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TECHNICAL SERIES, No. 17, PART I. Reprint of November 15, 1911.

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

A. D. HOPKINS, PH. D.,
In Charge of Forest Insect Investigations.

ISSUED JUNE 30, 1909.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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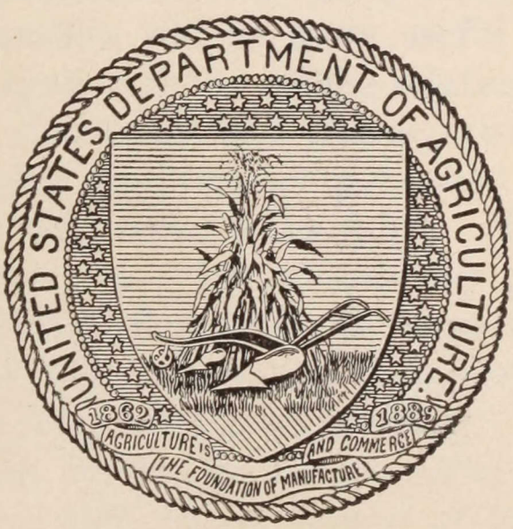

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LETTER OF TRANSMITTAL.

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,

interpretation, and recognition of generic and specific characters, on which depends the future success of economic work on the scolytid beetles, and as aids in the preparation of technical and economic contributions to the monograph.

I recommend the publication of this paper as Part I of Technical Series, No. 17, of the Bureau of Entomology.

Respectfully,

L. O. HOWARD,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE TO BULLETIN.

During the writer's investigations of extensive insect depredations in the forests of West Virginia, from 1890 to 1902, he was forcibly impressed with the importance of the forest-insect problem in any future efforts toward the successful management of the forests of this country, and was thus led to give special attention to the subject. It was soon realized that among the principal groups of insect enemies of forest trees the scolytid bark and wood boring beetles must occupy first rank, both in economic importance and in systematic interest. Subsequent investigations in West Virginia, in connection with the work of the West Virginia Agricultural Experiment Station, and in all of the principal forest regions of the country, in connection with the work of the Bureau of Entomology, have served to confirm these first impressions.

In these investigations special efforts have been made to acquire information on habits and seasonal history of the various species, and other facts relating to them, and to collect an abundance of material for systematic study—all to form a basis for conclusions in regard to the principal enemies of American forests and practical methods for their control.

The large amount of material has been pretty thoroughly worked over and identified, and synoptic tables and descriptions for the greater part have been completed for some time. Delay in publishing the results of the systematic part of the investigations has seemed necessary, in order that sufficient time might be given for the determination of taxonomic details as a basis for reliable conclusions in a comprehensive treatment of the group as a whole, but with increasing duties in the general work on forest insect investigations, and the more and more limited time available for systematic work, it is realized that these taxonomic studies can not be completed for many years.

To avoid further delay in the publication of data of immediate interest and importance, the writer has decided to postpone the discussion of the taxonomic and other subjects of a philosophical nature, required for a completed monograph, and for the present to issue separate contributions, each part to be restricted to one genus, or, at

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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.

CONTENTS.

	Page.
Introductory	1
Historical	3
Original description of genus	4
Translation	4
Synonymy	5
Revisional notes	5
Revised description of genus	5
Anatomical	5
Nomenclature	7
Illustrations	9
External characters of the imago	9
The head	11
The thorax	22
Divisions of the thoracic segment	23
Elements of the adult thorax	26
The prothorax	26
The mesothorax	28
Mesotergum	28
Mesoplura	29
Mesosterna	30
The metathorax	30
Metatergum	30
Metapleura	34
Metasterna	35
The abdomen	35
Abdominal tergites	36
Abdominal pleurites	38
Abdominal sternites	38
Spiracles	39
The legs	39
The wings	40
Mesothoracic and metathoracic wings	42
Metathoracic or hind wings	43
Mesothoracic wings or elytra	49
Internal anatomy	51
Digestive system	52
Secondary sexual characters	52
Pupa	53
Larva	57
External characters	57
Digestive system	64
Eggs	64
Physiological characteristics	64

Page.
Specific distinctions 66
Range or limits of specific variation 66
Progressive modifications 67
Distinction of major and minor divisions of the genus 68
Plan of synoptic treatment 69
Synopses of morphological and physiological characters 69
Synopsis of adult characters 69
Synopsis of secondary sexual characters 73
Synopsis of pupal characters 73
Synopsis of larval characters 75
Synopsis of gallery characters 76
Table of distribution 77
Table showing relation of species to host trees 78
Table of host trees 79
Revision and systematic notes, with descriptions of new species 79
Distinctive generic characters 79
Bibliography and synonymy of genus 80
Division I 81
Subdivision A 81
1. *Dendroctonus brevicomis* Le Conte 81
2. *Dendroctonus barberi* n. sp 85
3. *Dendroctonus convexifrons* n. sp 87
4. *Dendroctonus frontalis* Zimmerman 90
5. *Dendroctonus arizonicus* n. sp 95
6. *Dendroctonus mexicanus* Hopkins 97
7. *Dendroctonus parallelocollis* Chapuis 99
8. *Dendroctonus approximatus* Dietz 101
Subdivision B 105
9. *Dendroctonus monticolæ* Hopkins 105
10. *Dendroctonus ponderosæ* Hopkins 109
11. *Dendroctonus jeffreyi* n. sp 114
Division II 116
Subdivision C 117
12. *Dendroctonus simplex* Le Conte 117
13. *Dendroctonus pseudotsugæ* Hopkins 121
14. *Dendroctonus piceaperda* Hopkins 126
15. *Dendroctonus engelmanni* n. sp 130
16. *Dendroctonus borealis* n. sp 133
17. *Dendroctonus obesus* (Mannerheim) 135
18. *Dendroctonus rufipennis* (Kirby) 138
19. *Dendroctonus murrayanæ* n. sp 140
20. *Dendroctonus punctatus* Le Conte 142
21. *Dendroctonus micans* (Kugelann) 143
Subdivision D 146
22. *Dendroctonus terebrans* (Olivier) 147
23. *Dendroctonus valens* Le Conte 151
24. *Dendroctonus adjunctus* Blandford 157
Bibliography 159

ILLUSTRATIONS.

PLATES.

Page.

PLATE I. Classification of the genus *Dendroctonus*, showing technical and common names and species numbers 1

II. Map of world, showing geographical distribution of the genus *Dendroctonus* 80

III. *Dendroctonus* adults. Fig. 1.—*D. brevicomis*. Fig. 2.—*D. barberi*. Fig. 3.—*D. convexifrons*. Fig. 4.—*D. frontalis*. Fig. 5.—*D. arizonicus*. Fig. 6.—*D. mexicanus*. Fig. 7.—*D. parallelocollis* 164

IV. *Dendroctonus* adults. Fig. 8.—*D. approximatus*. Fig. 9.—*D. monticolæ*. Fig. 10.—*D. ponderosæ*. Fig. 11.—*D. jeffreyi* 164

V. *Dendroctonus* adults. Fig. 12.—*D. simplex*. Fig. 13.—*D. pseudotsugæ*. Fig. 14.—*D. piceaperda*. Fig. 16.—*D. borealis* 164

VI. *Dendroctonus* adults. Fig. 17.—*D. obesus*. Fig. 18.—*D. rufipennis*. Fig. 20.—*D. punctatus*. Fig. 21.—*D. micans* 164

VII. *Dendroctonus* adults. Fig. 22.—*D. terebrans*. Fig. 23.—*D. valens* 164

VIII. *Dendroctonus* larvæ. Fig. 1.—*D. brevicomis*. Fig. 19.—*D. murrayanæ*. Fig. 23.—*D. valens* 164

TEXT FIGURES.

FIG. 1. *Dendroctonus valens:* Adult, dorsal aspect 6

2. *Dendroctonus valens:* Adult, ventral aspect 8

3. *Dendroctonus valens:* Adult, lateral aspect 9

4. *Dendroctonus valens:* Head, dorsal and lateral aspects 12

5. *Dendroctonus valens:* Head, ventral aspect, and mouthparts 13

6. *Dendroctonus valens:* Head, oral aspect, epistoma, etc 14

7. *Pterostichus californicus:* Head, dorsal and ventral aspects 15

8. *Pissodes strobi:* Head, ventral aspect, and mouthparts 16

9. *Pissodes strobi:* Head, dorsal aspect, and mandibles 17

10. *Dendroctonus:* Epistomata 19

11. *Dendroctonus:* Antennæ 20

12. *Dendroctonus:* Antennæ 20

13. *Dendroctonus:* Antennæ 21

14. *Dendroctonus valens:* Mandible 22

15. *Dendroctonus:* Eyes 23

16. *Dendroctonus valens:* Areas of pronotum 23

17. *Dendroctonus valens:* Areas of prothorax, ventral aspect 24

18. *Dendroctonus valens:* Mesothorax, ventral aspect 24

19. *Dendroctonus valens:* Mesotergum and mesopleurum 28

20. *Dendroctonus valens:* Metatergum and metapleurum 31

21. *Dendroctonus valens:* Metatergum, inner aspect 33

22. *Dendroctonus valens:* Abdominal tergites 35

23. *Dendroctonus valens:* Male, abdominal tergites 7 and 8 36

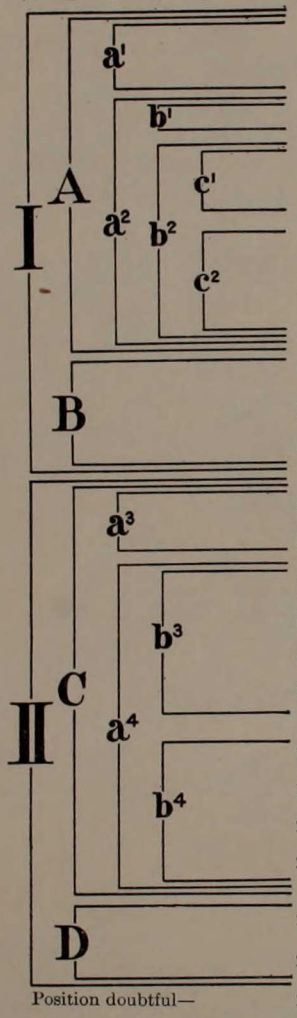
24. *Dendroctonus valens:* Female, abdominal tergites 7 and 8 37

Page.

FIG. 25. *Dendroctonus valens:* Abdominal sternites, ventral and lateral aspects 38
26. *Dendroctonus valens:* Tibia, tarsus, articulation, etc 40
27. *Dendroctonus:* Left tibiæ, dorsal and ventral aspects 41
28. *Dendroctonus:* Left tibiæ, dorsal and ventral aspects 42
29. *Dendroctonus:* Left tibiæ, dorsal and ventral aspects 43
30. *Dendroctonus valens:* Diagram of basal area of hind wing 44
31. *Dendroctonus valens:* Right elytron, ventral aspect 45
32. *Dendroctonus valens:* Basal process of right elytron 46
33. *Dendroctonus valens:* Declivital section of elytra 46
34. *Dendroctonus valens:* Diagram of elytron, showing striæ, interspaces, and tracheæ 47
35. *Dendroctonus valens:* Digestive organs of adult 52
36. *Dendroctonus valens:* Fore intestine, showing details 53
37. *Dendroctonus valens:* Pupa, dorsal, lateral, and ventral aspects 54
38. *Dendroctonus valens:* Pupa, lateral and anal aspects 55
39. *Dendroctonus valens:* Larva, dorsal, lateral, and ventral aspects 58
40. *Dendroctonus valens:* Head of larva 59
41. *Dendroctonus valens:* Mouthparts of larva 60
42. *Dendroctonus valens:* Mandibles of larva 63
43. *Dendroctonus valens:* Digestive organs of larva 65
44. *Dendroctonus brevicomis:* Egg galleries 82
45. *Dendroctonus brevicomis:* Bark showing pupal cells, exit burrows, and pitch tubes 83
46. *Dendroctonus brevicomis:* Distribution map 84
47. *Dendroctonus barberi:* Egg galleries 86
48. *Dendroctonus barberi:* Distribution map 87
49. *Dendroctonus convexifrons:* Egg galleries and larval mines 89
50. *Dendroctonus convexifrons:* Distribution map 90
51. *Dendroctonus frontalis:* Egg galleries and larval mines 91
52. *Dendroctonus frontalis:* Termination of egg galleries 92
53. *Dendroctonus frontalis:* Beginning of egg galleries 92
54. *Dendroctonus frontalis:* Bark showing pitch tubes, etc 92
55. *Dendroctonus frontalis:* Old egg galleries in living tree 93
56. *Dendroctonus frontalis:* Egg gallery in living tree, the resulting wound in process of healing 93
57. *Dendroctonus frontalis:* Distribution map 94
58. *Dendroctonus arizonicus:* Distribution map 97
59. *Dendroctonus mexicanus:* Section of egg galleries 98
60. *Dendroctonus mexicanus:* Distribution map 99
61. *Dendroctonus parallelocollis:* Section of egg gallery 100
62. *Dendroctonus parallelocollis* Distribution map 101
63. *Dendroctonus approximatus:* Single egg gallery 102
64. *Dendroctonus approximatus:* Egg galleries 103
65. *Dendroctonus approximatus:* Distribution map 104
66. *Dendroctonus monticolæ:* Egg galleries and larval mines in bark 107
67. *Dendroctonus monticolæ:* Egg galleries and larval mines grooved in surface of wood 108
68. *Dendroctonus monticolæ:* Distribution map 109
69. *Dendroctonus ponderosæ:* Egg galleries and larval mines 112
70. *Dendroctonus ponderosæ:* Tree with bark removed, showing egg galleries grooved and marked on surface of wood 113
71. *Dendroctonus ponderosæ:* Distribution map 114

Page.

FIG. 72. *Dendroctonus jeffreyi:* Distribution map 116
73. *Dendroctonus simplex:* Egg galleries and larval mines 119
74. *Dendroctonus simplex:* Distribution map 120
75. *Dendroctonus pseudotsugæ:* Egg galleries and larval mines 122
76. *Dendroctonus pseudotsugæ:* Egg gallery and larval mines 123
77. *Dendroctonus pseudotsugæ:* Section of log with bark removed, showing brood galleries marked and grooved on surface of wood 124
78. *Dendroctonus pseudotsugæ:* Distribution map 125
79. *Dendroctonus piceaperda:* Egg gallery and larval mines 128
80. *Dendroctonus piceaperda:* Distribution map 129
81. *Dendroctonus engelmanni:* Egg gallery and eggs in living bark 132
82. *Dendroctonus engelmanni:* Distribution map 133
83. *Dendroctonus borealis:* Distribution map 134
84. *Dendroctonus obesus:* Distribution map 137
85. *Dendroctonus rufipennis:* Distribution map 140
86. *Dendroctonus murrayanæ:* Distribution map 141
87. *Dendroctonus punctatus:* Distribution map 143
88. *Dendroctonus micans:* Egg galleries and larval chamber 145
89. *Dendroctonus micans:* Distribution map 146
90. *Dendroctonus terebrans:* Distribution map 150
91. *Dendroctonus valens:* Egg galleries and larval chamber 152
92. *Dendroctonus valens:* Work in bark at base of stump 153
93. *Dendroctonus valens:* Basal wound in living tree resulting from primary injury by this species 154
94. *Dendroctonus valens:* Distribution map 155
95. *Dendroctonus adjunctus:* Distribution map 158



Species number.	Technical name.	Common name.	Page.
1.	*brevicomis* Lec.	1. Western Pine Beetle.	70, 81
2.	*barberi* Hopk.	2. Southwestern Pine Beetle.	70, 85
3.	*convexifrons* Hopk.	3. Roundheaded Pine Beetle.	70, 87
4.	*frontalis* Zimm.	4. Southern Pine Beetle.	70, 90
5.	*arizonicus* Hopk.	5. Arizona Pine Beetle.	70, 95
6.	*mexicanus* Hopk.	6. Smaller Mexican Pine Beetle.	70, 97
7.	*parallelocollis* Chap.	7. Larger Mexican Pine Beetle.	70, 99
8.	*approximatus* Dietz.	8. Colorado Pine Beetle.	70, 101
9.	*monticolæ* Hopk.	9. Mountain Pine Beetle.	71, 105
10.	*ponderosæ* Hopk.	10. Black Hills Beetle	71, 109
11.	*jeffreyi* Hopk.	11. Jeffrey Pine Beetle	71, 114
12.	*simplex* Lec.	12. Eastern Larch Beetle.	71, 117
13.	*pseudotsugæ* Hopk.	13. Douglas Fir Beetle	71, 121
14.	*piceaperda* Hopk.	14. Eastern Spruce Beetle.	71, 126
15.	*engelmanni* Hopk.	15. Engelmann Spruce Beetle.	71, 130
16.	*borealis* Hopk.	16. Alaska Spruce Beetle.	72, 133
17.	*obesus* Mann.	17. Sitka Spruce Beetle	72, 135
18.	*rufipennis* Kirby.	18. Redwinged Pine Beetle.	72, 138
19.	*murrayanæ* Hopk.	19. Lodgepole Pine Beetle.	72, 140
20.	*punctatus* Lec.	20. Allegheny Spruce Beetle.	72, 142
21.	*micans* Kug.	21. European Spruce Beetle.	72, 143
22.	*terebrans* Oliv.	22. Black Turpentine Beetle.	72, 147
23.	*valens* Lec.	23. Red Turpentine Beetle.	72, 151
Position doubtful— 24.	*adjunctus* Blandf.	24. Guatemala Beetle	157

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. I. 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 1890–1902, 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.

Zimmermann (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.

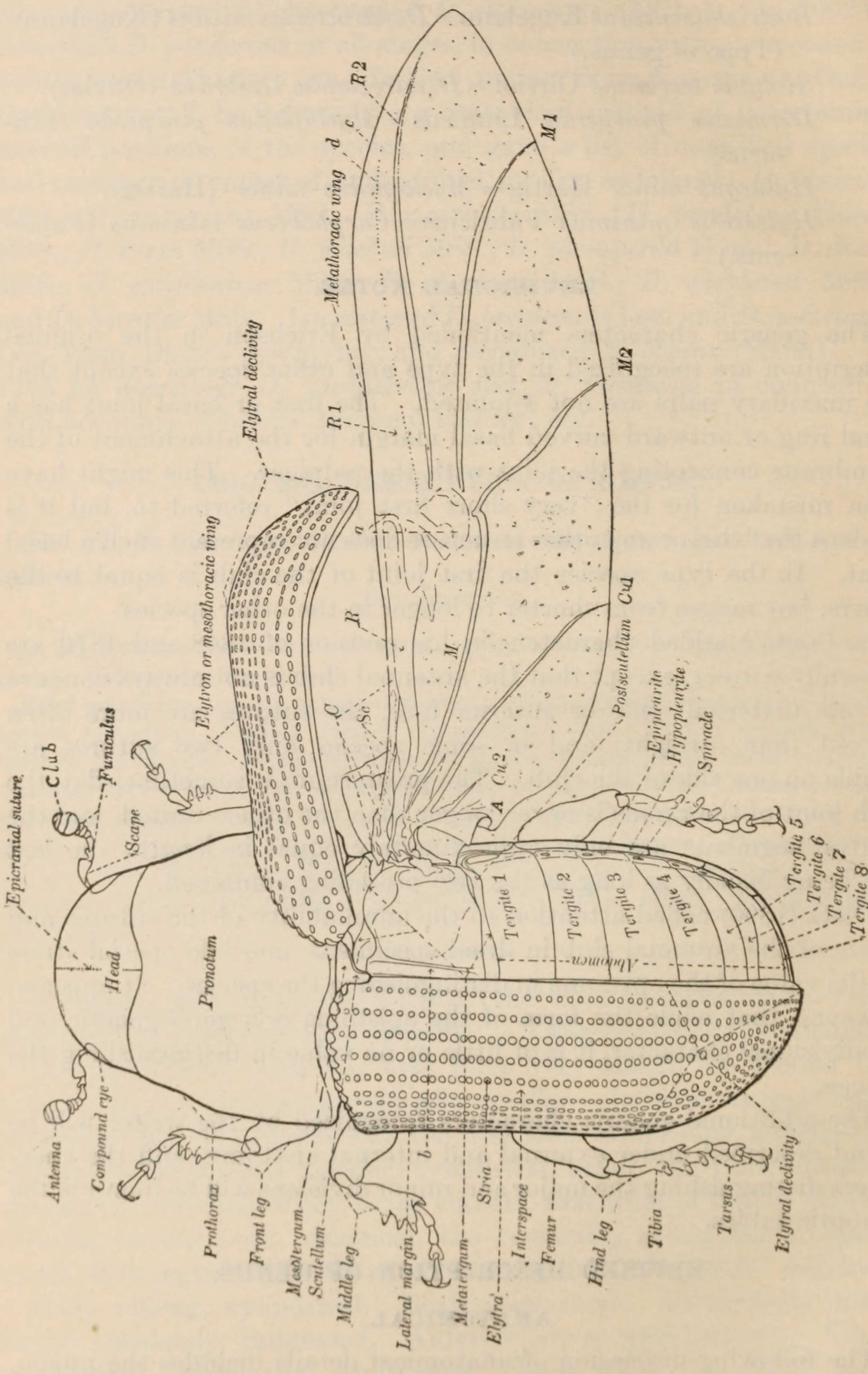


FIG. 1.—*Dendroctonus valens:* Adult, dorsal aspect. *a*, Median fold; *b*, scutellar groove; *c*, costal margin; *d*, inter-radial fold; *Sc*, subcosta; *R*, radius; *R1*, radius 1; *R2*, radius 2; *C*, costa; *M*, media; *M1*, media 1; *M2*, media 2; *Cu 1*, cubitus 1; *Cu 2*, cubitus 2; *A*, anal.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

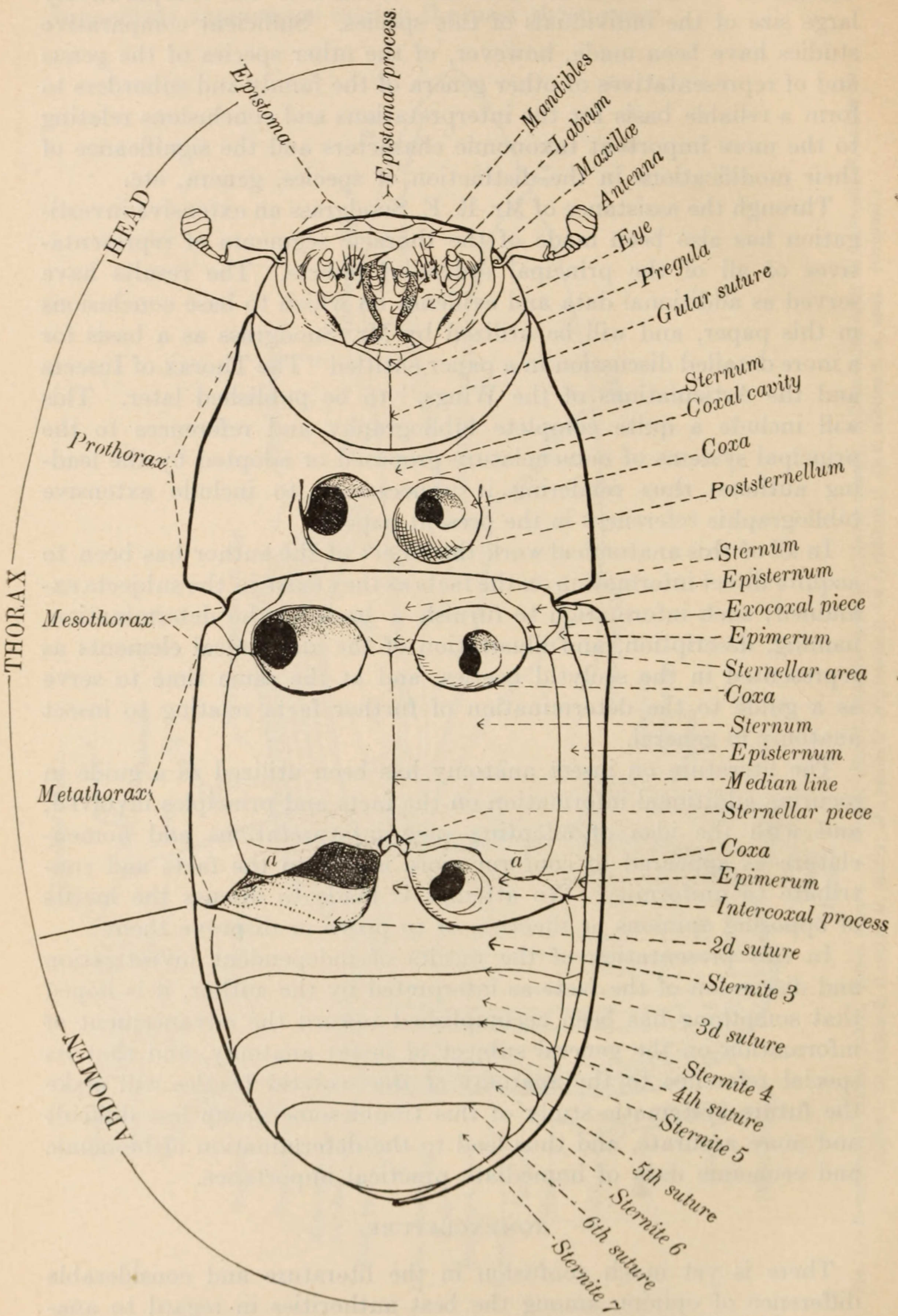


FIG. 2.—*Dendroctonus valens:* Adult, ventral aspect. *c*, Sternellar area. (Original.)

