, both distorted; *z*, apical papilli. (Original.)

Clypeus.—The so-called clypeus evidently does not represent an entirely distinct element, but a produced dilated preepistomal area or extension of the epistoma proper. In *Dendroctonus* larvæ it is twice as broad as long and narrowed toward the apical margin, which is usually slightly emarginate. The basal connection with the epistoma is continuous and rigid, and bears two widely separated bristles near the base. The sides are rounded to a rather acute impressed basal angle at the mandibular condyle.

Epistoma.—The epistoma is quite clearly defined as a thickened transverse area between the clypeus and the frontal area. It does not extend laterally to the frontal sutures, but the ends, where they join the pleural ridge or pleurostoma, bear the condyles for the dorsal articulation of the mandibles. As in the adults, this area is quite variable within the genus. It is elevated to flat, with the anterior margin ranging from curved to nearly straight and the lateral angles elevated or slightly produced so as to form the rigid support for the dorsal condyles.

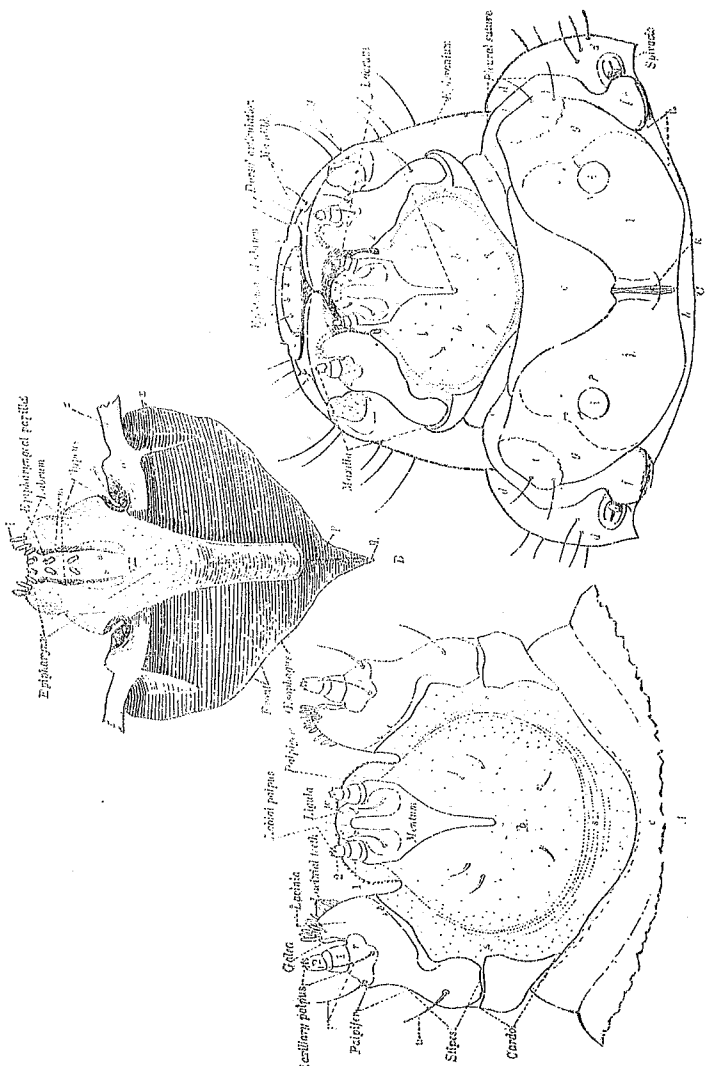

FIG. 41.—*Dendroctonus valens*: Mouthparts of larva. *A*, Ventral aspect of labium and maxillæ; *B*, ventral aspect of frontal plate. labrum, etc.; *C*, ventral aspect of head and prothoracic segment; *a*, pleurostomal membrane; *b*, submental lobe; *c*, presternal lobe; *d*, presental lobe; *e*, sternal lobe; *f*, epipleural lobe; *g*, hypopleural lobe; *h*, poststernellar lobe; *i*, foot calli; *j*, sternellar lobe; *k*, sternellar plate; *l*, apical papillæ of labrum; *m*, epipharyngeal braeons or labial hooks; *n*, condyle of dorsal articulation for mandible; *o*, epistomal apodeme; *p*, frontal apodeme; *q*, apex; *r*, vaginant membrane between palpus and palpifer; *s*, lateral area of submental lobe; *t*, hypopleural callus; *u*, stipal bristles; *v*, palpifer bristles; *w*, ligular papilli; *x*, apodeme between lateral angle of epistoma and dorsal angle of pleurostoma; *y*, pleurostoma; *z*, apodeme of pleurostoma. (Original.)