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

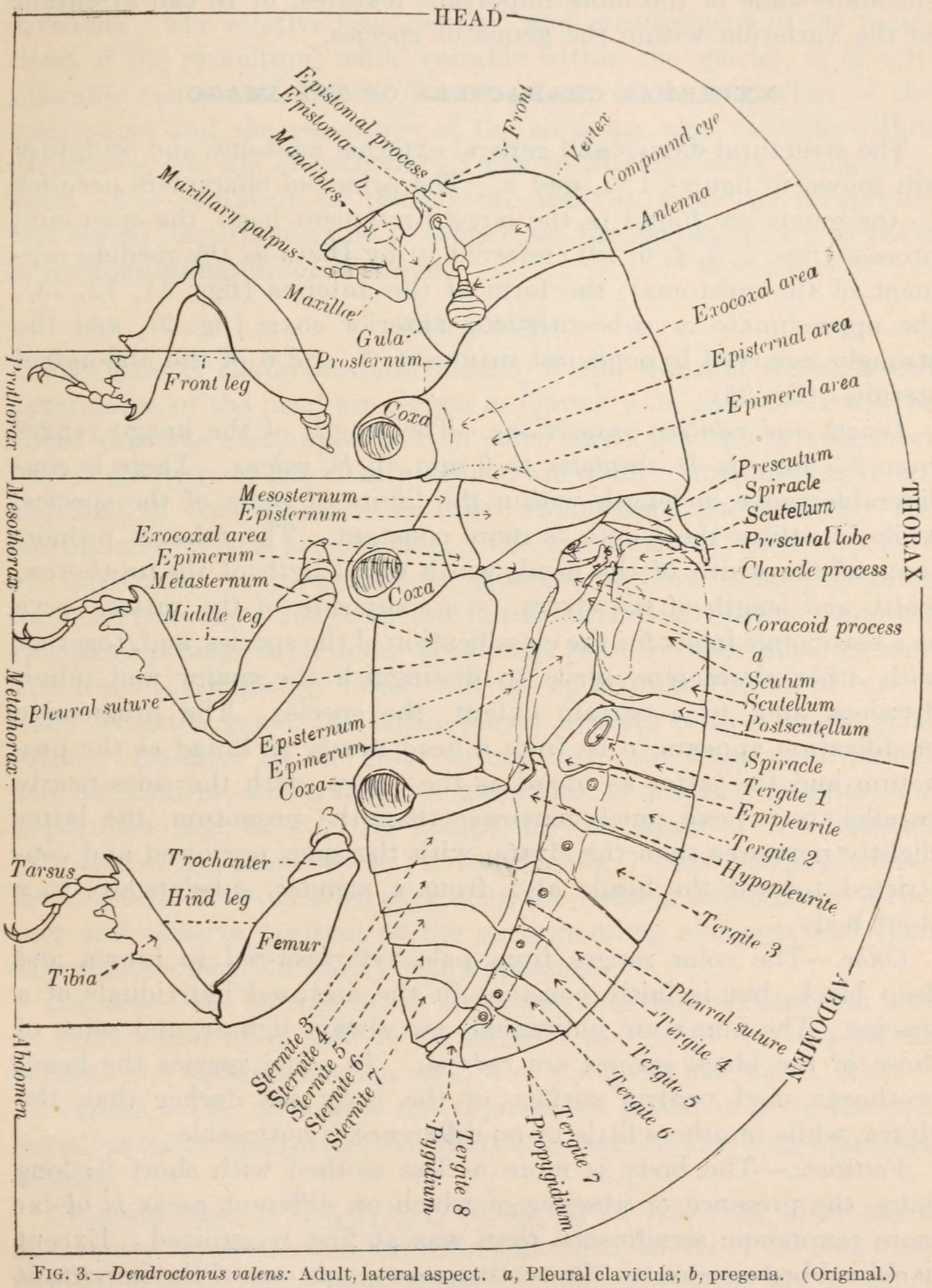


FIG. 3.—*Dendroctonus valens:* Adult, lateral aspect. *a*, Pleural clavicula; *b*, pregena. (Original.)

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-

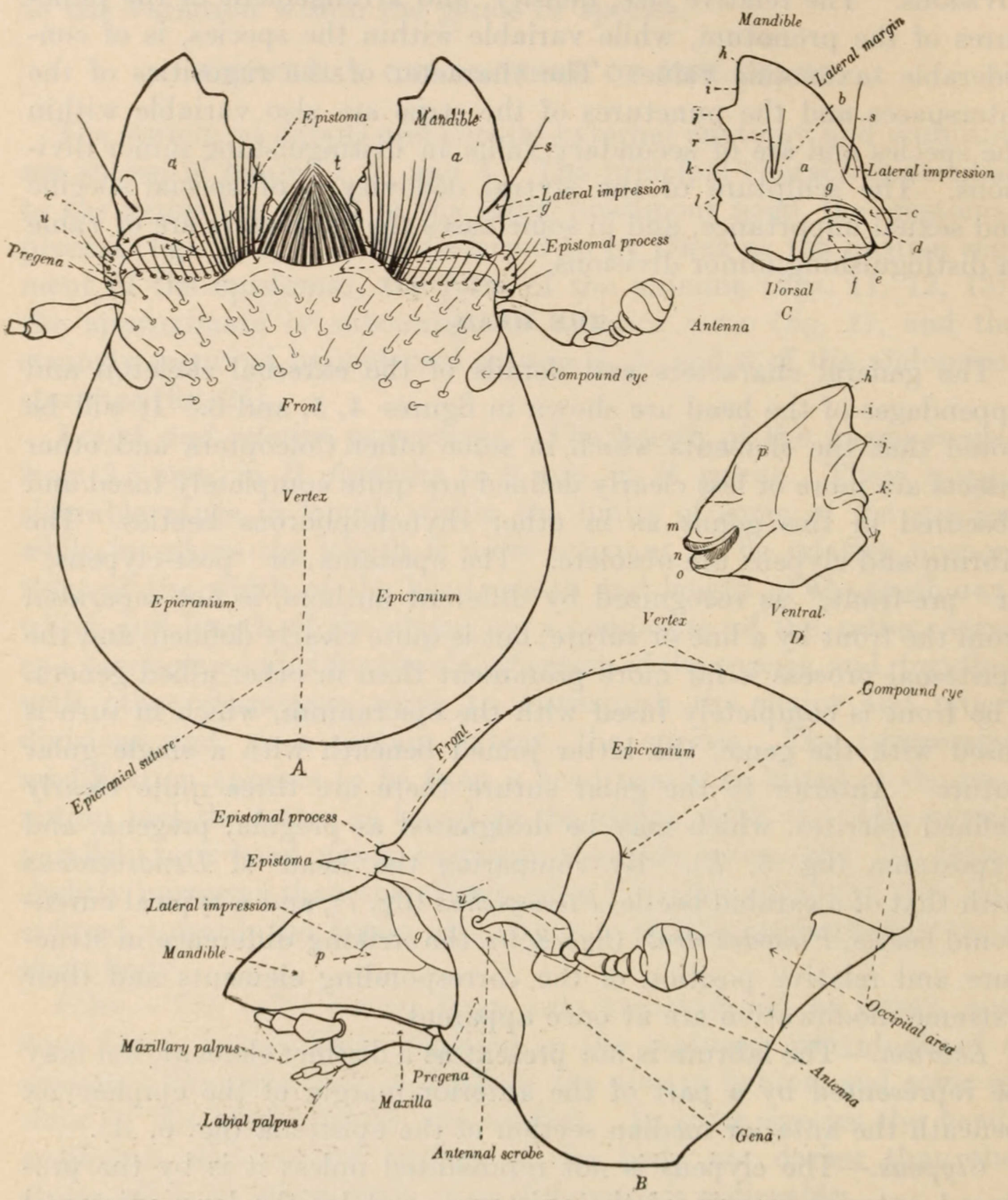


FIG. 4.—*Dendroctonus valens:* Head, dorsal and lateral aspects. *A*, Dorsal aspect of head; *B*, lateral aspect of head; *C*, dorsal aspect of right mandible; *D*, ventral aspect of right mandible; *a*, dorsal area; *b*, dorsal impression; *c*, anterior condyle; *d*, median fossa; *e*, median condyle; *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

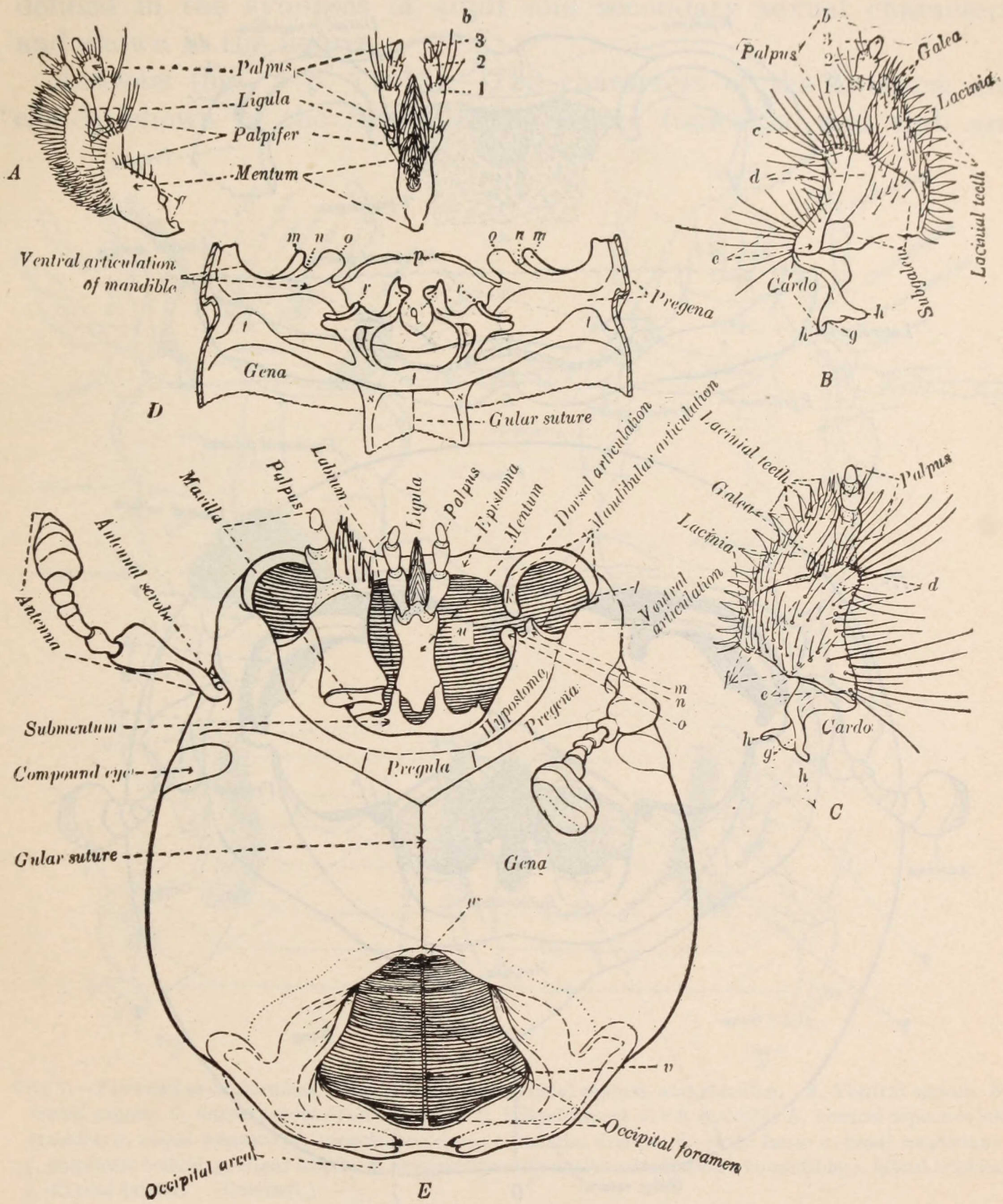


FIG. 5.—*Dendroctonus valens:* Head, ventral aspect, and mouthparts. *A*, Labium; *B*, maxilla, interno-lateral aspect; *C*, same, externo-lateral aspect; *D*, hypostomal region, dorsal aspect; *E*, head, ventral aspect; *a*, basal fossa of mentum; *b*, joints; *c*, basal membrane; *d*, palpiferal area; *e*, stipal area; *f*, subgaleal area; *g*, fossa; *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

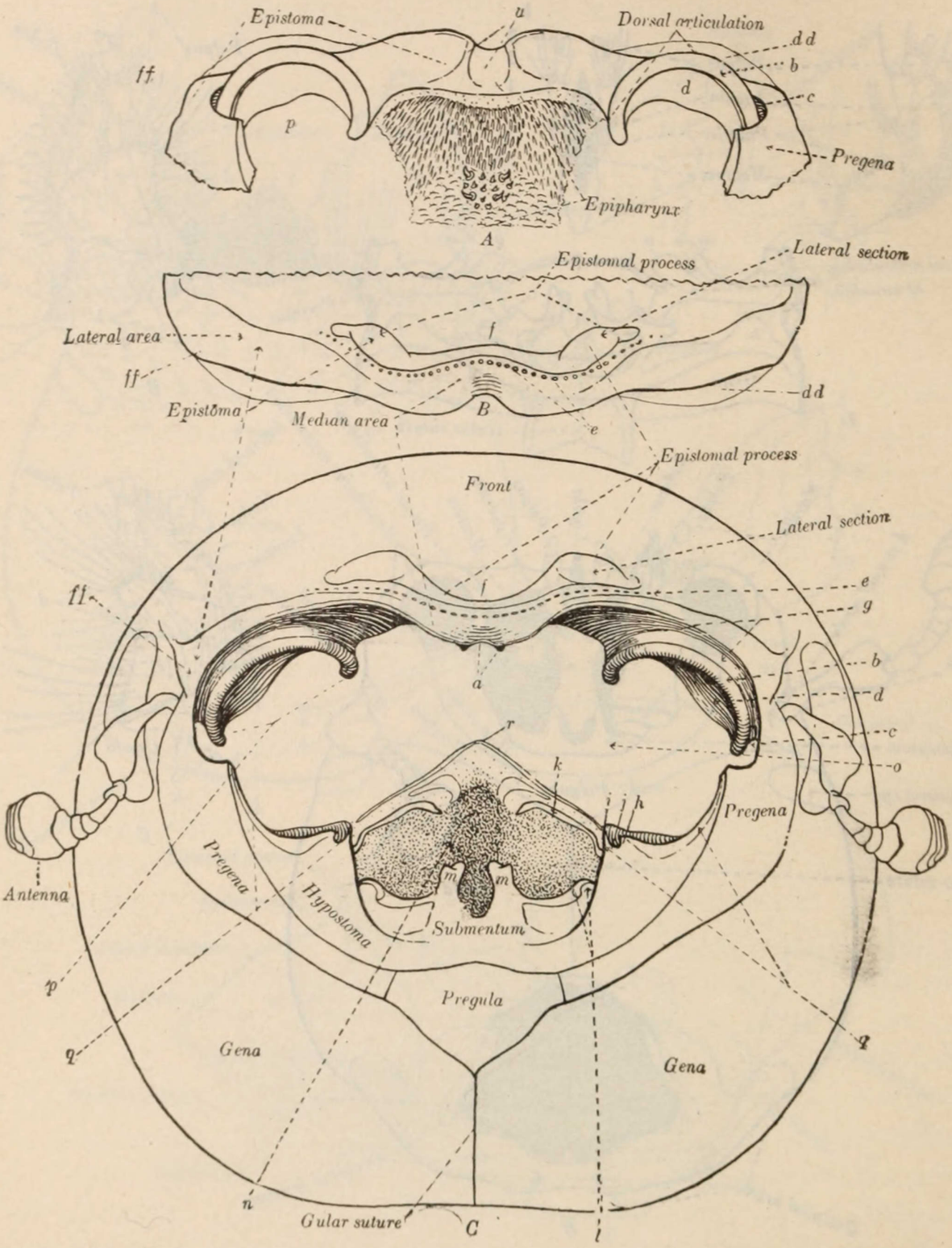


FIG. 6.—*Dendroctonus valens:* Head, oral aspect, epistoma, etc. *A*, Ventral aspect of epistomal region; *B*, dorsal aspect of epistomal region; *C*, oral aspect of head; *a*, median impression and longitudinal elevations; *b*, median condyle; *c*, lateral fossa; *d*, posterior fossa; *dd*, projection 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

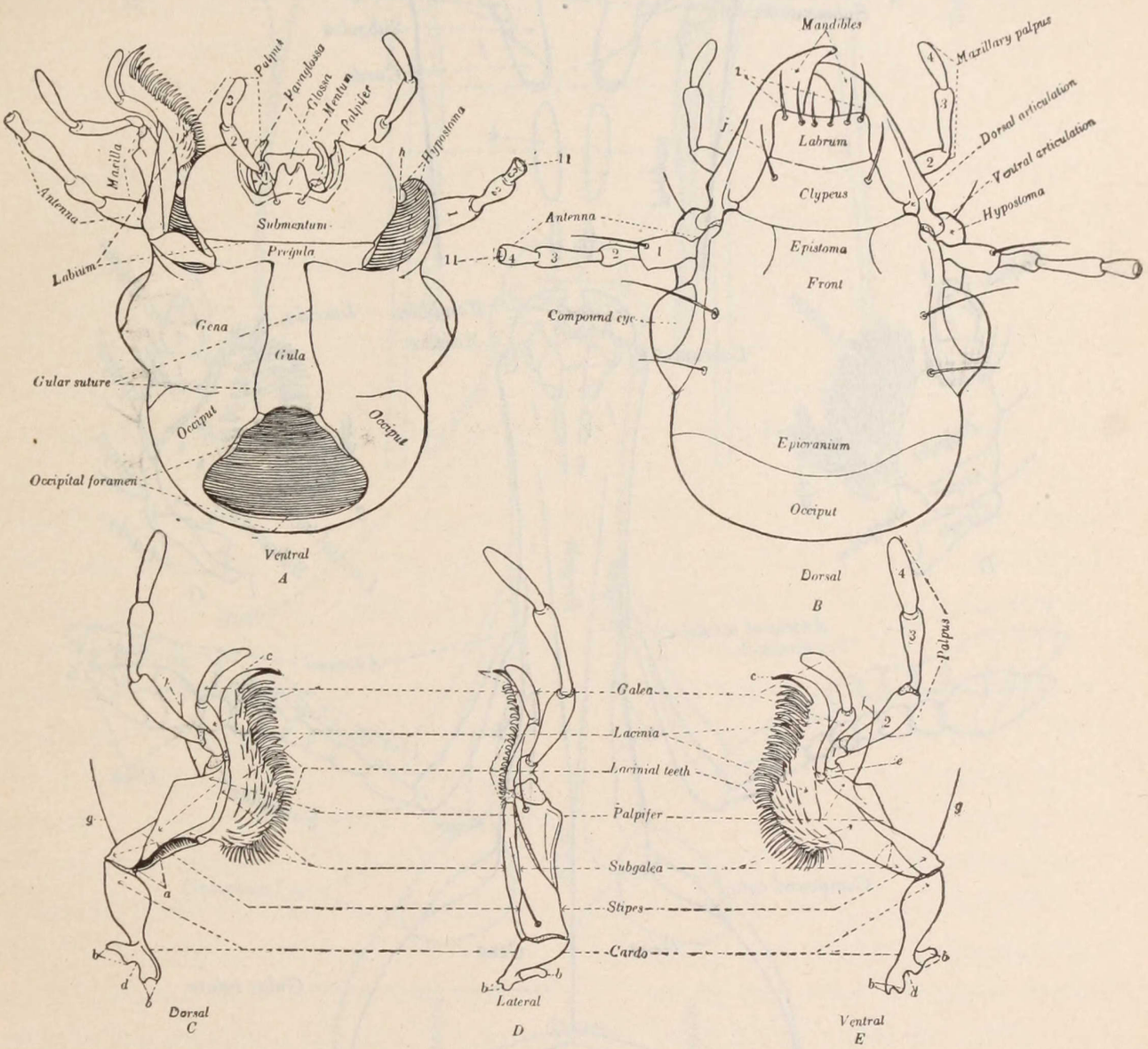


FIG. 7.—*Pterostichus californicus:* Head, dorsal and ventral aspects, and maxillæ. *A*, Ventral aspect; *B*, dorsal aspect; *C*, dorsal aspect of left maxilla; *D*, lateral aspect of left maxilla; *E*, ventral aspect of left maxilla; *a*, stipal foramen; *b*, muscle processes; *c*, lacinial digitus; *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,

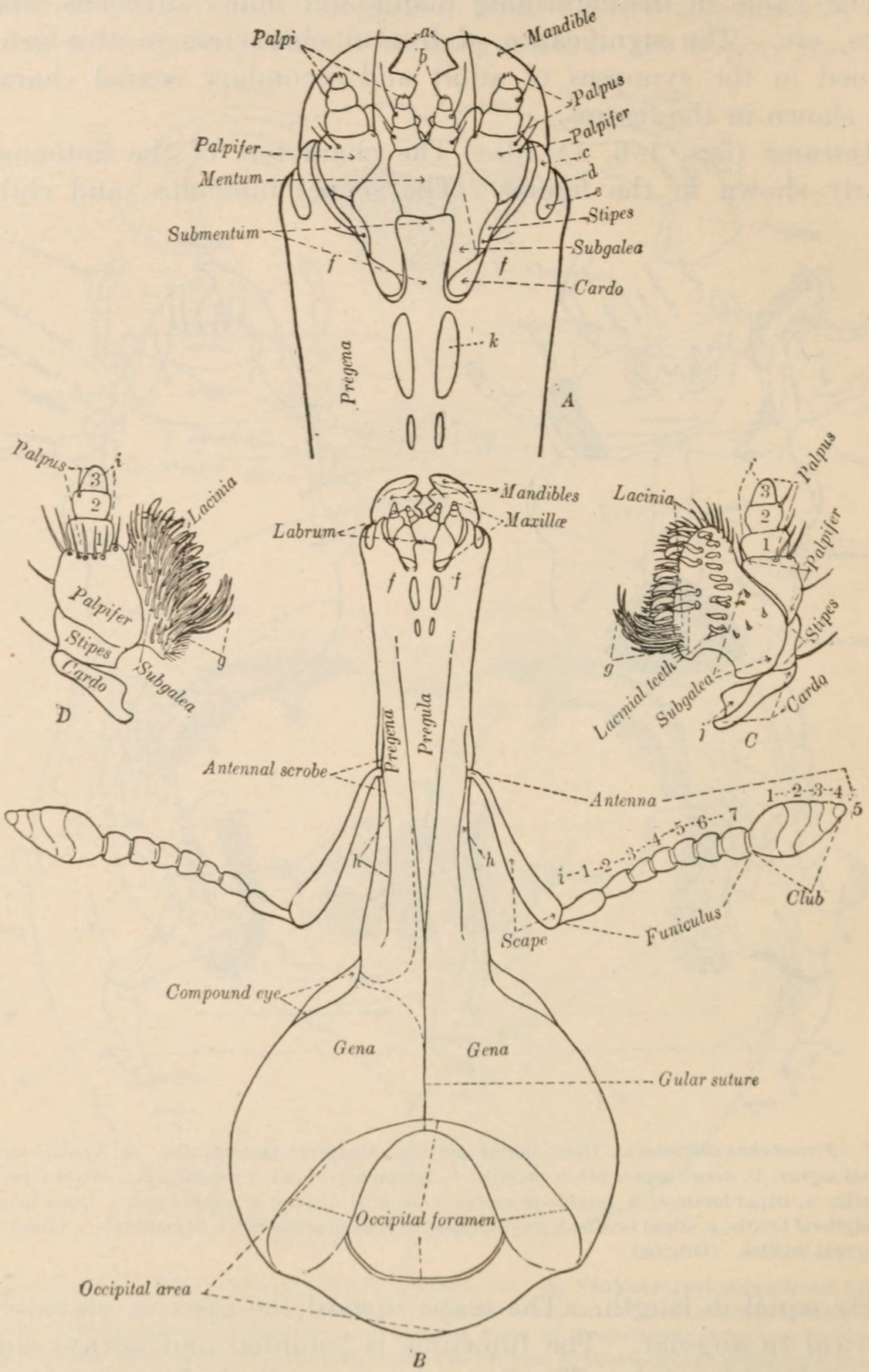


FIG. 8.—*Pissodes strobi:* Head, ventral aspect, and mouthparts. *A*, Ventral aspect of apical region of beak; *B*, ventral aspect of head; *C*, interno-lateral aspect of maxilla; *D*, externo-lateral aspect of maxilla; *a*, apical tooth; *b*, subapical tooth; *c*, lateral arm of hypostoma; *d*, pleurostoma; *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.

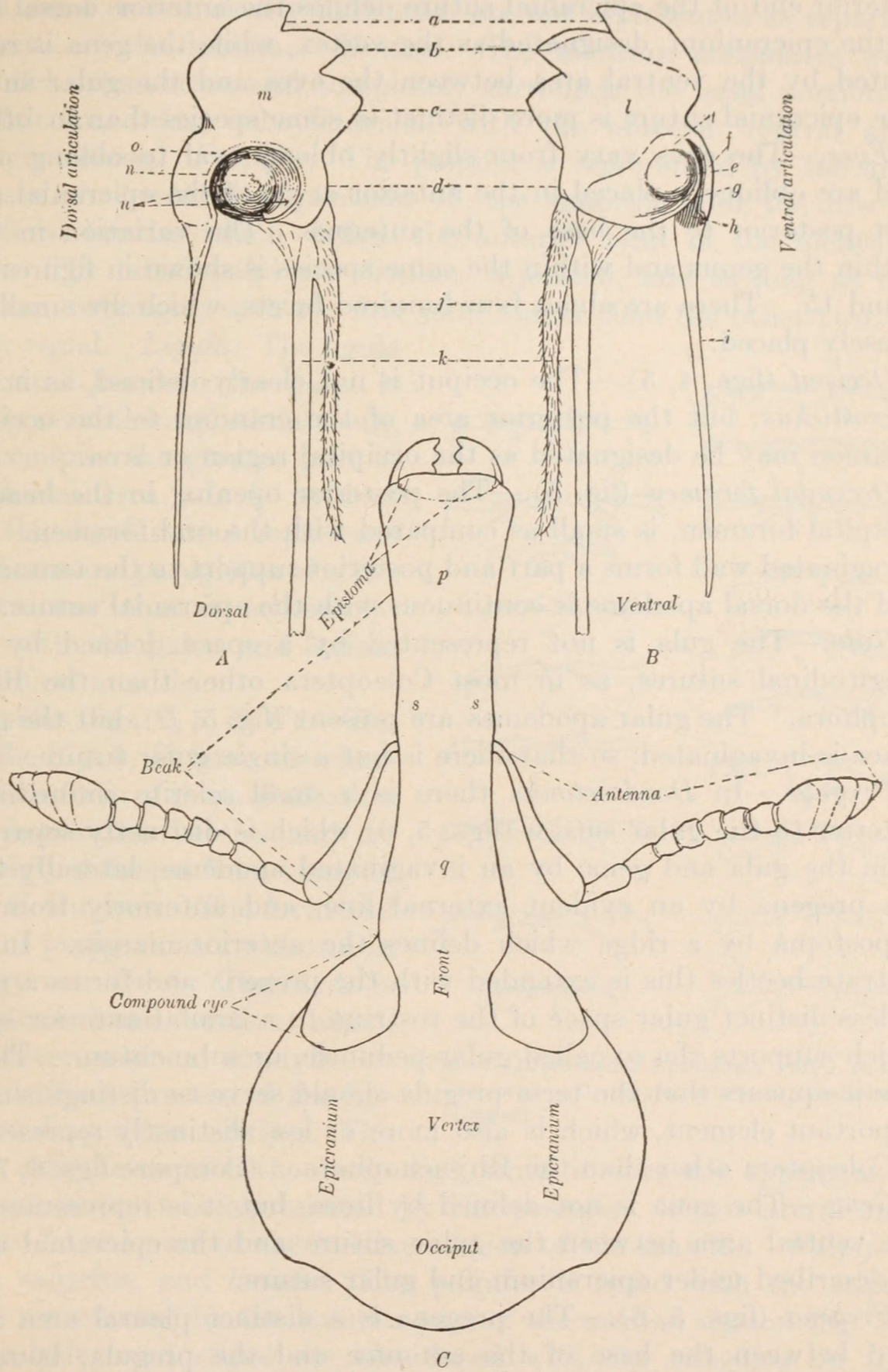


FIG. 9.—*Pissodes strobi:* Head, dorsal aspect, and mandibles. *A*, Dorsal aspect of left mandible; *B*, ventral aspect of left mandible; *C*, dorsal aspect of head; *a*, apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar; *e*, median condyle; *f*, lateral muscle process; *g*, lateral 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.

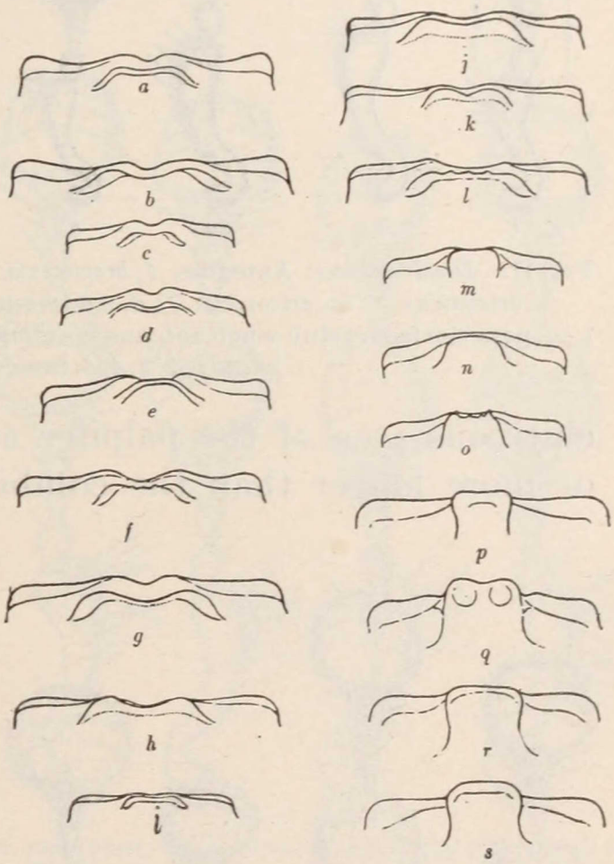


FIG. 10.—*Dendroctonus:* Epistomata. *a* to *l*, *D. valens*; *m* to *o*, *D. simplex*; *p* to *s*, *D. pseudotsugæ*. (Original.)

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

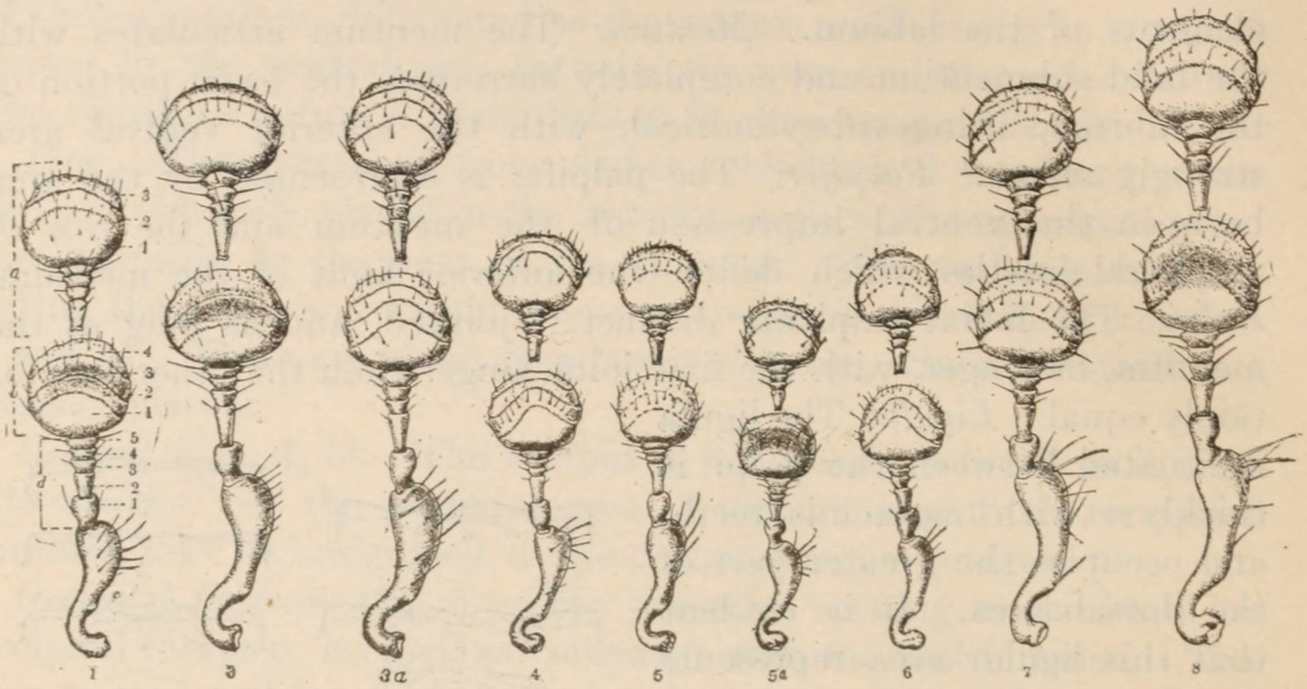


FIG. 11.—*Dendroctonus:* Antennæ. *1, brevicomis; 3, convexifrons* ♀; *3a, convexifrons* ♂; *4, frontalis* ♂; *5, arizonicus* ♂; *5a, arizonicus* ♀; *6, mexicanus; 7, parallelocollis; 8, approximatus* ♀. (Original.)
1—a, posterior face of club when antenna is extended at right angles to head, joints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

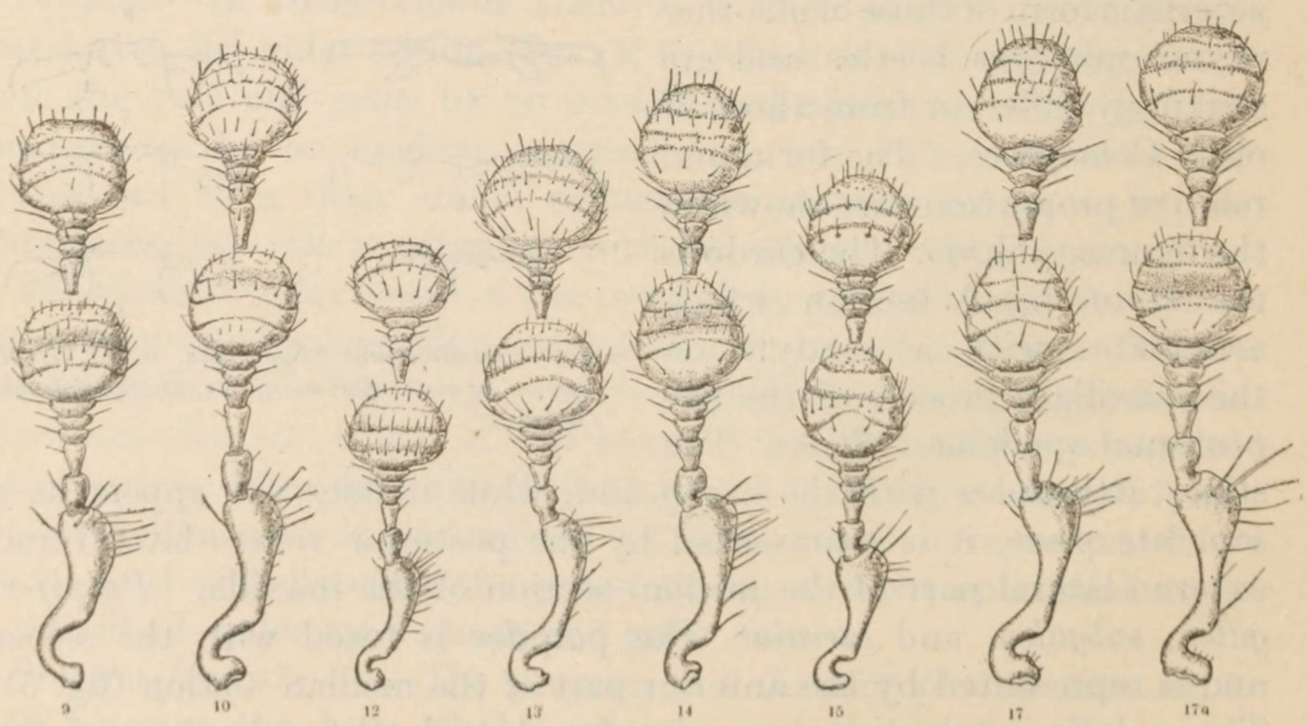


FIG. 12.—*Dendroctonus:* Antennæ. *9, monticolæ; 10, ponderosæ; 12, simplex; 13, pseudotsugæ* ♀; *14, piceaperda* ♀; *15, engelmanni; 17, obesus* ♂; *17a, obesus* ♀. (Original.)

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

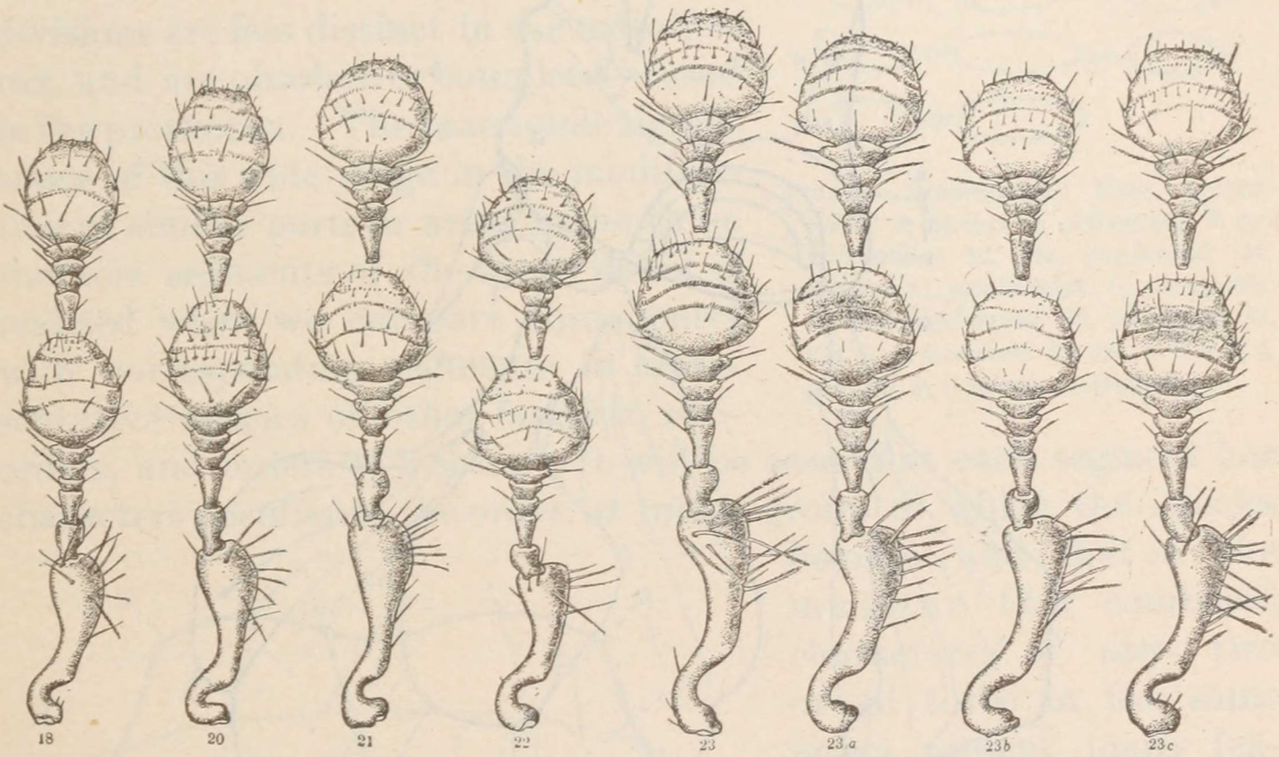


FIG. 13.—*Dendroctonus:* Antennæ. *18, rufipennis; 20, punctatus; 21, micans; 22, terebrans; 23, valens* ♂; *23a, valens* ♀; *23b, valens* ♂; *23c, valens* ♀. (Original.)

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

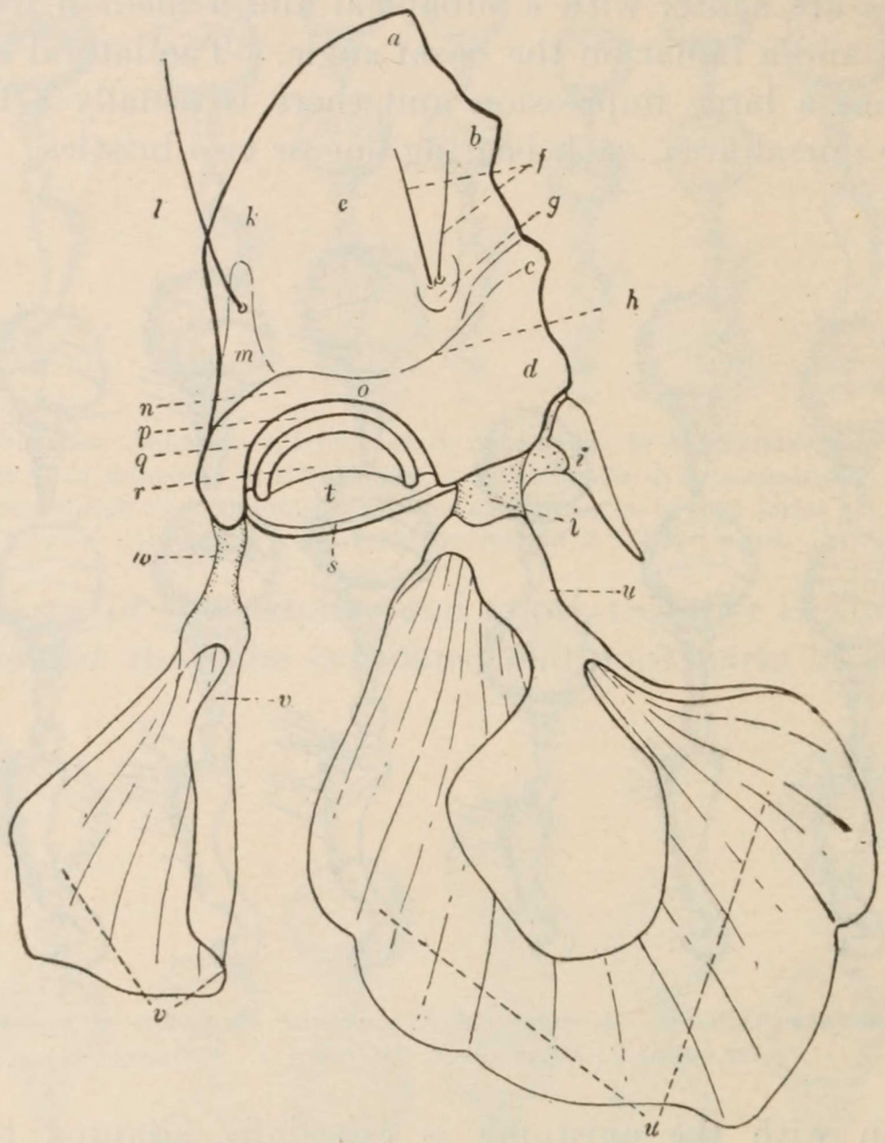


FIG. 14.—*Dendroctonus valens:* Mandible. *a*, Apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar tooth; *e*, dorsal area; *f*, dorsal bristles or setæ; *g*, dorsal impression; *h*, transverse ridge; *i*, pharyngeal process; *j*, retractor tendon; *k*, lateral area; *l*, lateral bristle; *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.

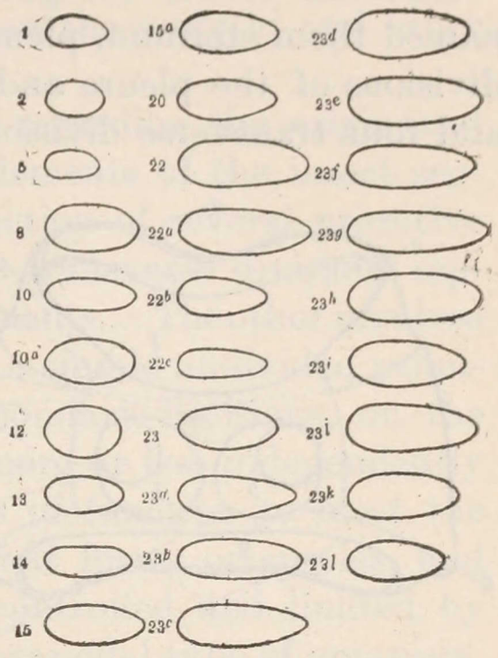


FIG. 15.—*Dendroctonus:* Eyes. *1, brevicomis; 2, barberi; 5, arizonicus; 8, approximatus; 10, 10a, ponderosæ; 12, simplex; 13, pseudotsugæ; 14, piceaperda; 15, 15a, engelmanni; 20, punctatus; 22, 22a, b, c, terebrans; 23, 23a, b, c, d, e, f, g, h, i, j, k, l, valens.* (Original.)

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.

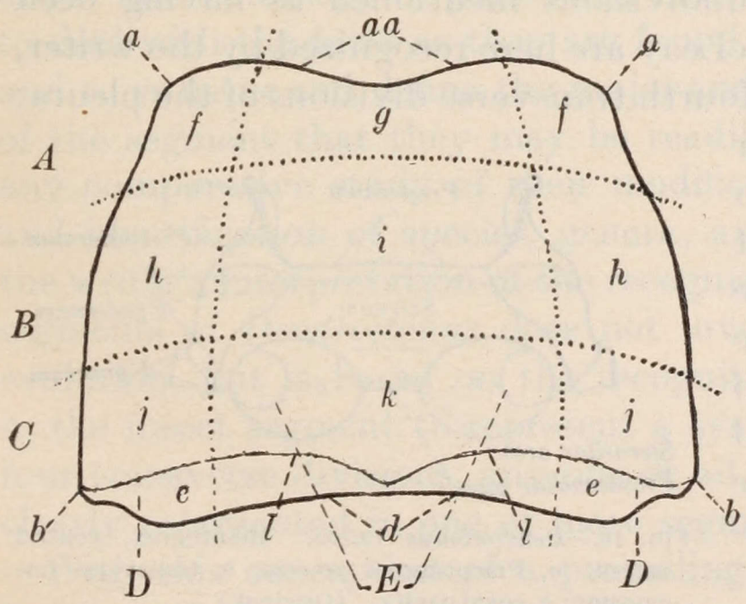


FIG. 16.—*Dendroctonus valens:* Areas of pronotum. *A*, anterior area; *B*, median area; *C*, posterior area; *D*, lateral area; *E*, dorsal area; *a*, anterior angle; *aa*, anterior margin; *b*, posterior angle; *d*, basal margin; *e*, posterior declivity; *f*, anterior section of lateral area; *g*, 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.