Hypostoma.—The hypostoma is not represented by an exposed piece, but by the apodeme which forms the thickened lateral and sub-

lateral margins of the maxillary foramen. The anterior end supports the fossa (*g*) of the ventral articulation for the mandible, and the ventral end supports the condyle for the articulation of the maxillary cardo. It is connected across the gular space by the entogular plate.

Pleurostoma (fig. 40, *e*).—The pleurostoma is represented by the thickened lateral margin of the oral foramen. The dorsal end contributes to the rigid support of the dorsal articulation for the mandible and the ventral end to that of the ventral articulation.

Front.—The front is situated posterior to the epistoma and between two oblique sutures which converge from the anterior angles to the epicranial suture. The median area is quite variable within the genus. It may be flat and smooth to elevated. In the latter case it may be small, smooth, and convex, or prominent, transverse, and rugose.

Epicranium.—The epicranium is represented by the dorsal areas of the two large lobes each side of the distinct epicranial suture and frontal area. These lobes are continuous throughout the occipital and genal areas and accommodate the very large retractor muscles of the mandible. The genal areas are connected by the broad entogular plate.

Occipital foramen.—The occipital foramen is situated in the posterior ventral section of the head and occupies about one-half of the ventral area. It is bounded posteriorly and laterally by a broad entoccipital rim and anteriorly by a subchitinous rim. The occipital apodeme arises from the posterior margin, and extends anteriorly immediately beneath the epicranial suture.

Entogular plate (fig. 40, *i*).—The entogular plate is the subchitinous plate which forms the entocranial connection between the genal areas and anteriorly between the lateral sections of the hypostoma. It is covered by the submental lobe, part of the muscles of which are attached to the posterior angles and posterior margin.

Maxillæ (fig. 41).—The maxillæ are quite simple in structural details. The cardo is present and distinct. Its basal articulation and attachment are by ligaments and a fossa to a condyle supported by the hypostomal apodeme. Its anterior attachment to the stipes is by articulating membrane. The median section is not divided into stipes, subgalea, and palpifer, but is one continuous piece with the anterior inner angle produced into a lacinial lobe which is armed with a number of papillæ situated on a membranous integument. The palpus is 2-jointed and telescopic as usual. The relative proportions, sculpture, and vestiture are shown in the figure.

Labium.—The labium of the larva is very different in structure from that of the adult. The submentum is represented by a lobe which is very broad and differs but slightly from the sternal lobe of the prothoracic segment with which its posterior integument is directly connected. The lateral integument is continuous with that

of the maxilla and the anterior angles are extended forward to the base of the palpi. The mentum is represented by the median triangular chitinous plate, the posterior section of which is produced and narrowed, and the anterior median section is produced anteriorly between the palpi and supports the ligula. The short, conical, 2-jointed palpi are situated on the anterior angles of the mentum and are scarcely longer than the simple lobelike ligula which bears a few simple papillæ.

Hypopharynx and epipharynx.—The position and character of these important elements of the oral opening are shown in figures 40, *D*, and 41, *B*.

Mandibles (fig. 42).—The mandibles are stout, with the laterodorsal surface rugose, except toward the apex, which is produced into an apical tooth; the inner edge toward the apex is provided with a subapical tooth and two small irregular medial teeth. The condyle of the ventral angle is globular and fits into the concave fossa (fig. 40, *g*) of the hypostoma, while in the dorsal articulation the fossa is borne by the mandible and the condyle by the epistoma (fig. 40, *d*). The small extensor muscle is attached to the outer basal margin midway between the condyles, while the large and powerful retractor muscle is attached to the margin of the more produced inner angle, thus giving a direct lateral motion to the mandibles.

Tergites (fig. 39).—The dorsal area of the tergum of the prothoracic segment is undivided, but evidently represents the scutum (*e*) and scutellum (*f*). The dorsal area of the mesothoracic and metathoracic segments has two divisions. The anterior division evidently represents the prescutal lobe (*g*). There is evidence of a scutal lobe (*e*) on the lateral area of both segments, as indicated in the abdominal tergites, where the scutal lobe appears between the anterior and the posterior lobe. Thus the latter evidently represents the scutellar division, or scutellar lobe (*f*).