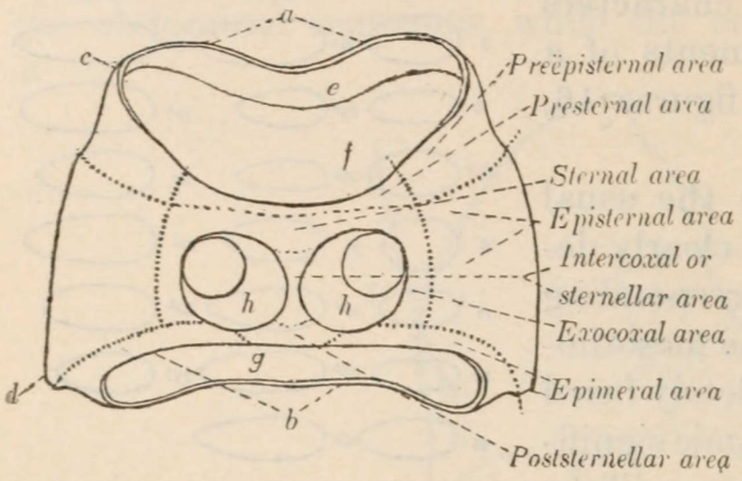


FIG. 17.—*Dendroctonus valens:* Areas of prothorax, ventral aspect. *a*, Anterior margin; *b*, posterior margin; *c*, anterior angle; *d*, posterior angle; *e*, anterior entothoracic fold for attachment of intersegmental membrane; *f*, anterior foramen; *g*, posterior foramen; *h*, coxal cavity. (Original.)

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

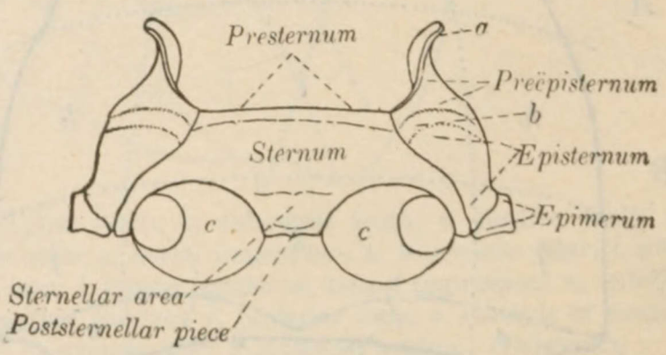


FIG. 18.—*Dendroctonus valens:* Mesothorax, ventral aspect. *a*, Preepisternal process; *b*, transverse impression; *c*, coxal cavity. (Original.)

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

[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.

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.

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

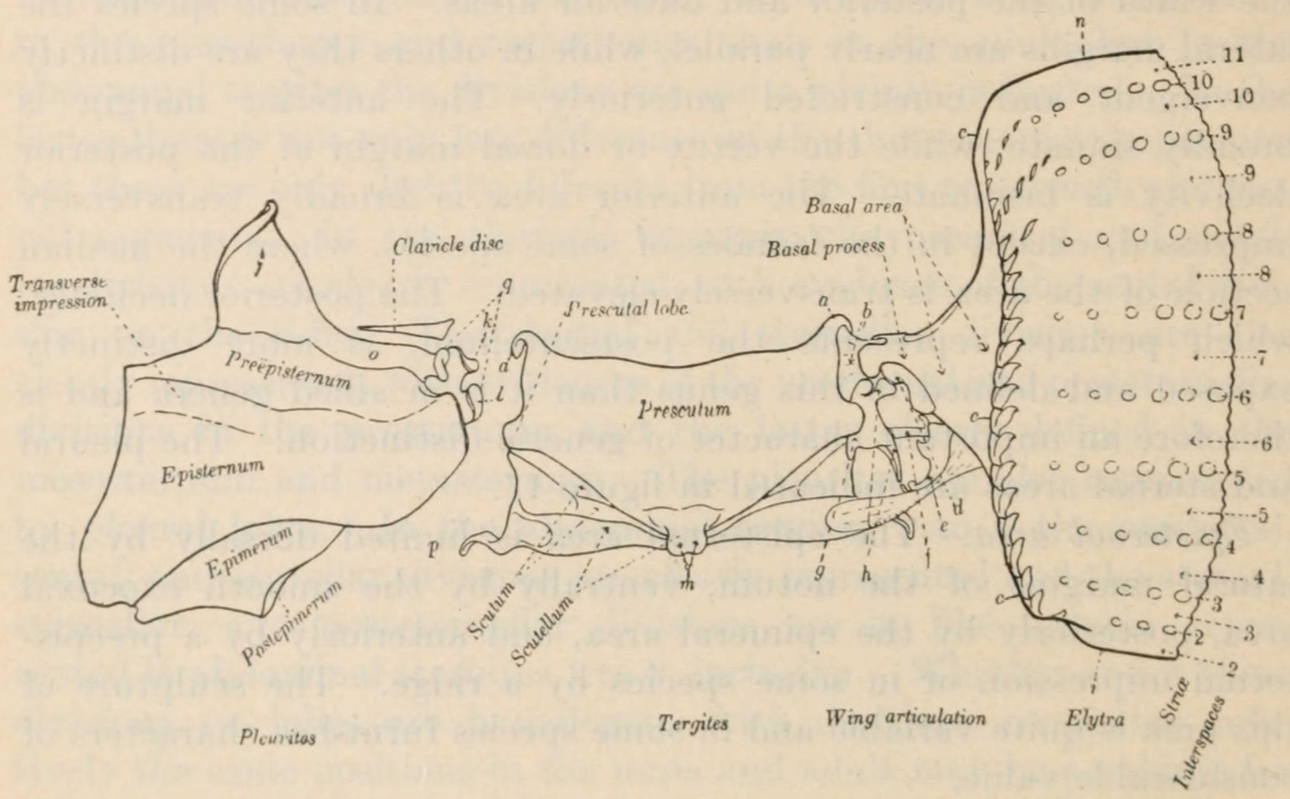


FIG. 19.—*Dendroctonus valens:* Mesotergum and mesopleurum. *a*, Lateral arm of prephragma and prescutum; *b*, wing root or connecting membrane; *c*, basal margin of elytra; *d*, radial plate; *e*, flexor plate; *f*, median plate; *g*, scapular plate; *h*, subscapular plate; *i*, sutural or anal margin; *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 postscu-

tellum. We also find that these transverse sutures are subject to great variation in position, contour, character of surface, manifesta-

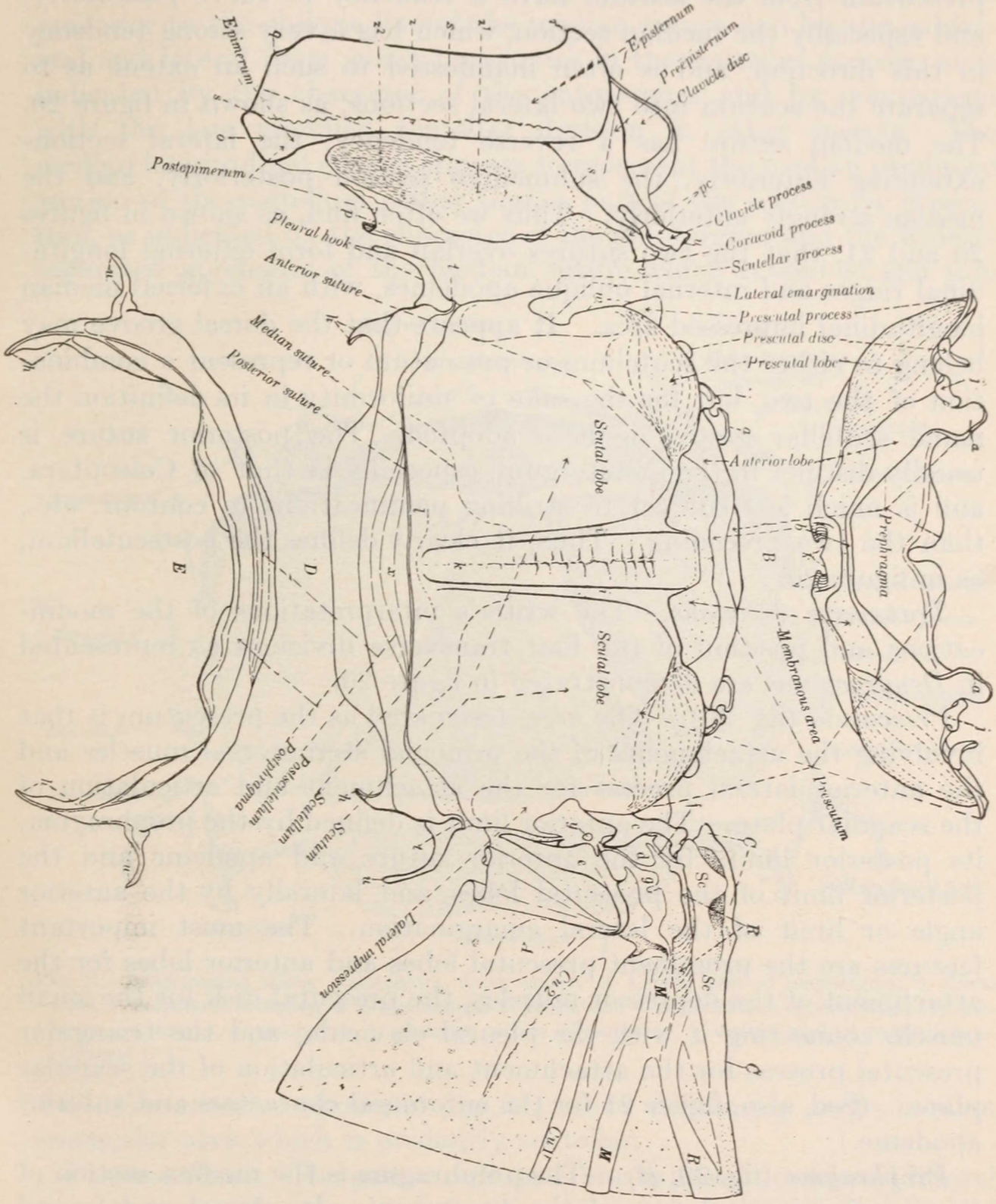


FIG. 20.—*Dendroctonus valens:* Metatergum and metapleurum. *B*, Anterior aspect of prephragma and prescutum; *D*, metatergum and metapleurum; *E*, posterior aspect of postphragma and postscutellum; *a*, lateral arm of prephragma; *b*, dorsal band; *c*, scapular plate; *d*, subscapular plate; *e*, flexor 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 poste-

riorly 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

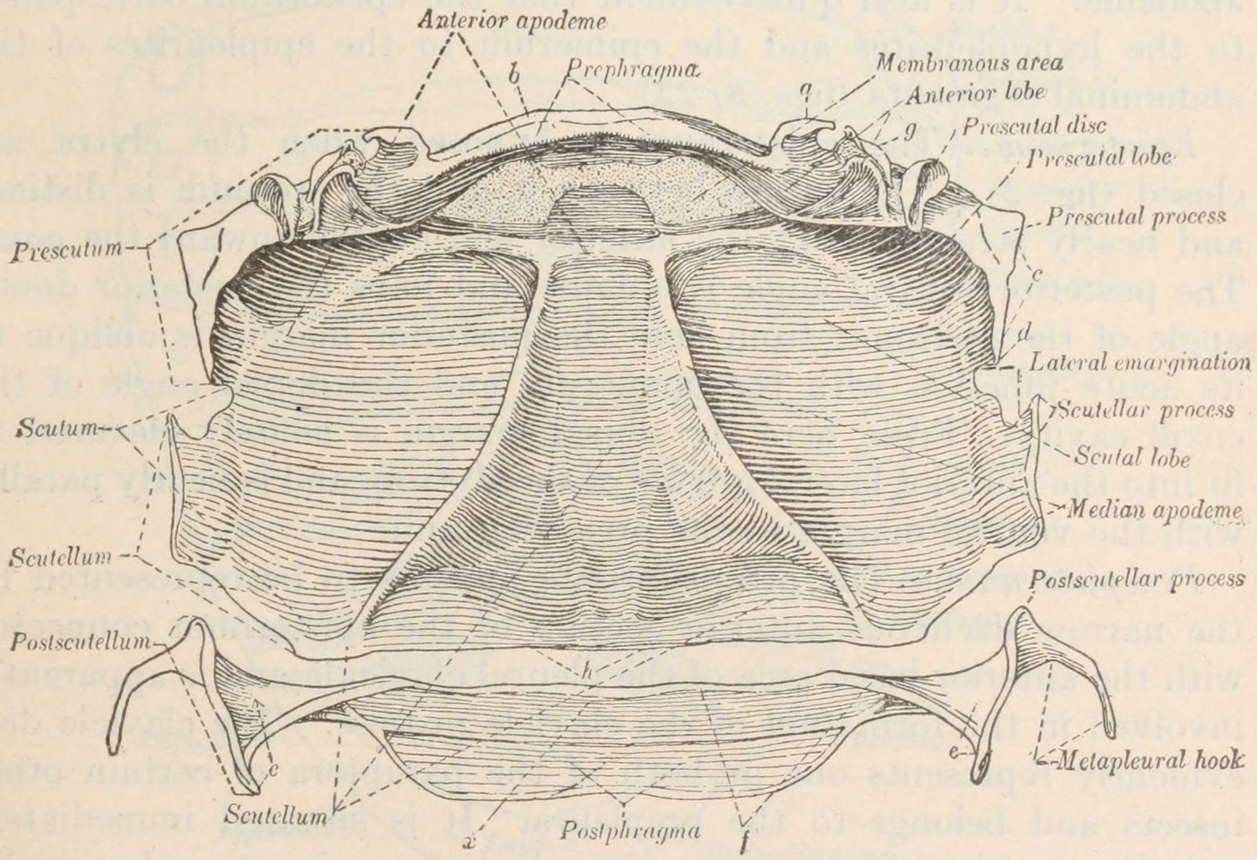


FIG. 21.—*Dendroctonus valens:* Metatergum, inner aspect. *a*, Lateral arm of prephragma; *b*, dorsal band; *c*, scapular articulation; *d*, posterior angle of prescutum; *e*, posterior arm of postphragma; *f*, posterior apodeme; *g*, anterior disk; *h*, posterior margin of scutellum; *x*, ventral wall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

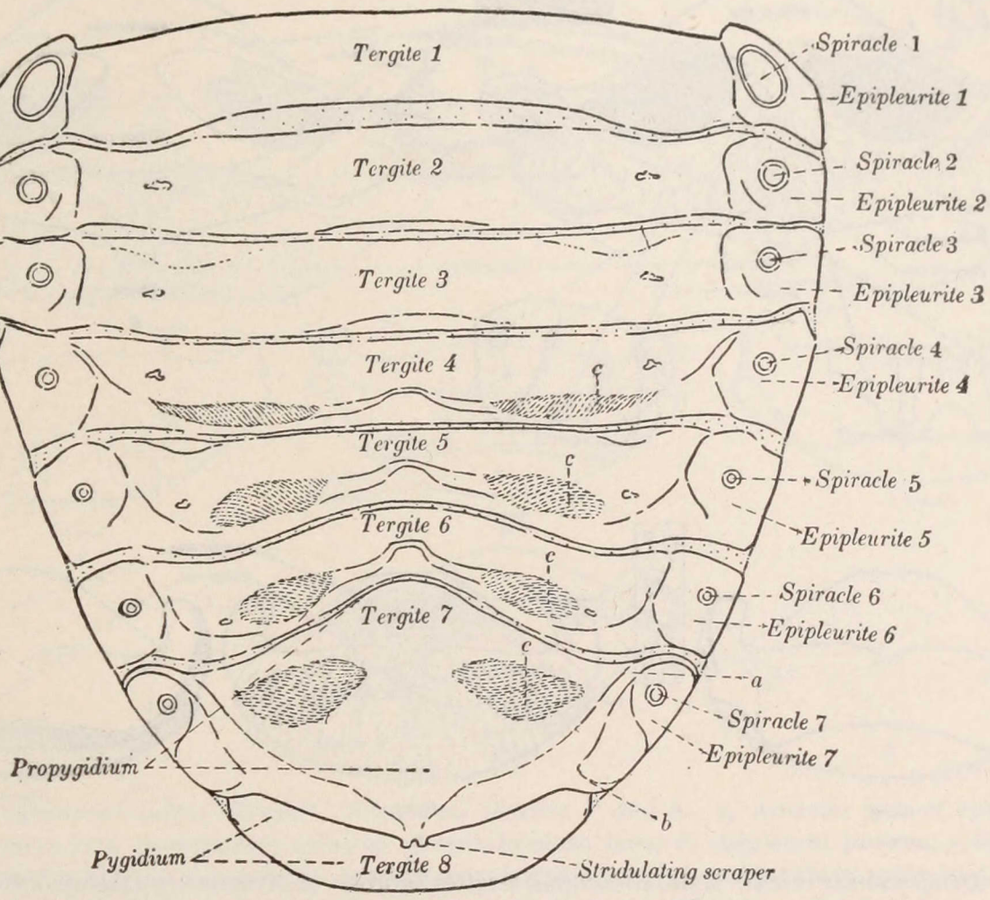


FIG. 22.—*Dendroctonus valens:* Abdominal tergites. *a*, Anterior arm of epipleurite 7; *b*, posterior arm of epipleurite 7; *c*, membranous lobes. (Original.)

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

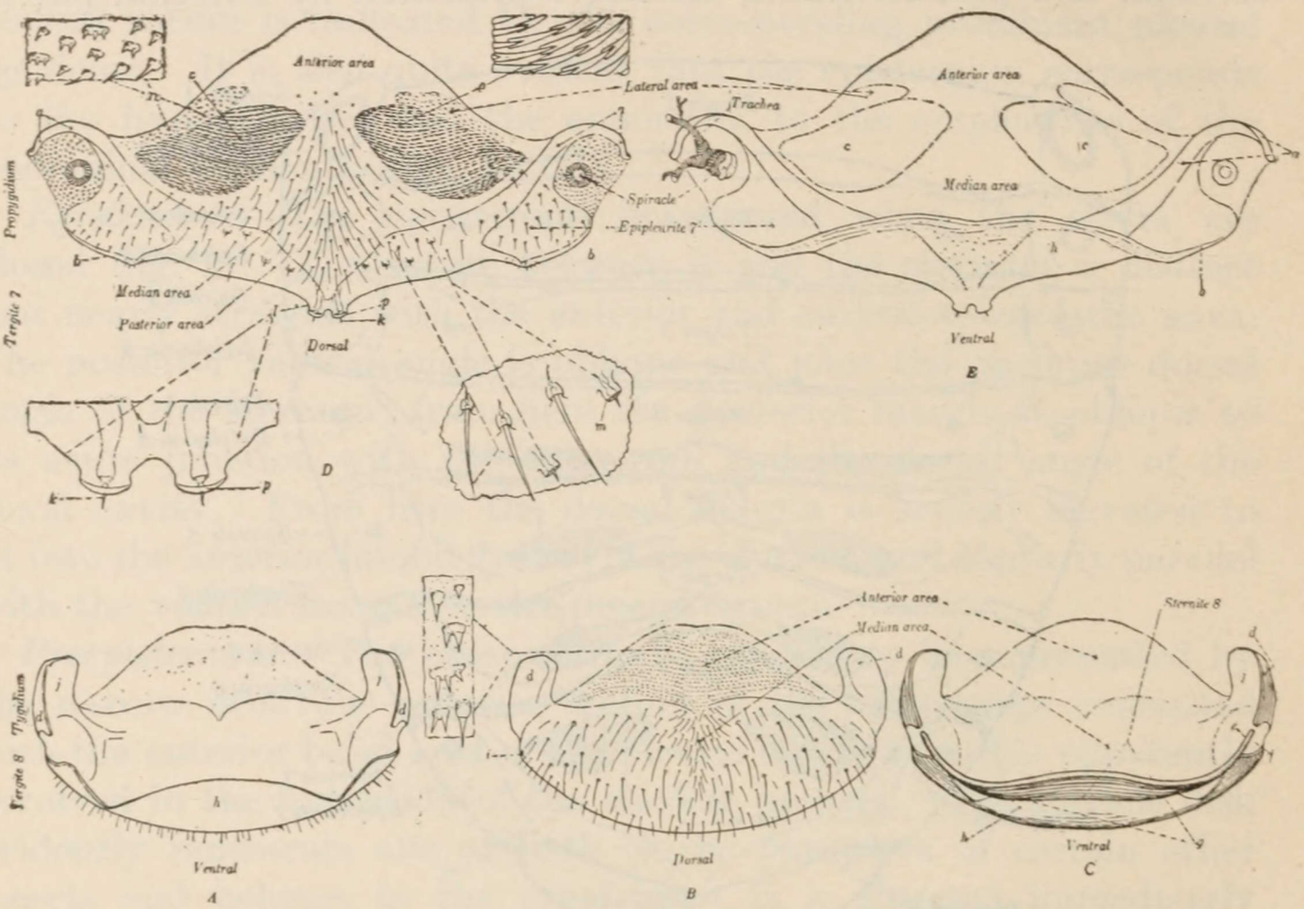


FIG. 23.—*Dendroctonus valens:* Male, abdominal tergites 7 and 8. *A*, Tergite 8 (pygidium), ventral; *B*, same, dorsal; *C*, same, ventral, showing position of sternite 8; *D*, tergite 7 (propygidium), dorsal; *E*, same, ventral; *a*, anterior arm of epipleurite 7; *b*, posterior arm of epipleurite 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*.