Sternites.—The sternum of each of the segments has three sections, anterior, median, and posterior, or sternal (*h*), sternellar (*i*), and poststernellar (*j*). In the thoracic segments the sternal is the larger and projects posteriorly over the middle of the sternellar lobe, which is represented by a coxal lobe each side of the sternal section. In some of the species these lobes have a median chitinous spot or foot callus at the point where a foot occurs in the legged larvæ of other Coleoptera. The abdominal sternites have the same number of sections, but the sternellar section is not covered by the sternal.

Pleurites.—The pleurum of each segment is divided longitudinally by an irregular pleural groove or suture (*w*). The lobe immediately below the groove at the end of the sternites may be referred to as the hypopleural (*k*) and that immediately above it as the epipleural (*l*). The hypopleura of the thoracic segments represent the episternum,

and the epimerum is obscurely represented by the epipleura, both of which are but little, if at all, different from those of the abdomen. The epipleural lobe of the prothoracic segment has a spiracle, while those of the mesothoracic and metathoracic segments are without a spiracle, but has lateral lobes or areas for the embryonic wing.

Spiracles.—It will be noted in figure 39 and Plate VIII that the prothoracic segment has a spiracle situated on the epipleurite near

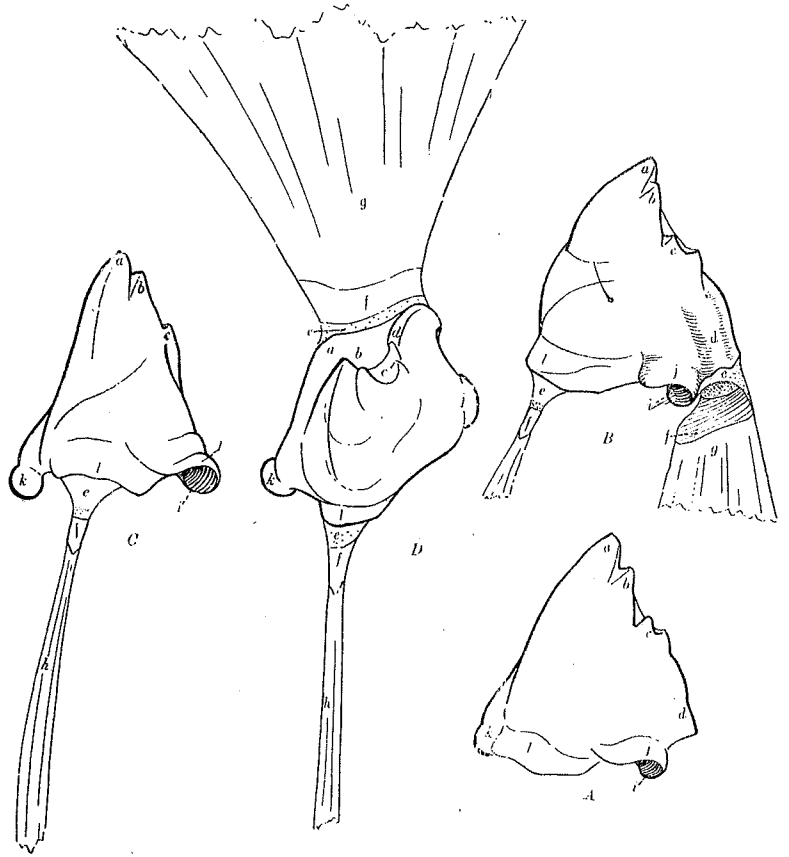

FIG. 42.—*Dendroctonus valens:* Mandibles of larva. *A*, Latero-dorsal aspect; *B*, dorsal aspect; *C*, lateral aspect; *D*, apical aspect; *a*, apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar tooth; *e*, extensor tendon; *f*, retractor muscle disk; *g*, retractor muscle; *h*, extensor muscle; *i*, dorsal fossa; *j*, dorsal condyle; *k*, ventral condyle; *l*, basal ridge. (Original.)

the epipleurite of the mesothoracic segment. The writer is not certain as to whether or not this really belongs to the prothoracic segment or, as in the abdomen, to the anterior or prescutal division of the mesothoracic segment. The metathoracic segment is plainly without spiracles, but the abdominal segments 1 to 8, inclusive, have spiracles which are more or less distinct, being rather obscure in the first division and in section a3 (see Pl. I) and without lateral tubercles, while in section a4 and subdivision D both the spiracles and

spiracular tubercles (Plate VIII) are distinct. The ninth segment is without spiracles.

Chitinous plates.—In some species (division I) there are no distinct chitinous plates or tubercles, while in others, section a4 and subdivision D, they are present and, excepting *Dendroctonus micans*, become more distinct toward and including subdivision D, in which the dorsal plates of the eighth and ninth abdominal segments are distinctly armed.

DIGESTIVE SYSTEM.

The peculiar characters of the digestive system of the larva are illustrated in figure 43, showing, at right, a median longitudinal section through the body from the oral to the anal opening. In every respect the anatomical details of the digestive system are much more simple in the larva than in the adult. The same primary divisions of fore, middle, and hind intestine are represented and there is the same number of malpighian tubes, but the fore intestine is very simple as compared with that of the adult, the crop and proventriculus being scarcely different in general details from the œsophagus.

EGGS.

The eggs of *Deudroctonus* have not been studied in detail, but they are short, oval to oblong-oval, pearly white and shining, and apparently without distinctive generic or specific characters.

PHYSIOLOGICAL CHARACTERISTICS.

In addition to the morphological characters which serve to distinguish the genus, there are certain physiological characteristics peculiar to the species of the genus which serve as additional evidence of distinction. Indeed, it becomes more and more evident that a correct interpretation of natural groups of individuals, termed species, and natural groups of species, termed genera, must be based not alone on a common plan of structure or similarity in one or more anatomical elements, but that, in order to come nearer the truth, the morphologic evidence of specific distinction must be supplemented by physiologic and bionomic evidence. Some of the physiological features common to the species of this genus, and more or less peculiar to them, are found in the character of their brood galleries, in their habit of attacking living trees, in their concentration of effort to overcome the resistance exerted by the tree attacked, and specially by their ability to manipulate and to dispose of the quantities of resin which flow into their burrows in the living bast and cambium; lastly, in their intimate bionomic relations to definite genera and species of conifers.[a]

[a] See, also, physiological characteristics of the species, as given in the forthcoming Bulletin No. 83, Part I, which deals with the bionomic and economic features, and other characteristics peculiar to the major and minor divisions as defined in the synoptic tables of galleries, host trees, and distribution in the present paper (pp. 76–79).