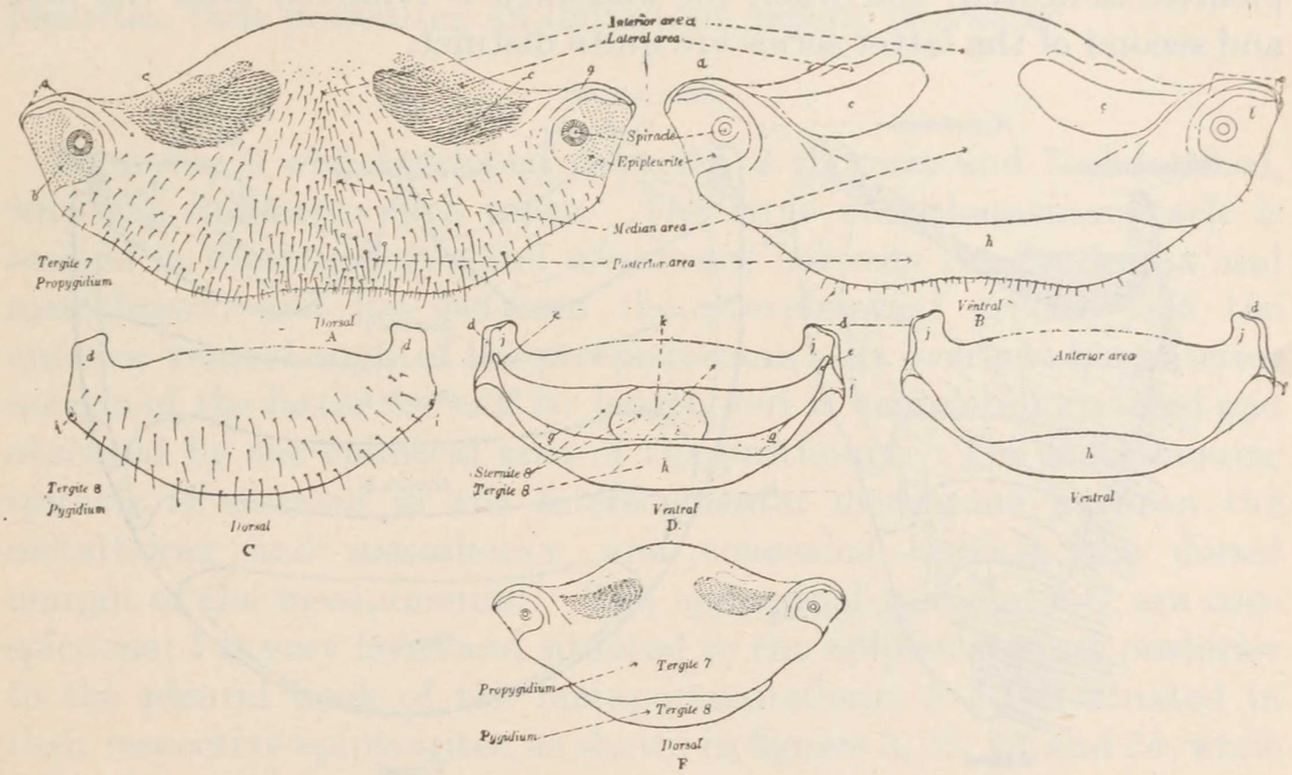


FIG. 24.—*Dendroctonus valens:* Female, abdominal tergites 7 and 8. *a*, Anterior arm of epipleurite 7; *b*, membranous area surrounding spiracle; *c*, membranous lobe; *d*, epipleural process; *e*, hypopleural process of sternite 8; *f*, pleural opening; *g*, anal space; *h*, ventral fold; *i*, rudimentary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

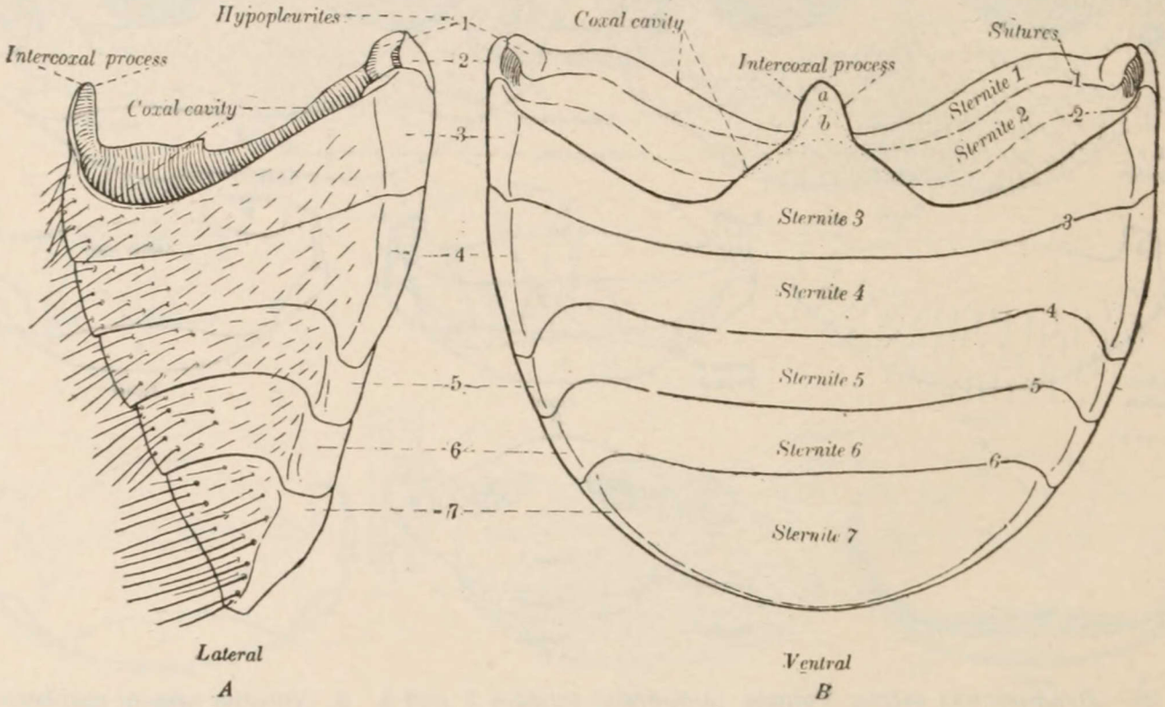


Fig. 25.—*Dendroctonus valens:* Abdominal sternites, ventral and lateral aspects. *A*, Lateral; *B*, ventral; *a*, sternite *1*, faintly indicated; *b*, sternite *2*, faintly indicated. (Original.)

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.

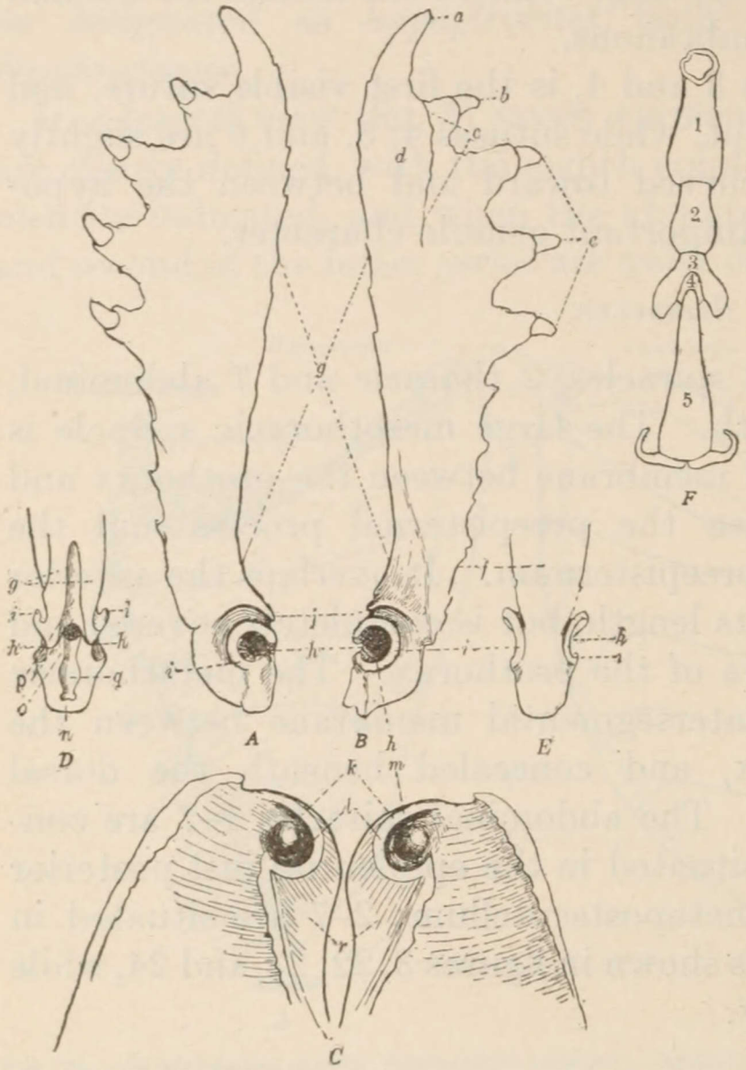


FIG. 26.—*Dendroctonus valens:* Tibia and tarsus, articulation, etc. *A*, Left tibia, ventral view; *B*, left tibia, dorsal view; *C*, left femora, ental view; *D*, left tibia, dextral view of base; *E*, left tibia, sinistral view of base; *F*, tarsus; *a*, apical tooth; *b*, subapical tooth; *c*, tarsal 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

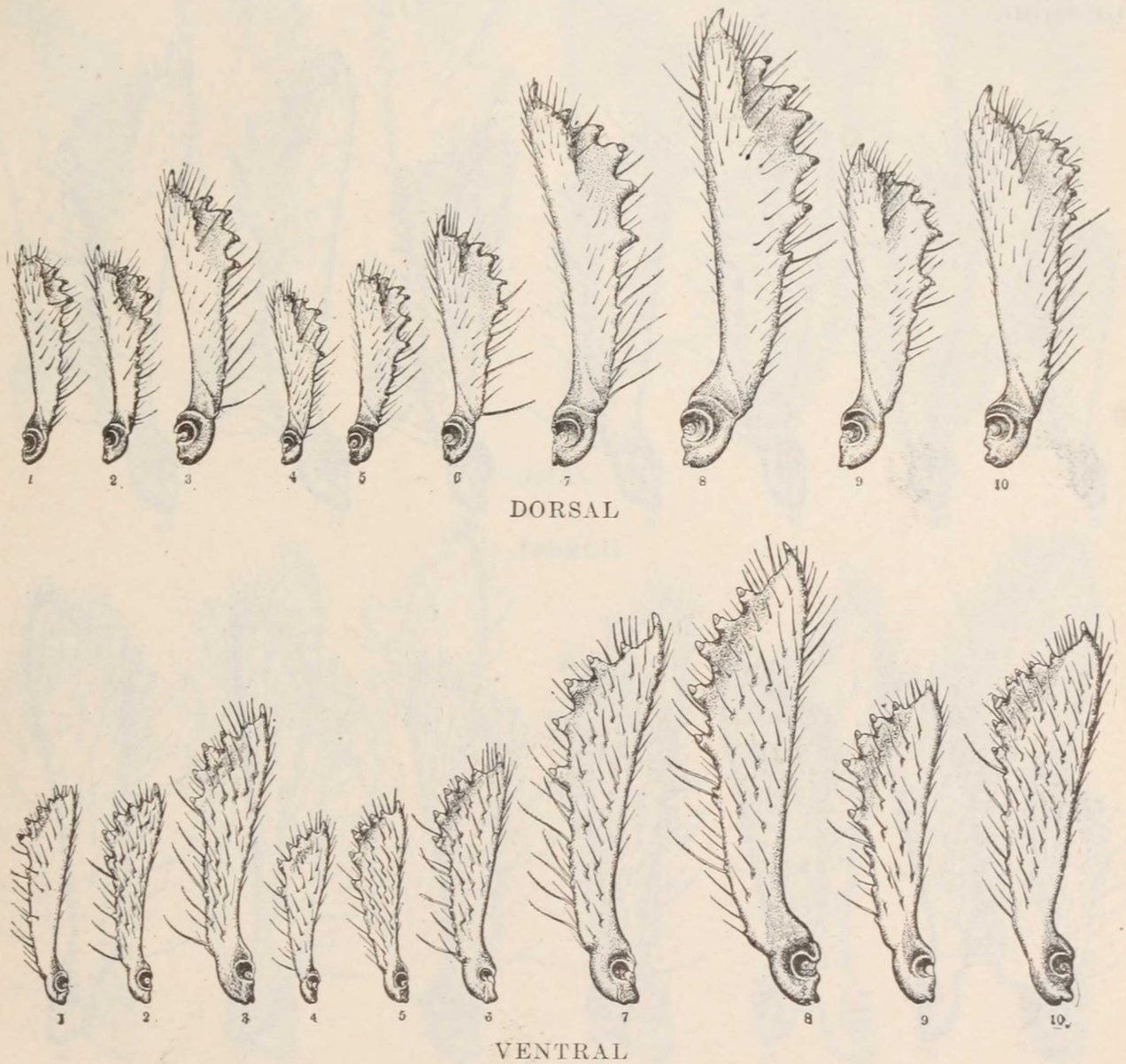


FIG. 27.—*Dendroctonus:* Left tibiæ, dorsal and ventral aspects. *1, brevicomis; 2, barberi; 3, convexifrons, 4, frontalis; 5, arizonicus; 6, mexicanus; 7, parallelocollis; 8, approximatus; 9, monticolæ; 10, ponderosæ.* (Original.)

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.

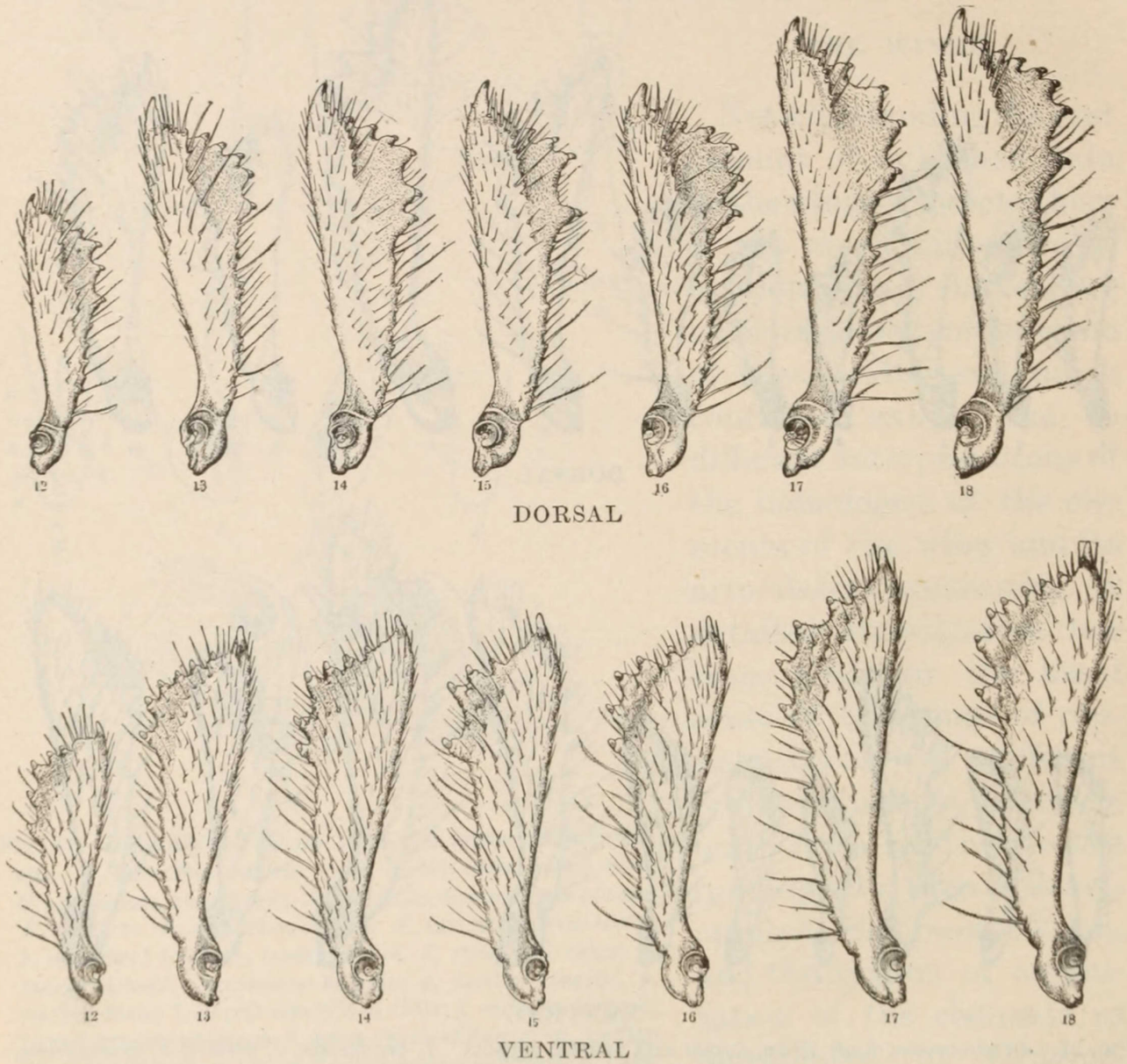


Fig. 28.—*Dendroctonus:* Left tibiæ, dorsal and ventral aspects. *12, simplex; 13, pseudotsugæ; 14, piceaperda; 15, engelmanni; 16, borealis; 17, obesus; 18, rufipennis.* (Original.)

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

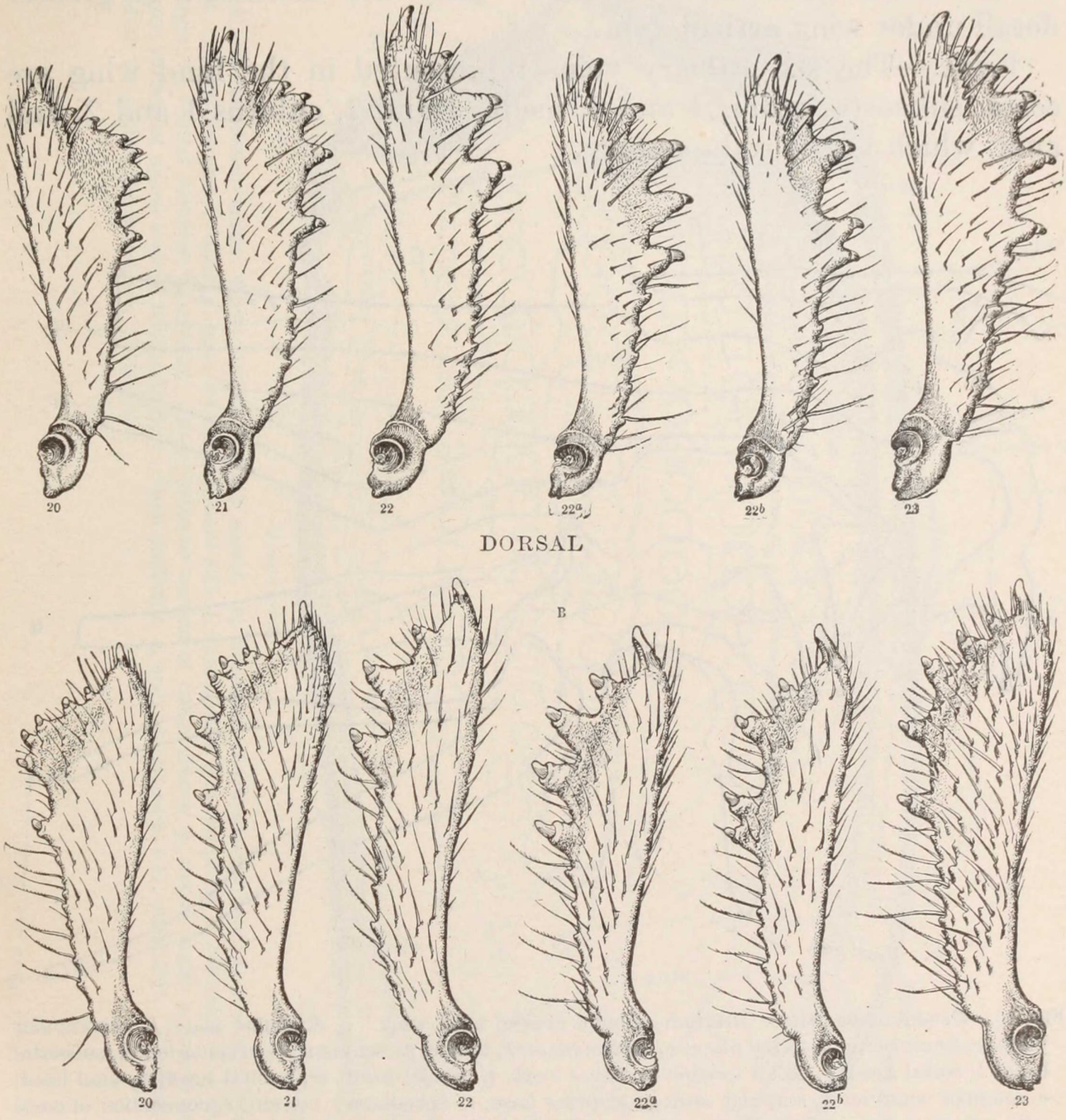


FIG. 29.—*Dendroctonus:* Left tibiæ, dorsal and ventral aspects. *20, punctatus; 21, micans; 22a, 22b, terebrans; 23, valens.* (Original.)

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.

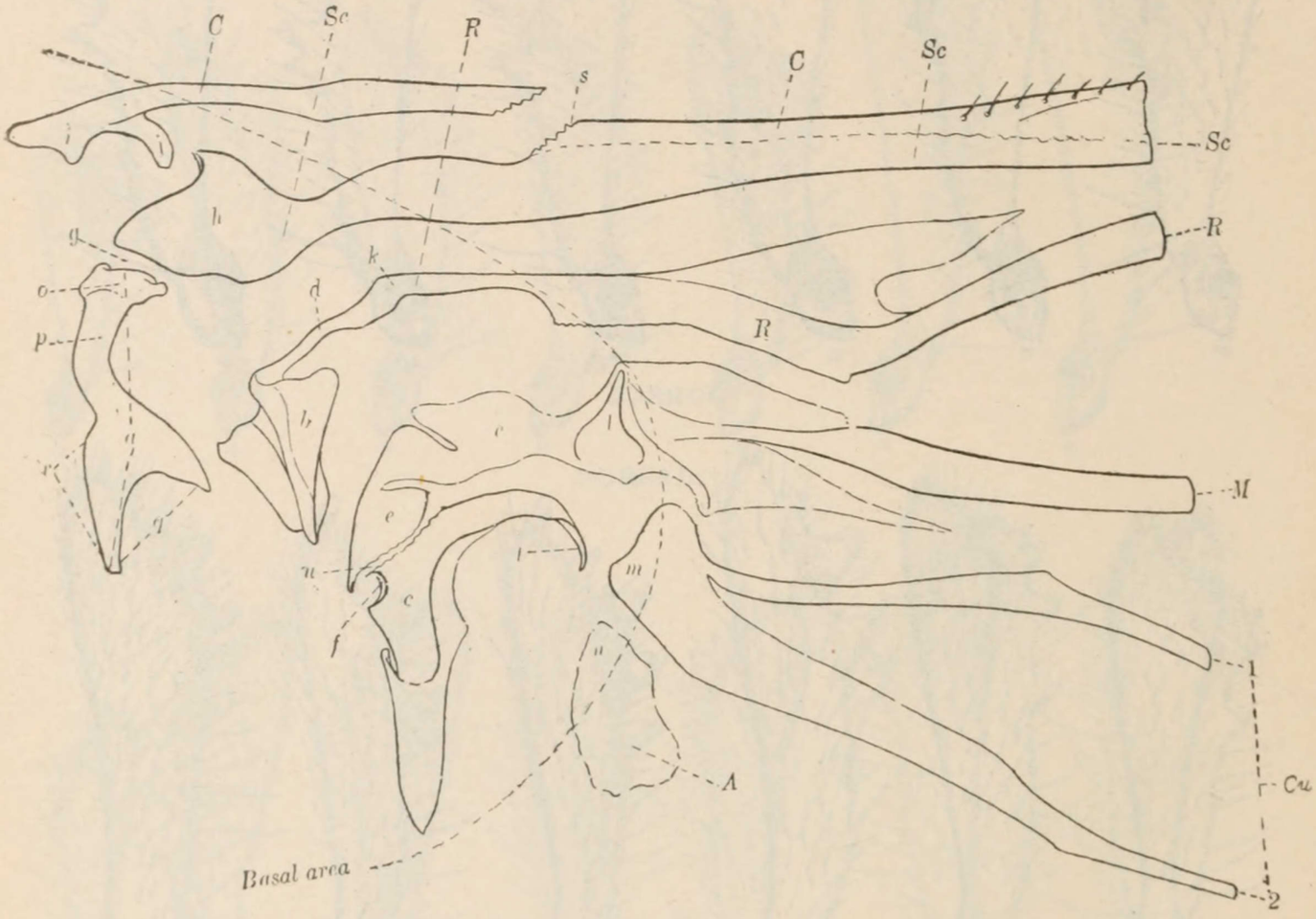


FIG. 30.—*Dendroctonus valens:* Diagram of basal area of hind wing. *a*, Scapular plate; *b*, subscapular plate; *c*, flexor plate; *d*, radial plate; *e*, medial plate; *f*, tendon attachment; *g*, articulation; *h*, subcostal head; *i*, costal head; *j*, costal tongue; *k*, radial head: *l*, medial 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 articulating head. It is broadest where it is joined by the costa, and is strongly narrowed to its junction with the radius.