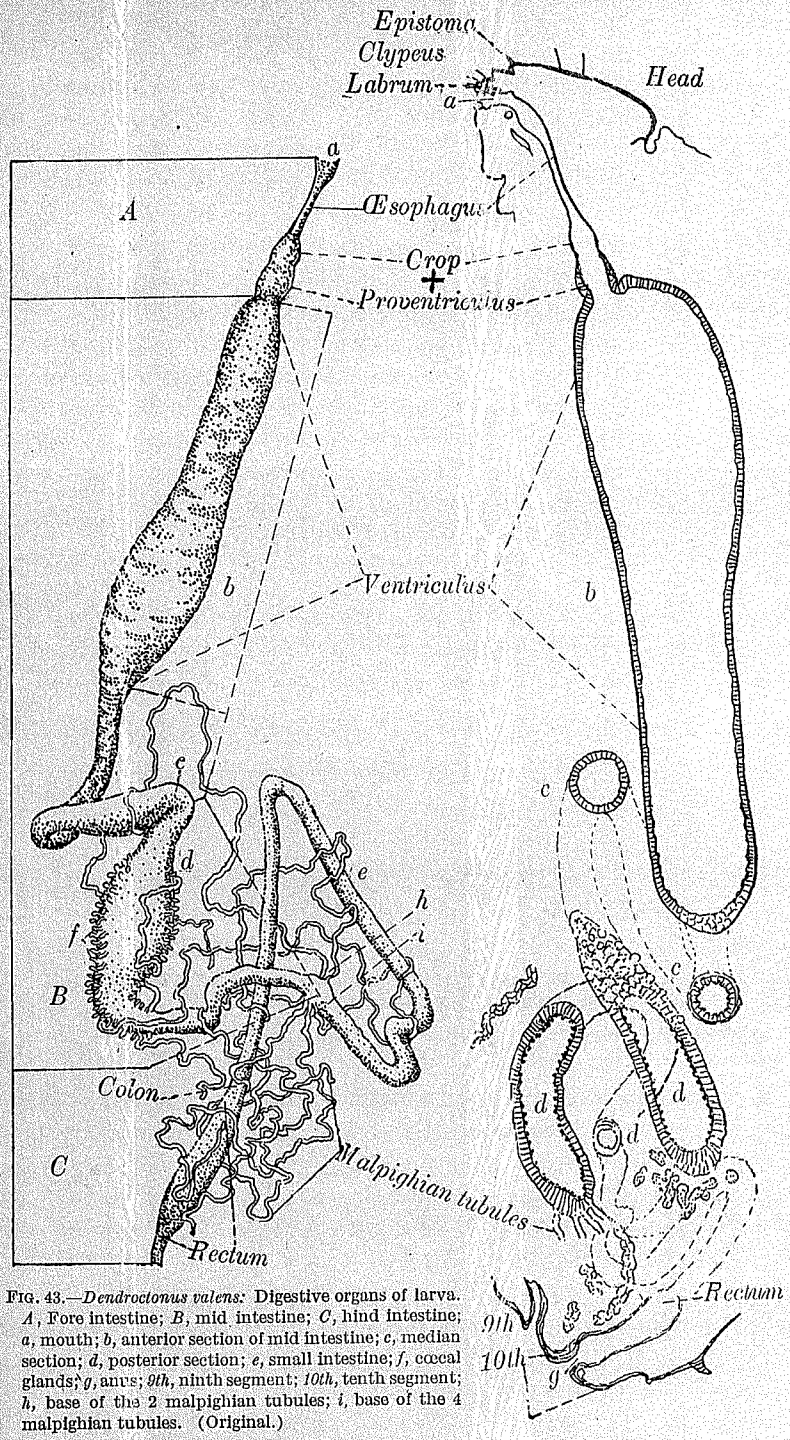

FIG. 43.—*Dendroctonus valens:* Digestive organs of larva. *A*, Fore intestine; *B*, mid intestine; *C*, hind intestine; *a*, mouth; *b*, anterior section of mid intestine; *c*, median section; *d*, posterior section; *e*, small intestine; *f*, cœcal glands; *g*, anus; *9th*, ninth segment; *10th*, tenth segment; *h*, base of the 2 malpighian tubules; *i*, base of the 4 malpighian tubules. (Original.)

SPECIFIC DISTINCTIONS.

In the literature on Scolytidæ, and, for that matter, on almost any group of insects of special systematic and economic importance, there is much confusion, due to different interpretations of specific distinction. Some authors have combined many described species into one, while others have recognized many distinct forms among those heretofore included in one species, and have proposed as many different names for them. It is evident that whenever "lumping" or "splitting" is necessary for the clear definition and recognition of a species it should be done, but it is equally evident that neither should be attempted without an adequate knowledge of at least the genus represented, in order that the true characters of specific distinction may be recognized from those which serve to distinguish the genus or the major and minor divisions of higher rank than the species.

RANGE OR LIMITS OF SPECIFIC VARIATION.

The determination of the range or limits of variation in characters utilized for the distinction of a species is one of the most troublesome questions with which the systematist has to deal. With one or a few specimens the line separating one recognized species from another may be distinct and definite, but as the number of specimens from different localities increases the line of distinction from allied forms often becomes less and less distinct until it is almost or quite obscure. Here is where expert judgment, based on experience and a technical knowledge of the special group involved, is required in order to decide whether or not two heretofore recognized and closely allied species should be kept separate or be combined. The recognition of prevailing variants or constants, or of forms having abnormal or normal morphologic and physiologic characters, is of special importance in this connection, as is also the recognition of the disturbing factor of parallel modification in characters and habits among species of the same genus, as well as among those of different genera.

If the variants connecting two allied groups comprise only a small percentage of the individuals, they may be considered as departures from the constants of the species more nearly represented, and thus the groups so slightly connected will serve the purposes and requirements of species and neither of them should, in the writer's opinion, be designated as a named subspecies, race, or variety; but if, on the other hand, the connecting variants comprise a large percentage of individuals, and no other characters sufficiently distinct and constant can be found by which individuals may be readily referred to one or the other of the heretofore recognized species, it would indicate that the two are not specifically distinct.

PROGRESSIVE MODIFICATIONS.

The writer has been forcibly impressed with the prevailing principle of progressive modification in relative proportions in form and structural details in scolytid and other beetles. Whenever these modifications in relative proportions are available for the statistical method of analysis it is often possible to express in numbers the difference between species and to indicate clearly the lines of modification and rates of departure among the species of a genus or larger group.

There are some good examples of this principle of progressive modification in the genus *Dendroctonus*, which is manifested not alone in the adults, but in the pupæ, larvæ, and character of work, and it is most interesting and significant to note that the modifications are in the same general direction in all cases. When the species are arranged in the order indicated by these modifications and other characters, the species of the first division to the last of those of the second division are found to be modified from small to larger size, the extremes being represented by *D. frontalis*, with the minimum length of 2.5 mm., to *D. valens*, with the maximum length of 9 mm. Naturally we find the same rate of difference in size of the immature stages and galleries. This same tendency toward increased size is manifested within each subdivision, section, or minor group of allied forms and appears to be a prevailing principle throughout the Scolytidæ, and thus serves, in connection with other lines of modification, as one of the first guides to a natural arrangement or classification of the species. In *Dendroctonus* the progressive modification of characters other than size is shown or indicated as follows:

PROGRESSIVE MODIFICATION OF CHARACTERS IN THE GENUS DENDROCTONUS.

ADULTS.

Primary characters.

Body slender to stouter.
Head large to smaller.
Prothorax long to shorter.
Pronotum with sides nearly parallel to distinctly narrowed or constricted anteriorly.
Pronotum as broad as elytra to narrower.
(A mean composite ratio of the above gives a number which expresses the relative proportions and serves as a species index.)
Front grooved and tuberculate to convex and smooth.
Elytra without long hairs to long hairs over entire surface.
Tibia from slender to broader with a tendency to dilate toward the apex.
Funiculus of antenna with second joint long to shorter.

Secondary sexual characters.

Front of head with sexual differences to similar or alike in both sexes.
Pronotum with sexual differences to alike in both sexes.
Elytral declivity without sexual differences to distinct differences.
Declivity rugosities small to coarse, smooth in female to coarse in male or reversed.
Mandibles alike or similar in both sexes, to much stouter in the male.

PUPÆ.

Front of head grooved to convex.
Body spines small to coarse.

LARVÆ.

Body simple, without chitinous plates or hairs, to distinct chitinous plates and more prominent hairs.
Eighth and ninth abdominal segments without chitinous plates to with plates, these last unarmed to armed.
Spiracles simple to complex, smooth to tuberculate.
Epipleurites without tubercle, to prominent tubercle.

GALLERIES.

Long and winding to short and straight.
Eggs isolated to grouped and massed.
Larval mines hidden to exposed and short to long.

HOSTS.

From one genus to many genera, and from one species to many species.
D. brevicomis is found in pine only, while *D. valens* infests *Pinus*, *Picea*, and *Larix*; *D. simplex* infests *Larix* only, and *D. pseudotsugæ* infests *Pseudotsuga* and *Larix*.

DISTINCTION OF MAJOR AND MINOR DIVISIONS OF THE GENUS.

In a comparative study of the species of the genus to determine their relative positions, as indicated by degrees of resemblance or difference, they are found to fall according to progressive modification of characters into major and minor divisions, which may be designated as divisions, subdivisions, sections, subsections, series, and subseries, to the smallest practicable minor division of the genus, viz, the species.

In this classification of the genus the rank of a primary division may be that of the subgenus of some authors and the lower series of closely allied species may be recognized by some systematists as occupying the rank of subspecies, races, or varieties; but the writer has been guided by the belief that the principle of a *less restricted range of generic and more restricted range of specific distinction* will contribute toward a more correct knowledge of the forms of life than if the reverse principle is followed.

The classification of the species of a genus into major and minor divisions is necessarily arbitrary, and is subject to changes as may be suggested by increased knowledge and the addition of species. To a more limited extent, the designation of a species is arbitrary and with additional material and information is subject to revision; but since the species, next to the individual, is the constant or unit of classification and investigation, it should represent *the lowest practical division of a genus* that is recognizable from a description of a typical form or by comparison with the type on which the description was based.

PLAN OF SYNOPTIC TREATMENT.