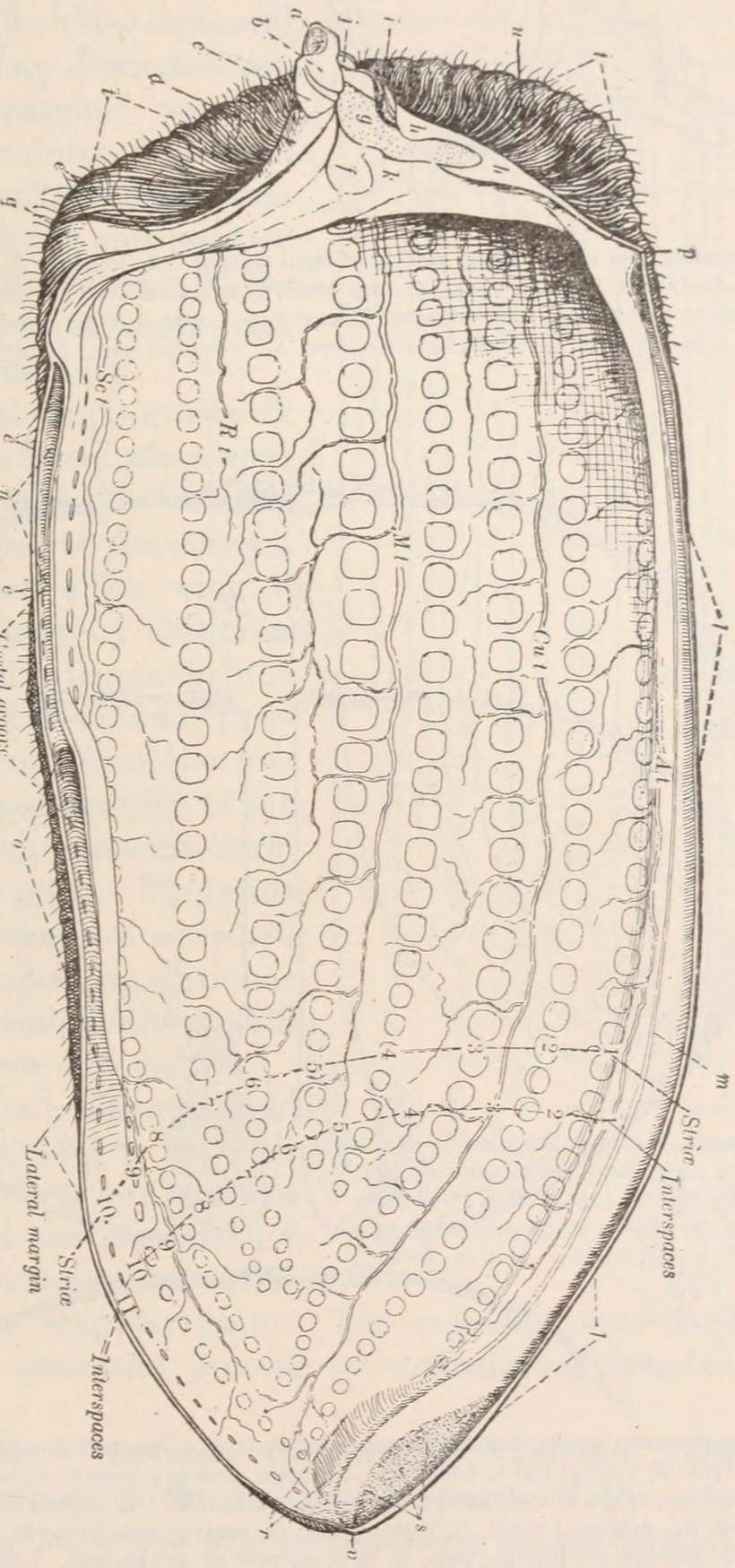


FIG. 31.—*Dendroctonus valens:* Right elytron, ventral aspect. *a*, Foramen of articulatory head; *b*, subcostal head; *c*, costal head; *d*, costal fold; *e*, costal margin; *f*, callus; *g*, basal foramen; *h*, anal fold; *i*, muscle disk; *j*, radial plate; *k*, ventral area; *l*, anal margin, dorsal, 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.)

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

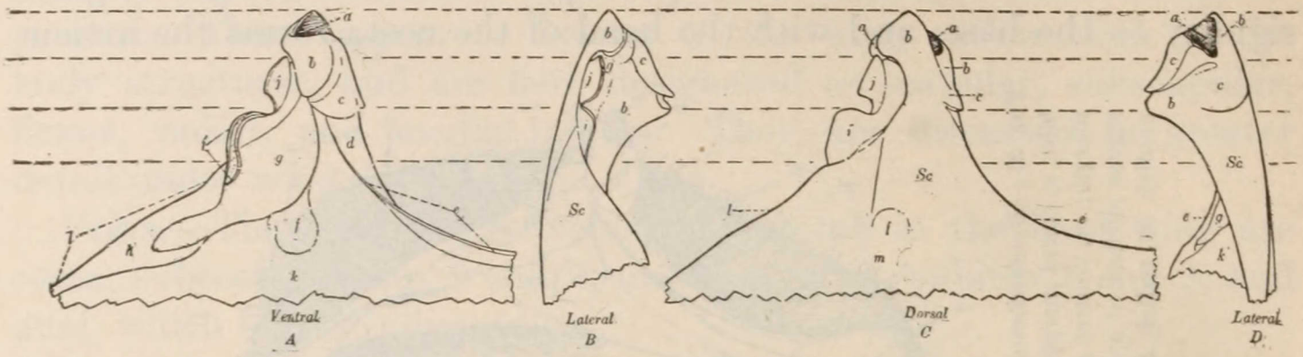


FIG. 32.—*Dendroctonus valens:* Basal process of right elytron. *A*, Ventral; *B*, latero-sinistral; *C*, dorsal; *D*, latero-dextral; *a*, foramen of articulatory head; *b*, subcostal head; *c*, costal head; *d*, costal fold; *e*, costal margin; *f*, callus; *g*, basal foramen; *h*, anal fold; *i*,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

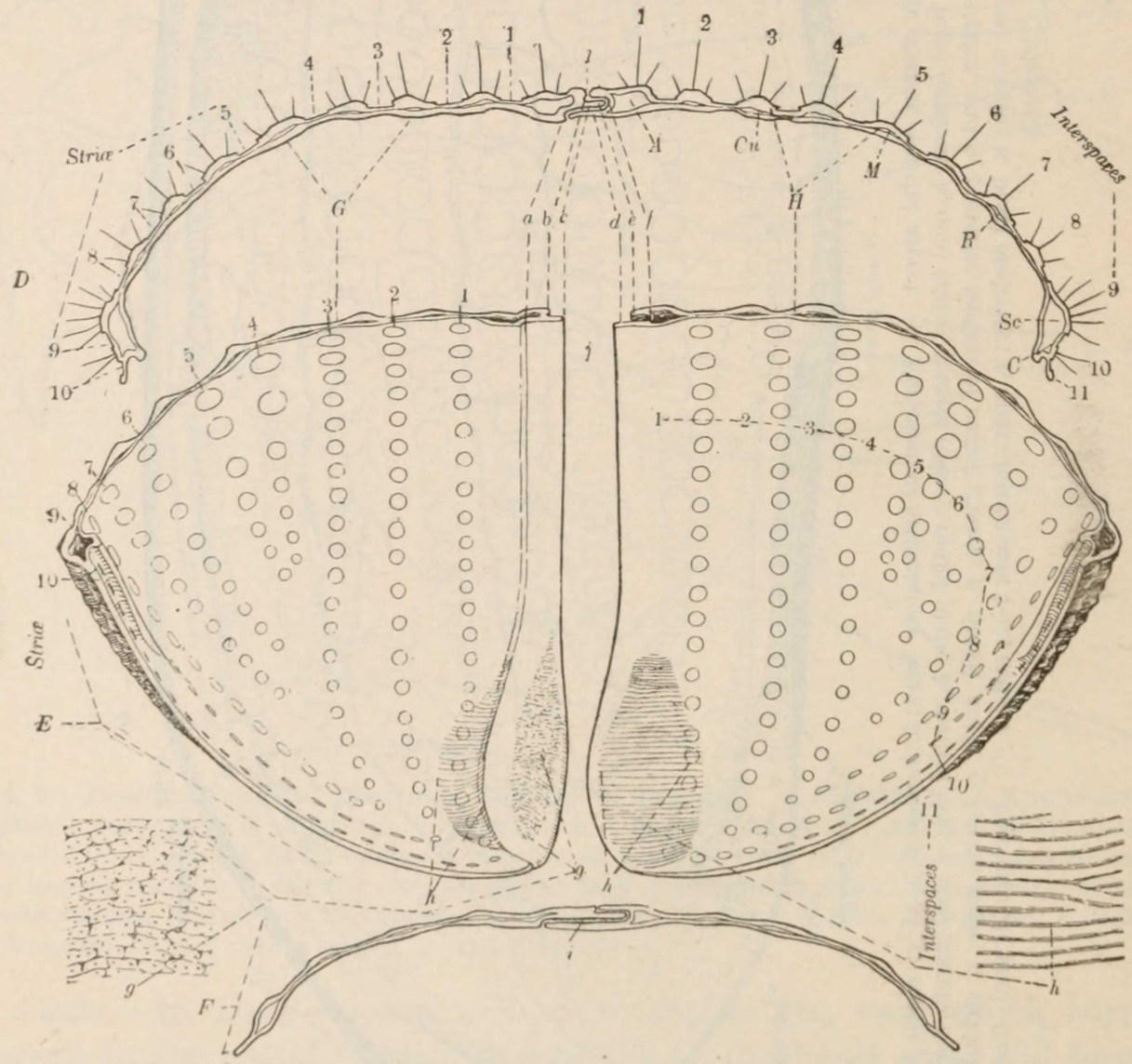


FIG. 33.—*Dendroctonus valens:* Declivital section of elytra. *a*, Ventral shoulder; *b*, dorsal shoulder; *c*, sutural tongue; *d*, ventral lip; *e*, dorsal lip; *f*, sutural groove; *g*, rugose surface of apical wing-lock; *h*, stridulating rasp; *i*, apical wing-lock; *j*, suture; *A*, anal canal; *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, flexible medial plate, which is joined to the flexor, radial, and subscapular plates by membrane and flexible chitin. Near the distal limit of the basal area there is an evident fold or cross vein connecting the base of the media with the base of the cubitus, from which it proceeds outward to the hinge, and from this point two branches extend to the anal margin.

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

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

Wing attachment.—The wing is attached to the body by chitinous dorsal and ventral integument, the latter arising from the dorsal margin of the epimerum, and the former from the lateral margins of the prescutum, scutum, and scutellum, as indicated in the pupa. The heads or roots of the veins are attached by a system of connecting chitinous tendons and ligaments to the pleural and tergal processes and disks.

Wing articulation.—The principal articulation of the wing is between the wing head formed by the costa and subcosta and the condyles of the clavicle and coracoid processes together with the scapular plate. The scapular plate is also connected with the prescutal process by articulating membrane and ligaments.

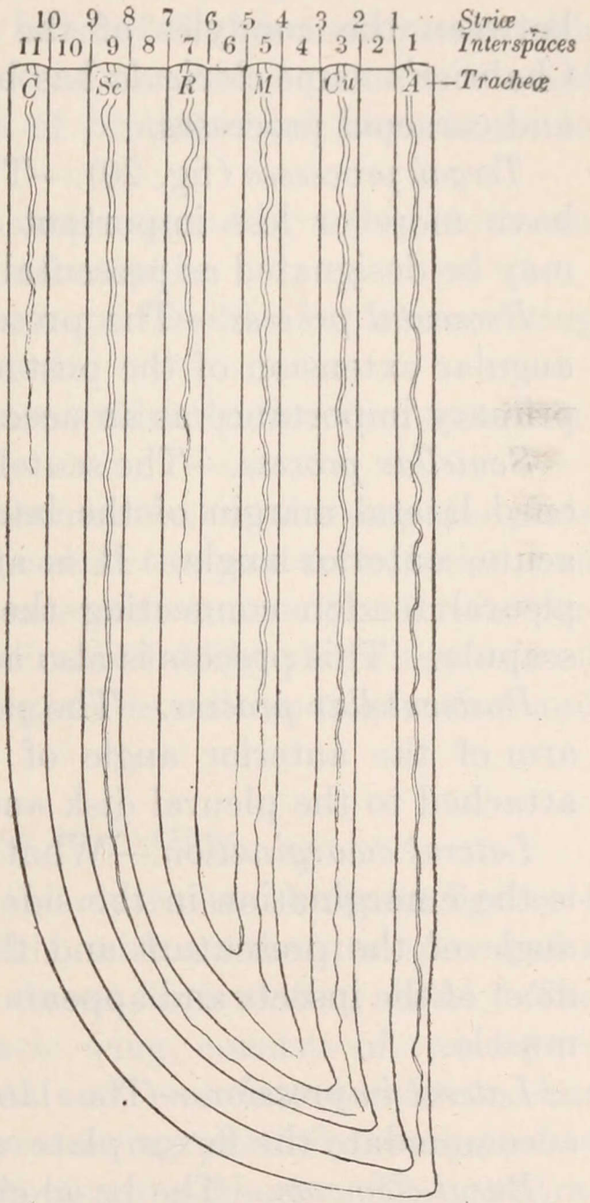


FIG. 34.—*Dendroctonus valens:* Diagram of elytron, showing striæ, interspaces, and tracheæ. Striæ 1–10; interspaces 1–11. Tracheæ: *C*, costal; *Sc*, subcostal; *R*, radial; *M*, medial; *Cu*, cubital; *A*, anal. (Original.)

Pleural clavicula ("clavicula thoracique," Chabrier, 1820).—The position and function of the articular processes of the episternum and epimerum (fig. 20, *pc*), as represented more or less distinctly in all insects, are in *Dendroctonus* so strikingly analogous with that of the *clavicle* and *coracoid* in winged vertebrates as to suggest to the writer the same names. The giving of these names conforms with the practice 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.

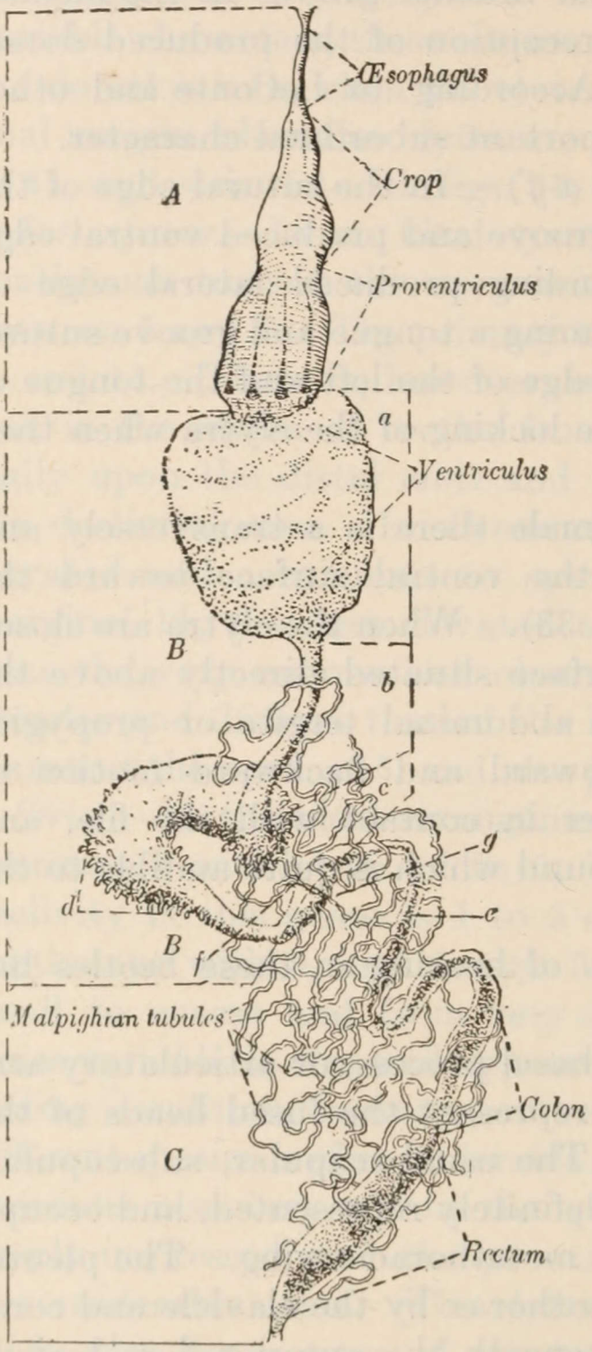


FIG. 35.—*Dendroctonus valens:* Digestive organs of adult. *A*, Fore intestine; *B*, mid intestine; *C*, hind intestine; *a*, anterior section of mid intestine; *b*, median section of mid intestine; *c*, posterior section of mid intestine; *d*, cœcal glands; *e*, ileum or small intestine; *f*, base of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

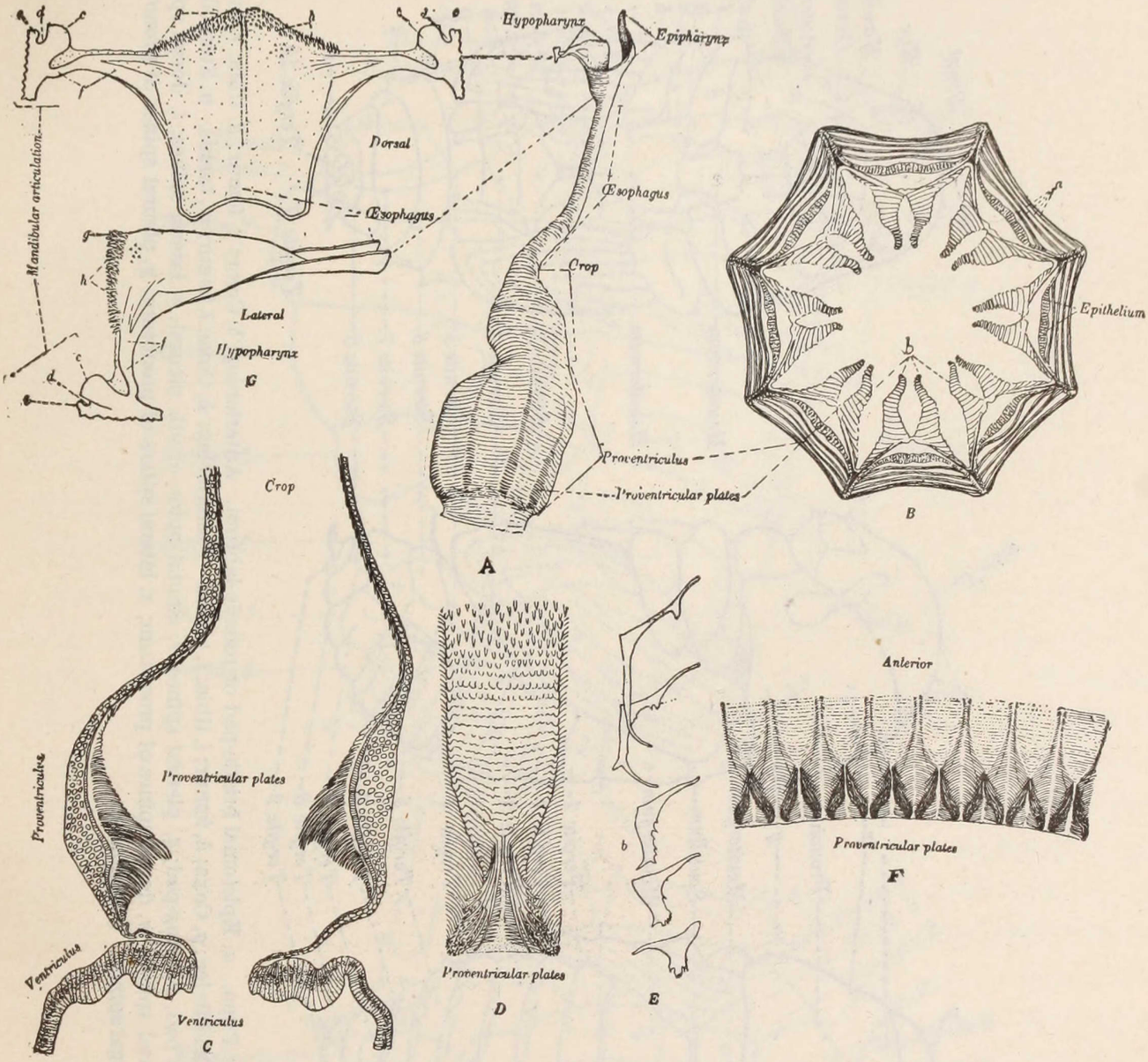


FIG. 36.—*Dendroctonus valens:* Fore intestine, showing details. *A*, Fore intestine; *B*, transverse section of proventriculus; *C*, longitudinal section of same; *D*, single plate; *E*, teeth; *F*, plates; *G*, hypopharynx; *a*, muscles; *b*, proventricular teeth; *c*, posterior condyle of mandibular 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

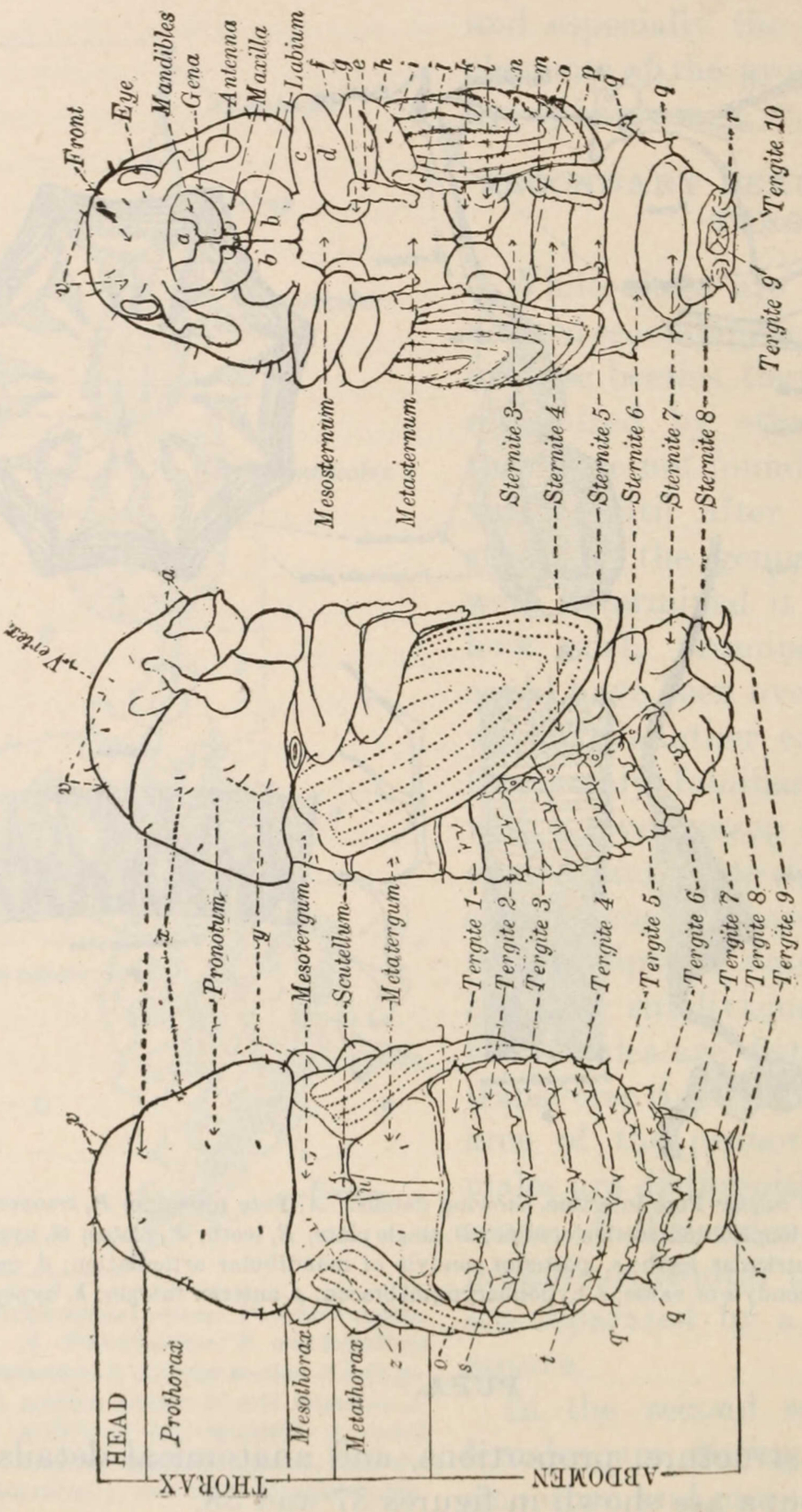


FIG. 37.—*Dendroctonus valens:* Pupa. *a*, Epistomal bristle-pad or pseudo-labrum. Anterior leg: *b*, Coxæ; *c*, femur; *d*, tibia; *e*, tarsus; *f*, apical spines of femur. Middle leg: *g*, Coxa; *h*, femur; *i*, tibia; *j*, tarsus. Posterior leg: *k*, Coxa; *l*, femur; *m*, tarsus. *n*, Sternellar 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