The plan here applied for the classification and synoptic treatment of the species of the genus is one which appears to be most available and practicable for the clear definition of the progressive modification of taxonomic characters and for indicating the relative systematic positions and limits of the major and minor divisions and the species. It is not radically different from some of the more generally adopted dichotomous systems, and it conforms to the primary objects of a synopsis in that it provides (*a*) for a direct comparison of opposing characters, (*b*) for a direct line of references leading down to the specific characters, or vice versa.

With this method of indicating the supposed natural relation of the species, the described characters of the major and minor divisions and sections, together with those of specific distinction, serve as a description of the species. Thus, division I, subdivision A, section a2, subsection b2, series c2, defines the characters common to species 6, 7, and 8, which are separated by their respective specific characters. Some additional advantages of this method are the consecutive arrangement of letters and figures which throughout a given table are not duplicated. The Roman numerals indicate at once the primary divisions, the capital letters the subdivisions, and the combined small letter and Arabic numeral the sections, subsections, series, etc., to any desired limit. The reference from right margin to center, instead of to left margin, is also an advantage in defining the limits of a major and minor division. It also provides for full paragraphs, thus economizing space and cost of printing.

SYNOPSES OF MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS.

SYNOPSIS OF ADULT CHARACTERS.

Pronotum somewhat *elongate* and as broad as elytra; not distinctly narrowed anteriorly except in subdivision B; anterior dorsal half of elytra without long hairs. Division I, pages 69, 81.

Pronotum *stout;* usually narrower than elytra, and distinctly narrowed and constricted anteriorly; anterior dorsal half of elytra normally with long hairs, except in *terebrans*..... Division II, pages 71, 116.

DIVISION I.

Body somewhat *slender*, pronotum but slightly narrowed anteriorly; elytral declivity with second stria straight, second interspace not distinctly broader or narrowed toward apex; head with frontal groove and tubercles except in *convexifrons*. Subdivision A, pages 69, 81.

Body *stout;* pronotum distinctly narrowed and constricted anteriorly; elytral declivity with second stria curved, second interspace broad and distinctly narrowed toward apex; head without frontal tubercles or groove. Subdivision B, pages 71, 105.

SUBDIVISION A.

Elytral declivity *without* long hairs..... Section a1, page 70.
Elytral declivity *with* long hairs..... Section a2, page 70.

Section a1.

Length 3 to 5 mm., brownish to nearly black; elytral rugosities fine, densely placed, the striæ obscure and but slightly or not at all impressed. California, Oregon, Washington, and Idaho, in *Pinus*..... 1. *brevicomis* Lec., page 81.

Length 2.5 to 4.7 mm., brownish to black; elytral striæ moderately to distinctly impressed; interspacial rugosities moderately coarse and obtuse to coarse and acute. Arizona, New Mexico, southern Colorado, southern Utah, and southern California. 2. *barberi* n. sp., page 85.

Section a2.

Head *without* frontal tubercles or groove, but with posterior impression. Subsection b1, page 70.

Head *with* more or less prominent frontal tubercles each side of a distinct median groove..... Subsection b2, page 70.

Subsection b1.

Length 4 to 6 mm.; reddish-brown to black, shining; body slender; elytral rugosities moderately coarse but not densely placed, except toward base, the striæ faintly impressed, with rather coarse indistinct punctures; pronotum with long, erect hairs on the entire lateral area; declivity shining. Arizona, New Mexico, southern Colorado, and southern Utah, in *Pinus*..... 3. *convexifrons* n. sp., page 87.

Subsection b2.

Elytral striæ *distinctly* punctured..... Series c1, page 70.

Elytral striæ *not distinctly* punctured..... Series c2, page 70.

Series c1.

Length 2.5 to 4 mm.; brownish to black; elytral rugosities obtuse, moderately coarse, not very densely placed, and but moderately coarser toward the base and vertex than elsewhere; pronotum usually with a few long hairs on the anterior section of the lateral area. Pennsylvania to Florida, westward to Ohio and Texas, in *Pinus* and *Picea*..... 4. *frontalis* Zimm., page 90.

Length 4 to 5 mm.; brownish to black; elytral rugosities subacute, moderately coarse and distinctly coarser toward the base and vertex; pronotum with long erect hairs on the anterior half of the lateral areas; elytra with long hairs confined to declivity and posterior areas. Central Arizona, in *Pinus*.... 5. *arizonicus* n. sp., page 95.

Series c2.

Striæ *distinctly* impressed.

Length 3 to 4.5 mm.; brownish to black; elytral rugosities distinctly coarser toward the base and vertex, and with an evident row of acute rugosities on the first interspace; pronotum clothed with stout reclining hairs and the entire lateral area with long, erect hairs; elytral striæ moderately distinct. Southern Mexico, in *Pinus*..... 6. *mexicanus* Hopk., page 97.

Striæ *not distinctly* impressed.

Length 5 to 6 mm.; black; elytral rugosities obtuse, rather densely placed, moderately coarse toward dorsal suture, fine and less evident toward side; striæ obscure, especially on the side; pronotum distinctly pubescent, with very long erect hairs on the entire lateral area; punctures moderately coarse. Southern Mexico, in *Pinus*..... 7. *parallelocollis* Chap., page 99.

Length 4 to 7.4 mm.; black; elytral rugosities rather coarse and sparse; the striæ toward the side rather distinct; pronotum moderately pubescent, with long hairs on the anterior two-thirds of the lateral area; punctures usually fine. Arizona, New Mexico, southern Colorado, and Utah, in *Pinus*. 8. *approximatus* Dietz, page 101.

SUBDIVISION B

Pronotum with *deep* punctures.

Length 3.7 to 6.4 mm.; brownish to black; elytra with striæ moderately impressed, punctures usually small or moderately coarse and distinct. North and west of northwestern Colorado, southward to Yosemite National Park, California, in *Pinus*..... 9. *monticolæ* Hopk., page 105.

Length 4.5 to 7 mm.; black; elytral striæ distinctly impressed, punctures distinct and coarse. Black Hills, South Dakota, southward through Colorado and southern Utah, into New Mexico and Arizona, in *Pinus* and *Picea*. 10. *ponderosæ* Hopk., page 109.

Pronotum with small *shallow* punctures.

Length 6 to 8 mm.; black; punctures of elytral striæ distinct throughout; pronotum distinctly shining. Yosemite National Park, California, in *Pinus jeffreyi* and *P. ponderosa*..... 11. *jeffreyi* n. sp., page 114.

DIVISION II.

Front usually *with* posterior impression; pronotum with large and small punctures intermixed..... Subdivision C, pages 71, 117.

Front *without* posterior impression; pronotum with regular punctures. Subdivision D, pages 72, 146.

SUBDIVISION C.

Elytral declivity with striæ *deeply* impressed; epistomal process narrow, flat, with lateral sections nearly parallel; pronotum with punctures moderately regular, and with long hairs on dorsal and lateral areas..... Section a3, page 71.

Elytral declivity with striæ *not deeply* impressed; epistomal process broad, concave, and the lateral sections oblique; punctures of pronotum distinctly irregular. Section a4, page 71.

Section a3.

Pronotum with *coarse* punctures.

Length 3.5 to 5 mm.; reddish to brown; pronotum with short dorsal and lateral hairs; apex of epistomal process not extending beyond the anterior frontal margin. New Brunswick to Michigan and West Virginia, in *Larix*. 12. *simplex* Lec., page 117.

Pronotum with *fine*, shallow punctures.

Length 4 to 7 mm.; reddish to dark brown; pronotum shining, with long dorsal and lateral hairs; apex of epistomal process usually extending beyond the anterior margin of epistoma. British Columbia southward to Texas, westward to California, in *Pseudotsuga* and *Larix*..... 13. *pseudotsugæ* Hopk., page 121.

Section a4.

Posterior half of proepisternal area *not distinctly* punctured. Subsection b3, page 71.

Posterior half of proepisternal area *distinctly* punctured..... Subsection b4, page 72.

Subsection b3.

Length 4.7 to 6 mm.; body stout; reddish to black; elytral striæ quite distinctly impressed toward sides, with punctures coarse and distinct; interspaces convex; rugosities acute, rather closely placed, irregular. New Brunswick, through Canada, New England, and Michigan, in *Picea*... 14. *piceaperda* Hopk., page 126.

Length 5 to 7 mm.; reddish to black, shining; punctures of prothorax and elytra coarser; striæ of lateral area not distinctly impressed, the interspaces scarcely convex or rugose. Idaho and Black Hills, South Dakota, to New Mexico and westward to California, in *Picea*..... 15. *engelmanni* n. sp., page 130.