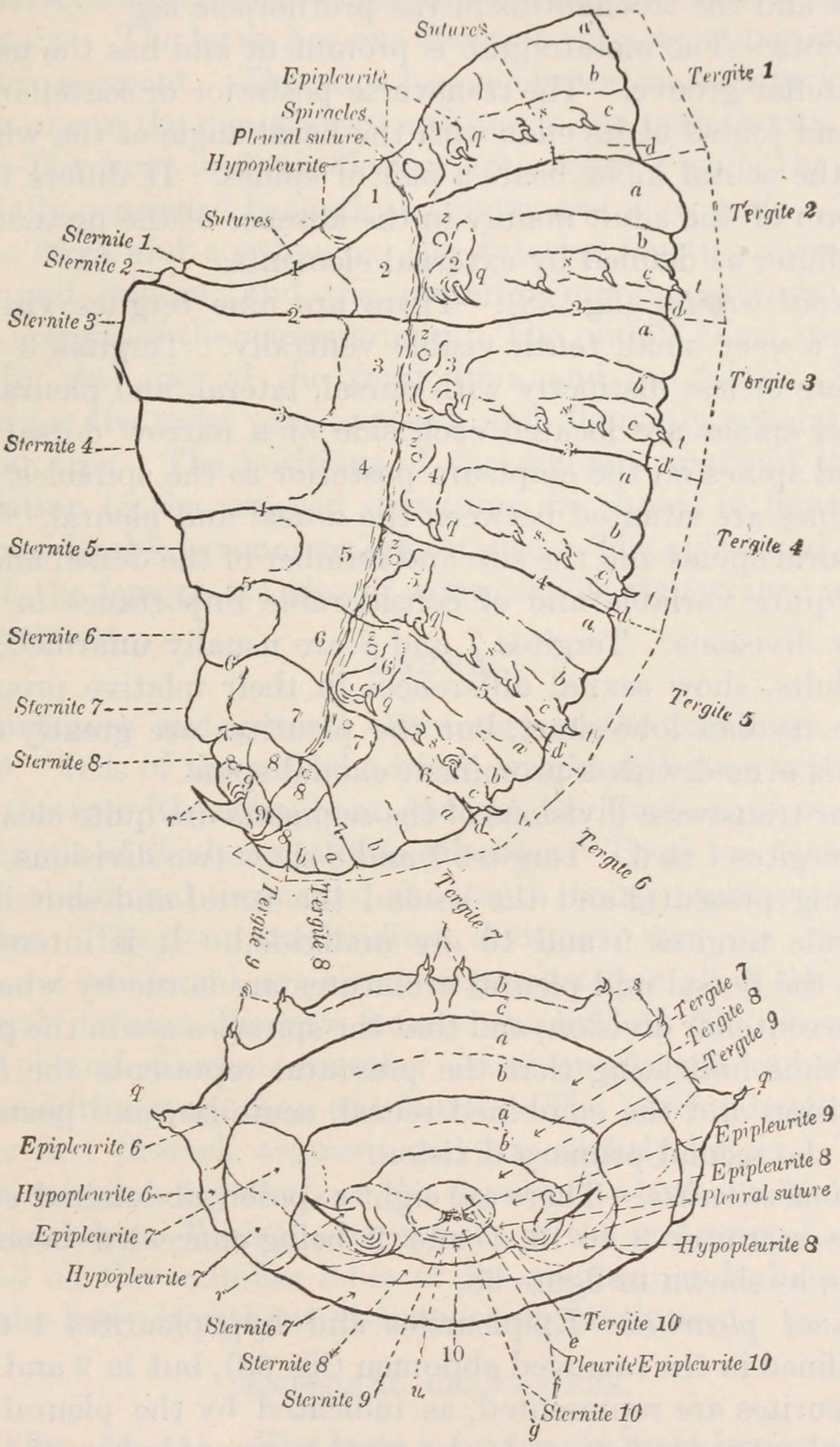


FIG. 38.—*Dendroctonus valens:* Abdomen of pupa, lateral and anal aspects. *a*, Prescutal lobe; *b*, scutal lobe; *c*, scutellar lobe; *d*, postscutellar area; *e*, supraanal lobe; *f*, paranal lobe; *g*, infraanal lobe; *q*, pleural spines; *r*, caudal spine or epipleural spine of the 9th segment; *s*, 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 labrum, 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

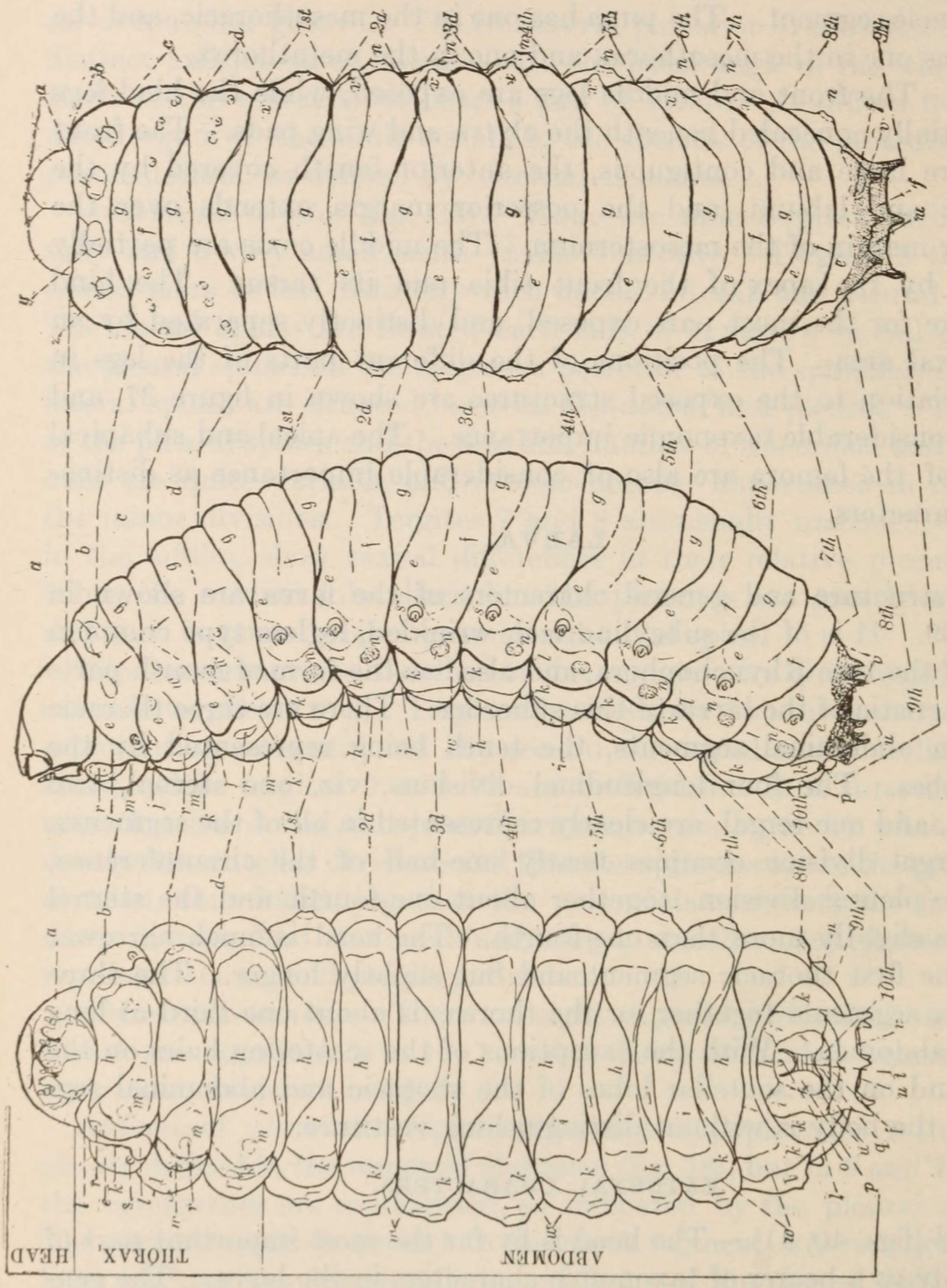


FIG. 39.—*Dendroctonus valens:* Larva. *a*, Head; *b*, prothoracic segment; *c*, mesothoracic segment; *d*, metathoracic segment. Lobes: *e*, Scutal; *f*, scutellar; *g*, prescutal; *h*, sternal; *i*, sternellar; *j*, poststernellar; *k*, hypopleural; *l*, epipleural. *m*, *m*, Foot calli; *n*, *n*, epipleural calli and tubercles; *o*, infraanal lobe or sternite of the 10th segment; *p*, paranal lobe or 10th pleurite; *q*, supraanal lobe or 10th 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.

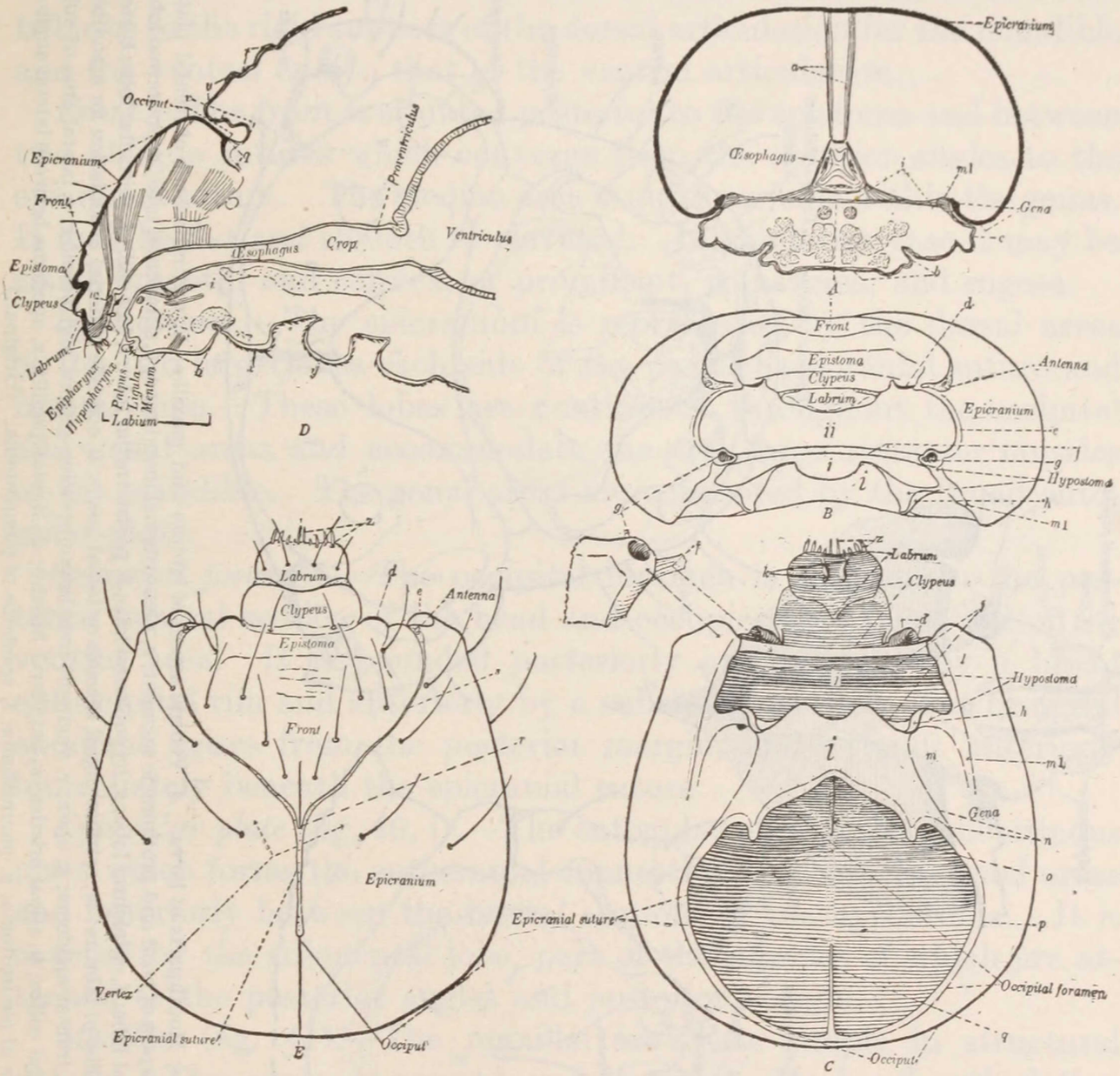


FIG. 40.—*Dendroctonus valens:* Head of larva. *A*, Transverse section; *B*, oral aspect; *C*, ventral aspect; *D*, longitudinal section; *E*, dorsal aspect; *a*, muscles; *b*, submental lobe; *c*, maxilla; *d*, condyle of dorsal articulation of mandible; *e*, pleurostoma; *f*, hypopharyngeal bracon; *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 vari-

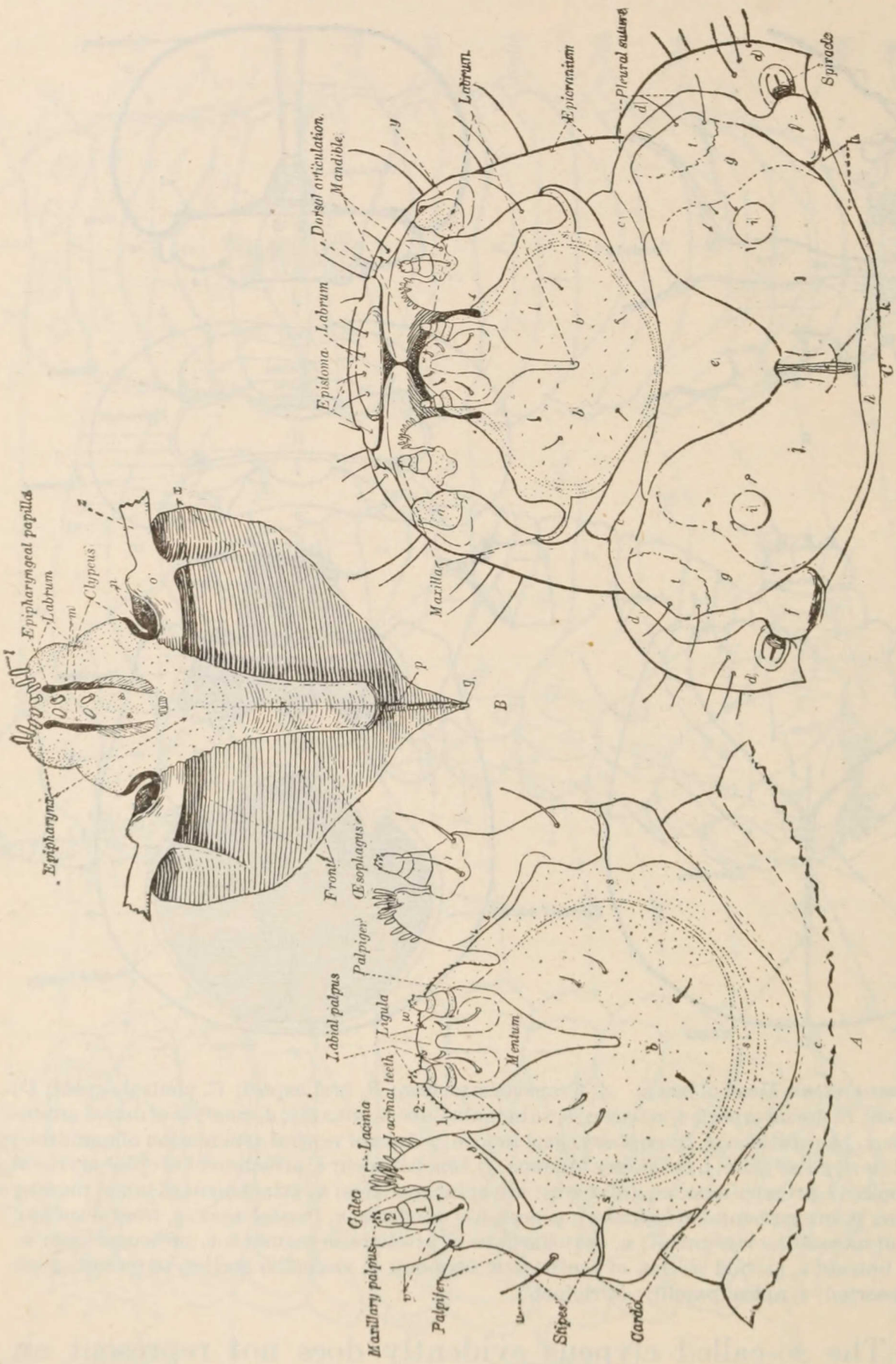


FIG. 41.—*Dendroctonus valens:* Mouthparts of larva. *A*, Ventral aspect of labium and maxillæ; *B*, ventral aspect of frontal plate, labrum, etc.; *C*, ventral aspect of head and prothoracic segment; *a*, pleurostomal membrane; *b*, submental lobe; *c*, presternal lobe; *d*, prescutal lobe; *e*, sternal 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 bracons 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*, palpiferal bristles; *w*, ligular papilli; *x*, apodeme between lateral angle of epistoma and dorsal angle of pleurostoma; *y*, pleurostoma; *z*, apodeme of pleurostoma. (Original.)

able 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.

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

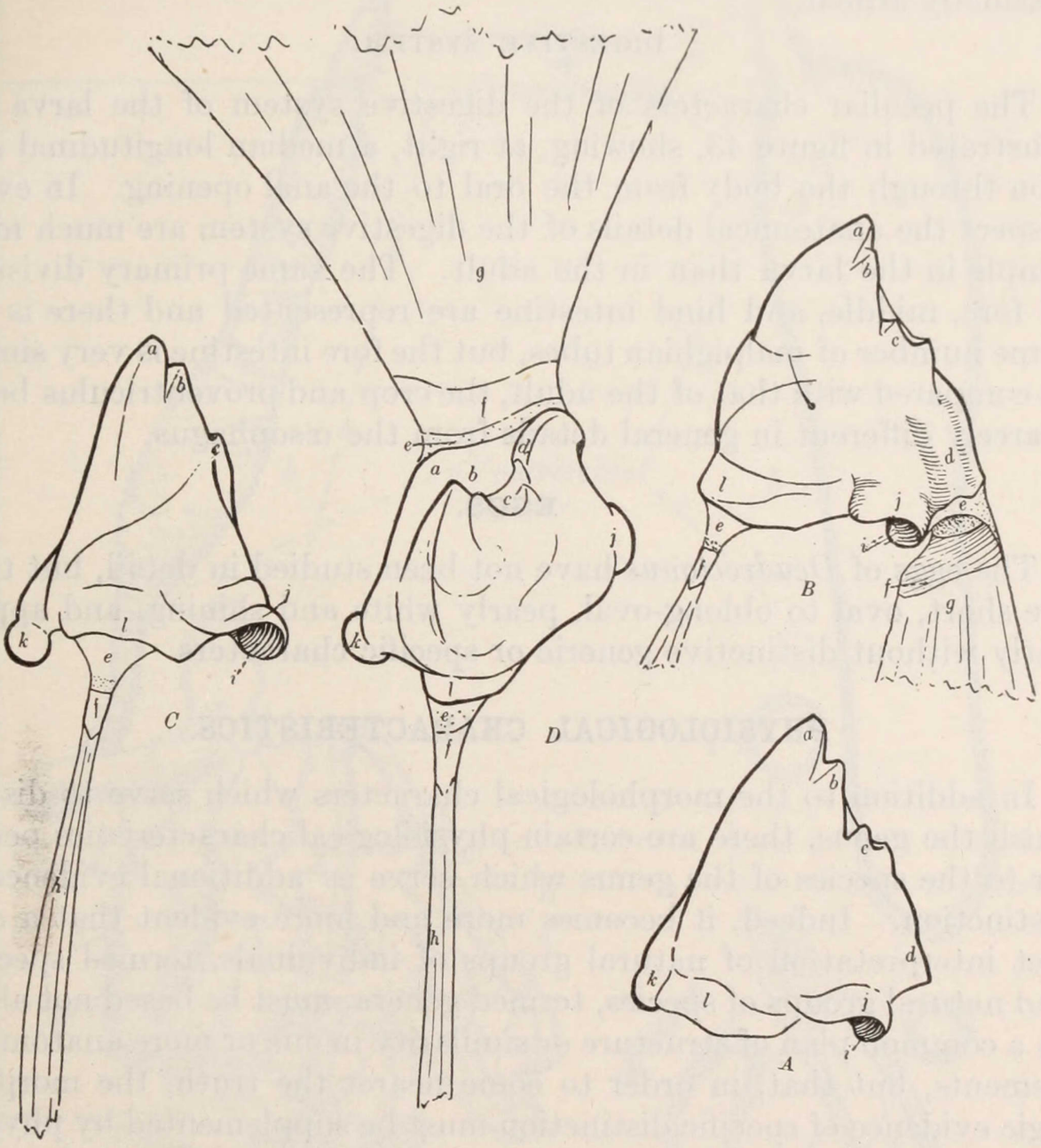


FIG. 42.—*Dendroctonus valens:* Mandibles of larva. *A*, Latero-dorsal aspect; *B*, dorsal aspect; *C*, lateral aspect; *D*, apical aspect; *a*, apical tooth; *b*, subapical tooth; *c*, median tooth; *d*, molar tooth; *e*, extensor tendon; *f*, retractor muscle disk; *g*, retractor muscle; *h*, extensor 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 especially 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).

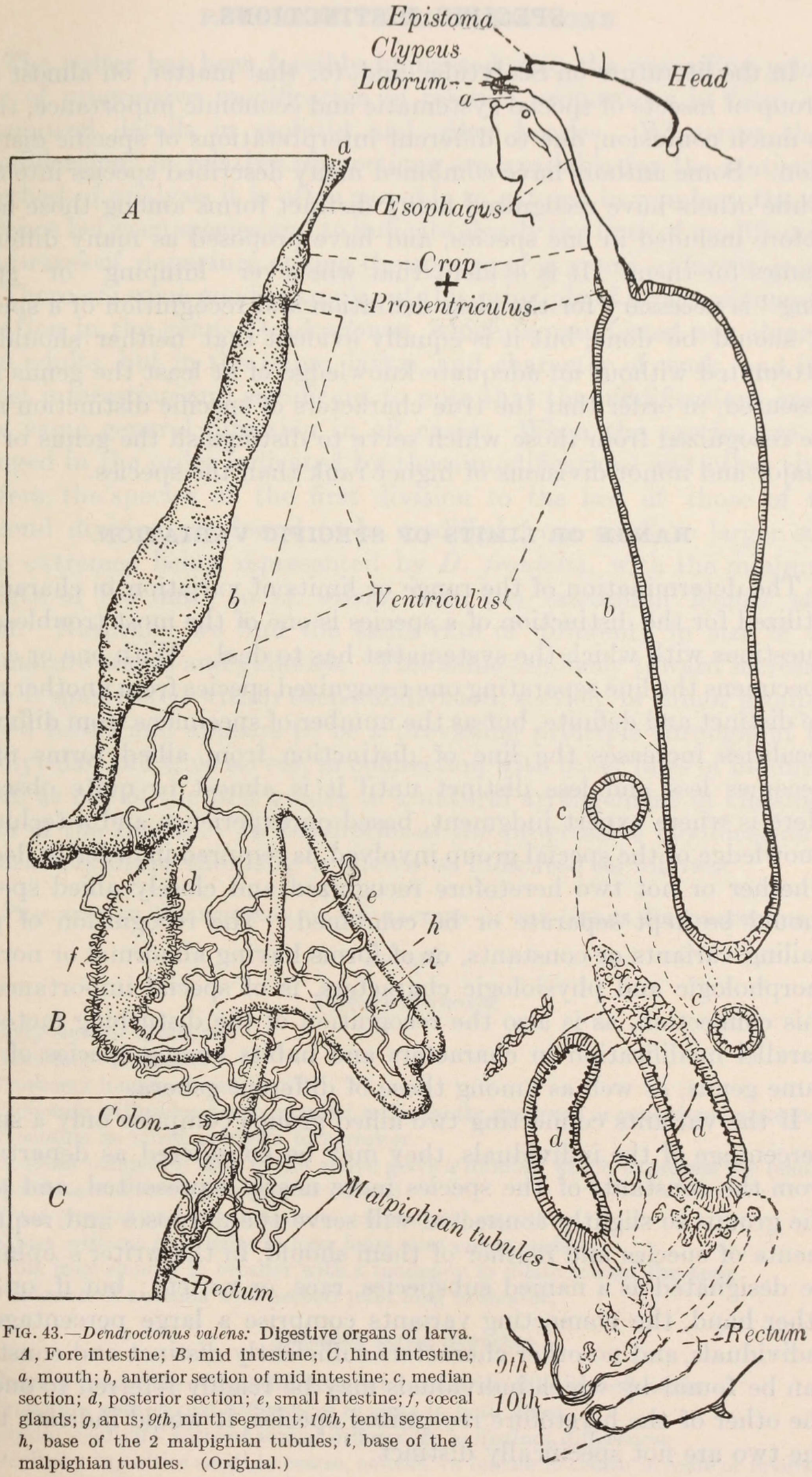


FIG. 43.—*Dendroctonus valens:* Digestive organs of larva. *A*, Fore intestine; *B*, mid intestine; *C*, hind intestine; *a*, mouth; *b*, anterior section of mid intestine; *c*, median section; *d*, posterior section; *e*, small intestine; *f*, cœcal glands; *g*, anus; *9th*, ninth segment; *10th*, tenth 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.

Length 6 mm.; elytra reddish; pronotum darker; elytral striæ moderately impressed, punctures of striæ of dorsal area small, obscure, and those of the lateral area moderately coarse; interspaces flat, with rugosities moderately coarse, obtuse, and rather densely placed; pronotum with punctures more regular in size than usual. Alaska..... 16. *borealis* n. sp., page 133.

Length 6 to 7 mm.; black; elytral striæ but faintly impressed; punctures rather coarse; interspaces flat; rugosities moderately coarse, not dense, acute toward vertex; pronotum with fine punctures, moderately dense, coarser toward sides. Pacific coast, Oregon to Sitka, in *Picea sitchensis*..... 17. *obesus* (Mann.), page 135.

Subsection b4.

Striæ of declivity with *fine* punctures..... Series c3, page 72.

Striæ of declivity with *coarse* punctures..... Series c4, page 72.

Series c3.

Length 5 to 7.3 mm.; elytra red; pronotum brown to black; body rather stout; elytral striæ scarcely impressed, except on dorsal area; strial punctures moderately coarse; rugosities of interspaces moderately coarse, acute, not dense; pronotal punctures coarse, deep, moderately dense; elytral declivity with interspaces moderately punctured. Lake Superior, in *Pinus strobus*.

18. *rufipennis* (Kirby), page 138.

Length 5.4 to 6.5 mm.; elytra dark reddish; pronotum dark; body somewhat slender, as compared with species 18; elytral striæ moderately impressed; punctures coarse, shallow; pronotal punctures coarse, not distinctly irregular and moderately dense; elytral declivity with interspaces finely densely produced. Yellowstone National Park and Keystone, Wyoming; Alberta, and British Columbia, in *Pinus*..... 19. *murrayanæ* n. sp., page 140.

Series c4.

Length 6.5 mm.; brownish; elytral striæ impressed; punctures coarse, interspaces narrow and moderately coarse, acute, rugosities coarser toward the suture. New York to West Virginia, in *Picea*..... 20. *punctatas* Lec., page 142.

Length 7 to 8 mm.; brownish; elytral striæ not impressed on dorsal or lateral areas, punctures moderately coarse, shallow; interspaces broad, flat, shining; rugosities small, obtuse, sparse. Europe, etc., in *Picea*, *Larix*,? and *Abies*?

21. *micans* (Kug.), page 143.

SUBDIVISION D.

Pronotum somewhat elongate, slightly narrower than elytra, moderately constricted toward head, median and posterior dorsal areas without long hairs, but hairs present on anterior and lateral areas; head broad, epistomal process usually broad, concave, with sides strongly oblique; elytral rugosities variable, usually coarse.

Body black.

Length 5 to 8 mm.; black; epistomal process moderately broad, with apical angles usually tuberculate; pronotal punctures very coarse, regular, moderately dense, scarcely decreasing in size toward base; elytra without long hairs toward base. Long Island, New York, south to Florida, west to West Virginia and Texas, in *Pinus*..... 22. *terebrans* (Oliv.), page 147.

Body reddish.

Length 5.7 to 9 mm.; reddish, never black; epistomal process broad, with apical angles obtuse, never tuberculate; pronotum with punctures smaller and denser toward base; elytra with long hairs toward base. Eastern United States and Canada, north of mountains of North Carolina, westward to Pacific coast, south from British Columbia into Mexico, in *Pinus* and *Picea*.

23. *valens* Lec., page 151.

SYNOPSIS OF SECONDARY SEXUAL CHARACTERS.

DIVISION I.

Females: Anterior pronotal area *with* transverse ridge ..... Subdivision A.
Females: Anterior pronotal area *without* transverse ridge..... Subdivision B.

Subdivision A.

Females: With transverse ridge across the anterior area; elytral declivity slightly smoother, more shining, and less rugose..... Species 1 to 8, inclusive.
Males: Without transverse ridge across the anterior area, but with broad impression. Species 1 to 8, inclusive.

Subdivision B.

Females: Elytral declivity with interspaces more shining, rugosities less prominent. Species 9 to 11, inclusive.
Males: Elytral declivity with interspaces more opaque, rugosities more prominent. Species 9 to 11, inclusive.

DIVISION II.

Elytral declivity *with* distinct sexual characters in both sexes..... Subdivision C.
Elytral declivity *without* distinct sexual characters in either sex.... Subdivision D.

Subdivision C.

Females: Interspaces of elytral declivity rugose. *Males:* Interspaces of elytral declivity smooth.
Striæ of elytral declivity *impressed;* interspaces convex in both sexes. Section a3, Species 12 and 13.
Striæ of elytral declivity *not impressed;* interspaces flat..... Section a4.

Section a4.

Females: Striæ of elytral declivity slightly impressed; interspaces subconvex. Species 14 to 21, inclusive.
Males: Striæ of elytral declivity not impressed; interspaces flat. Species 14 to 17, inclusive.
Males: Striæ of elytral declivity slightly impressed; interspaces subconvex, but smoother than in female..... Species 18 to 21, inclusive.

Subdivision D.

Females: Head with front moderately broad; mandibles shining, moderately stout; antennal club broader..... Species 22 and 23.
Males: Head with front broad; mandibles opaque, stout; antennal club narrow, more elongate and less compressed..... Species 22 and 23.

SYNOPSIS OF PUPAL CHARACTERS.

Vertex of head *distinctly to faintly grooved*, and with two small or prominent frontal spines on or toward the vertex each side of groove..... Division I.
Vertex of head *faintly impressed*, flat or convex, and with two small, widely separated frontal granules toward vertex..... Division II.

DIVISION I.

Frontal spines *small;* elytral pads smooth; abdominal tergites 2 to 6 with or without small pleural spines..... Subdivision A.
Frontal spines *large*, prominent; elytral pads rugose; abdominal tergites 2 to 6 with prominent pleural spines..... Subdivision B.

SUBDIVISION A.

Anterior and middle femora *smooth;* abdominal tergites 3 to 6 with small pleural spines; 1 and 2 without distinct dorsal and lateral spines. Section a1, Species 1, 2, and 3.
Anterior and middle femora *with small apical spines* ..... Section a2.

Section a2.

Abdominal tergites 2 to 6 *without* distinct pleural spines; 7 and 8 with small granules..... Species 4.
Abdominal tergites 2 to 6 *with* small pleural spines of *equal size;* 7 and 8 with small granules..... Species 5.
Abdominal tergites 1 to 6 *with* small pleural spines, *increasing in size;* 7 and 8 smooth. Species 8.

SUBDIVISION B.

Apex of anterior and middle femora with *two spines*..... Species 9.
Apex of anterior and middle femora with *one spine;* abdominal spines and elytral rugosities coarser than in species 9..... Species 10.
Apex of anterior and middle femora with *two spines;* abdominal spines apparently less prominent than in species 9 and 10..... Species 11.

DIVISION II.

Vertex of head *flattened* or faintly impressed; apex of front and middle femora smooth or with minute granule; abdominal tergites with pleural and dorsal spines moderately prominent..... Subdivision C.
Vertex of head *convex;* front and middle femora each with a minute pilated, subapical granule; abdominal tergites with less distinct pleural and dorsal spines. Subdivision D.

SUBDIVISION C.

Tergal spines of abdomen *with pale or white tips;* segment 7 smooth..... Section a3.
Tergal spines of abdomen *with pale, dark, or black tips;* segment 7 with a few setigerous granules..... Section a4.

Section a3.

Anterior and middle femora *with* minute apical spines; abdominal tergites 2 to 6 with stout, prominent pleural spines; 3 to 6 with prominent dorsal spines. Species 12.
Anterior and middle femora *without* apical spines; abdominal tergites 2 to 6 with moderately stout pleural spines, and 3 to 6 with small dorsal ones..... Species 13.

Section a4.

Vertex of head *moderately impressed;* anterior and middle femora without apical spines; abdominal tergites 2 to 6 with very small pleural spines; 4 to 6 with small dorsal spines, all with pale tips..... Species 14.
Vertex of head *distinctly impressed;* abdominal tergites 2 to 6 with distinct pleural spines, and 3 to 6 with distinct dorsal ones..... Species 15.
Abdominal tergites 2 to 6 with very small pleural, lateral, and dorsal spines, all with dark tips..... Species 17.

SUBDIVISION D.

Abdominal tergites 1 to 6 with moderately small pleural spines, 2 to 6 with small dorsal and lateral ones, all with pale tips..... Species 22.
Same as preceding, except spines have darker to black tips..... Species 23.

SYNOPSIS OF LARVAL CHARACTERS.

Abdominal tergites 8 and 9 *without* dorsal plates..... Division I.
Abdominal tergites 8 and 9 *with* dorsal plates, except in section a3..... Division II.

DIVISION I.

Front *with or without* median convexity..... Subdivision A.
Front *with transverse* elevation slightly more prominent toward the sutures. Subdivision B.

Subdivision A.

Front *without* median convexity..... Section a1.
Front *with* median convexity..... Section a2.

Section a1.

Clypeus with apex *subacutely* emarginate..... Species 1.
Clypeus with apex *broadly* emarginate..... Species 2.

Section a2.

Prothoracic lobes *without* foot calli..... Subsection b1.
Prothoracic lobes *with* distinct foot calli..... Subsection b2.

Subsection b1.

Front smooth, with shining convexity; clypeus with apex broadly emarginate. Species 3.

Subsection b2.

Front smooth, with median *smooth* convexity; clypeus with apex deeply emarginate..... Species 4.
Front with anterior third transversely *rugose* and with transverse median convexity, produced toward apex; clypeus with apex broadly emarginate..... Species 5.
Front with broad convexity; clypeus with apex truncated..... Species 8.

Subdivision B.

Front of head with posterior apex *subacute;* frontal elevation moderately stout in the middle; clypeus with faint median tubercle toward the base..... Species 9.
Front of head with posterior apex *subobtuse;* frontal elevation stout slightly *posterior* to the middle; clypeus with a faint median groove and elevation toward base. Species 10.
Front of head with posterior apex *subacute;* frontal elevation narrow, situated in the *middle*, not more distinctly elevated toward suture; clypeus with faint median groove, without elevation..... Species 11.

DIVISION II.

Abdominal tergites 8 and 9 without dorsal plate, or with *unarmed* plates. Subdivision C.
Abdominal tergites 8 and 9 with *armed* plates..... Subdivision D.

Subdivision C.

Abdominal tergites 8 and 9 *without* dorsal plates..... Section a3.
Abdominal tergites 8 and 9 *with* dorsal plates, excepting *micans*, in which 8 is unarmed..... Section a4.

Section a3.

Front with *indistinct* transverse elevation; clypeus with distinct median impression. Species 12.

Front with *distinct* transverse elevation; clypeus with median impressed line. Species 13.

Section a4.

Abdominal tergites 8 and 9 with rugose but unarmed plates; front with faint transverse elevation anterior to middle; clypeus with median groove..... Species 14.

Frontal elevation *near the middle*..... Species 15.

Frontal elevation distinctly *anterior to middle*..... Species 16.

Front with lateral impressions toward the anterior angles, and frontal elevation anterior to middle..... Species 19.

Abdominal tergite 9 with dorsal plate; frontal elevation anterior to middle; clypeus with median groove..... Species 21.

SUBDIVISION D.

Abdominal tergites 8 and 9 each with dorsal plate and armed with three permanent teeth; front of head without elevation; clypeus with faint median groove. Species 22 and 23.

SYNOPSIS OF GALLERY CHARACTERS.

Egg galleries *winding to straight; eggs isolated or in approximate groups*, but never in masses; larval mines exposed or concealed in inner bark..... Division I.

Egg galleries *longitudinal*, straight to slightly winding; *eggs in groups or masses;* larval mines and pupal cells exposed in inner bark..... Division II.

DIVISION I.

Pupal cells in *outer bark;* eggs *isolated*, never in groups; egg galleries winding; larval mines short, narrow to broad, exposed or concealed..... Subdivision A.

Pupal cells in *inner bark;* eggs in *approximate groups;* egg galleries slightly winding to straight; larval mines short, broad, always exposed..... Subdivision B.

SUBDIVISION A.

Larval mines *concealed* in inner bark..... Section a1.

Larval mines *exposed* or concealed..... Section a2.

Section a1.

Egg galleries *subtransverse*, winding..... Species 1.

Egg galleries *distinctly transverse*..... Species 2.

Section a2.

Larval mines *exposed.*

Egg galleries *longitudinal*, winding..... Species 3.

Egg galleries *sublongitudinal*, winding..... Species 4.

Larval mines *concealed.*

Egg galleries evidently transverse, or subtransverse, winding, with concealed larval mines..... Species 5.

Egg galleries *subtransverse*, winding..... Species 6.

Egg galleries *longitudinal*, winding, with transverse branches.. Species 7 and 8.

SUBDIVISION B.

Egg galleries *winding to straight*..... Species 9.

Egg galleries *usually straight*..... Species 10 and 11.

DIVISION II.

Larval mines *separate*, especially beyond the middle..... Subdivision C.
Larval mines *contiguous*, forming broad larval chamber..... Subdivision D.

SUBDIVISION C.

Egg galleries slightly winding to straight; eggs in groups, but larval mines separate from the beginning..... Section a3.
Egg galleries broad, nearly straight; eggs in small to large groups, the larval mines usually contiguous toward the egg gallery..... Section a4.

Section a3.

Larval mines normally *short* and *broad*..... Species 12.
Larval mines normally *long*..... Species 13.

Section a4.

Subsection b3.

Larval mines separated beyond the middle..... Species 14, 15, and 16.

Subsection b4.

Larval mines usually not separated beyond the middle, but forming a common chamber. Species 19 to 21.

SUBDIVISION D.

Egg galleries broad to very broad, short to very long, straight to winding; larval mines forming a large common chamber..... Species 22 and 23.

TABLE OF DISTRIBUTION.[a]

America, north of Guatemala, and in northern Europe..... The genus.

DIVISION I.

SUBDIVISION A.

North American continent, in South Atlantic and Gulf States and Southwestern States, southward to Guatemala and northward in Sierra Nevada and Cascade Mountains to British Columbia..... Sections a1 and a2.

Section a1.

West of western Montana and southwestern Idaho, and southward to Santa Barbara County, California..... Species 1, page 81.
South of southern Colorado and Utah, into Texas and Mexico, and westward into southern California, and possibly in the Coast Range and northward along the forested foothills into northern California..... Species 2, page 85.

Section a2.

Southern Colorado and Utah, southward into Mexico..... Species 3, page 87.
Atlantic and Gulf States, southwestward into Texas..... Species 4, page 90.
Central to southern Arizona..... Species 5, page 95.
Southern Mexico..... Species 6 and 7, pages 97, 99.
Central Colorado and southern Utah, southward to southern Arizona, and New Mexico. Species 8, page 101.

[a] For exact and probable distribution see maps under description of each species.

SUBDIVISION B.

West of western Montana and southwestern Idaho, south through the Sierra Nevada Mountains of California..... Species 9, page 105.
Western South Dakota and southern Wyoming, southward through Utah, Colorado, to southern Arizona and New Mexico..... Species 10, page 109.
Northern California, southward in Sierra Nevada, into San Bernardino County, California..... Species 11, page 114.

DIVISION II.

SUBDIVISION C.

Maine to western Michigan, southward into northwestern West Virginia. Species 12, page 117.
Northern Idaho and Montana, south to southern Arizona and New Mexico, and northern Washington, south into Santa Barbara County, California. Species 13, page 121.

Section a4.

Maine to northeastern Minnesota, southward to central Pennsylvania. Species 14, page 126.
Northern Idaho, east to western South Dakota, southward to southern Arizona and New Mexico..... Species 15, page 130.
Alaska..... Species 16, page 133.
Alaska?, along the coast to northwestern California..... Species 17, page 135.
Lake Superior region..... Species 18, page 138.
Western Montana southeast to central Colorado..... Species 19, page 140.
Higher mountains of New York, Pennsylvania, and West Virginia. Species 20, page 142.
Central Europe to Denmark, Russia, and eastward into Siberia. Species 21, page 143.

SUBDIVISION D.

Atlantic States south of Massachusetts, to Tampa, Florida, westward to western West Virginia and Texas..... Species 22, page 147.
Mountains and foothills of North Carolina, northward into Maine and northwestern Washington, southward into Guatemala..... Species 23, page 151.
Guatemala..... Species 24, page 157.

TABLE SHOWING RELATION OF SPECIES TO HOST TREES.

DIVISION I.

Section a1.

Species 1. *Pinus lambertiana, ponderosa.*
Species 2. *Pinus ponderosa* var. *scopulorum, edulis; Pseudotsuga taxifolia.*

Section a2.

Species 3. *Pinus scopulorum.*
Species 4. *Pinus strobus, tæda, rigida, virginiana, pungens, echinata, glabra, palustris; Picea rubens* and *excelsa.*
Species 5. *Pinus scopulorum.*
Species 6. *Pinus teocotl?, lejophilla,* and *ayacahuite?*
Species 7. Same as 6.
Species 8. *Pinus arizonica, scopulorum,* and *chihuahuana.*

SUBDIVISION B.

Species 9. *Pinus monticola, lambertiana, ponderosa, murrayana; Picea engelmanni.*
Species 10. *Pinus flexilis* and *strobiformis.*
Species 11. *Pinus lambertiana* and *ponderosa.*

DIVISION II.

Section a3.

Species 12. *Larix laricina.*
Species 13. *Larix occidentalis; Pseudotsuga taxifolia* and *macrocarpa.*
Species 14. *Picea mariana, rubens, canadensis.*
Species 15. *Picea canadensis* and *engelmanni.*
Species 16. *Picea canadensis.*
Species 17. *Picea sitchensis.*

Subsection b4.

Species 18. *Pinus strobus.*
Species 19. *Pinus murrayana; Picea engelmanni.*
Species 20. *Picea rubens.*
Species 21. *Pinus, Picea, Abies?, Larix.*

SUBDIVISION D.

Species 22. *Pinus strobus, tæda, rigida, serotina, echinata, palustris.*
Species 23. *Pinus strobus, monticola, lambertiana, strobiformis, ponderosa, scopulorum, jeffreyi, chihuahuana, murrayana, radiata, rigida, virginiana; Larix laricina; Picea rubens, canadensis, excelsa.*

TABLE OF HOST TREES.

	Dendroctonus species number.
Pinus strobus	4, 18, 22, 23.
monticola	9, 23.
lambertiana	1, 9, 11, 23.
flexilis	10.
strobiformis	10, 23.
edulis	2, 23.
arizonica	8, 23.
ponderosa	1, 9, 11, 23.
scopulorum	2, 3, 5, 8, 10, 23.
jeffreyi	11, 23.
chihuahuana	3, 8, 23.
murrayana	9, 10, 19, 23.
radiata	23.
tæda	4, 22.
rigida	4, 22, 23.
serotina	22.
virginiana	4, 23.
pungens	4.
Pinus echinata	4, 22.
glabra	4.
palustris	4, 22.
sylvestris	23.
teocotl	6, 7.
lejophilla	6, 7.
ayacahuite	6, 7.
Larix laricina	12, 23.
occidentalis	13.
Picea mariana	14.
rubens	4, 14, 20, 22, 23.
canadensis	14, 15, 16, 23.
engelmanni	9, 10, 15, 19.
sitchensis	17.
excelsa	4, 23.
Pseudotsuga taxifolia	2, 13.
macrocarpa	13.

REVISION AND SYSTEMATIC NOTES, WITH DESCRIPTIONS OF NEW SPECIES.

DISTINCTIVE GENERIC CHARACTERS.

Adult (figs. 1, 2, 3).—Antennal funiculus 5-jointed; club broad, thickened at base, compressed toward apex, and usually with 4 distinct segments, the sutures curved or nearly straight; tarsi with joint 3 bilobed; tibia with inner angle produced and armed with a single tooth; outer angle oblique and armed with 3 or more stout teeth; distinct dorsal impression toward apex for the retractile tarsus.

Anterior cŏxæ approximate or subcontiguous. Abdominal sternites with ends of sutures 4, 5, and 6 strongly recurved. Body cylindrical, subelongate to stout, ranging in color from reddish and brown to deep black. Head prominent and large, with distinct epistomal process at anterior margin of front. Eyes transversely placed and oblong-oval to oblong-ovate. Antennal insertion in front of ventral end of eye. Pronotum with sides nearly parallel to narrowed and constricted toward head, one-fourth to one-third broader than long. Elytra with base elevated and rugose, remaining surface rugose, with punctured striæ and the declivity convex to subconvex.

Pupa (figs. 37, 38).—The pupa is of the general size of the adult, and is distinguished by its broad prominent head, and the form of the prothorax. The sculpture and armature vary with the age of the specimen. In the preimaginal stage the granules and spines become more obscure.

Larva (text fig. 39; Pl. VIII).—The body of a matured larva of a given species is somewhat longer than the adult or pupa, and is cylindrical, deeply wrinkled, legless, and with a few long hairs on each segment, becoming longer on the posterior ones. The head is moderately large, shining, yellowish, and with a few hairs on the scutellar lobes. Front distinct; antennæ present, but obscure; eye spots not present. The thoracic segments are larger and more prominent in some species than in others. Abdominal segments 1 to 9 are of about equal width and length; 10 is represented by the anal lobe.

Egg.—Short, oval to oblong-oval, pearly white and shining, and apparently without sculpture and specific characters, except in relative size, corresponding with the size of adult representatives of the species.

Galleries.—The primary or egg galleries are excavated in the inner bark and sometimes mark or groove the wood and vary in their course in the bark of the tree from transverse and winding to longitudinal and straight, and normally are of the single unbranched type.

Distribution (Pl. II).—Eastern continent: Central and northern Europe, from Denmark into Siberia. Western continent: Guatemala, northward through the United States into Alaska and Labrador.

Host trees.—Pinus, Picea, Pseudotsuga, Larix, and *Abies,* the latter rarely, if at all.

BIBLIOGRAPHY AND SYNONYMY OF GENUS.

Erichson, 1836, pp. 52–53, original description, to include *D. micans* (Kug.) (type), *D. terebrans* (Oliv.) (cotype), *Myelophilus piniperda* (L.), *Myelophilus minor* (Hartig), and *Carphoborus minimus* (Fab.). Eichhoff, 1864, pp. 26–27, Pl. I, figs. 5, 6, 7, tibia, maxilla, labium, revised description to include the single European species, *D. micans* (Kug.). Lacordaire, 1866, pp. 360–361, revision to include *D. micans* (Kug.) and *D. terebrans* (Oliv.). Zimmermann, 1868, pp. 148–149, revision to include *Carphoborus bifurcus* Eich., *D. terebrans* (Oliv.), and *D. frontalis* Zimm. Le Conte, 1868, pp. 172–173, revision to include *D. terebrans* Lec., *D. obesus* (Mann.), *D. rufipennis* (Kirby), *D. punctatus* Lec.,

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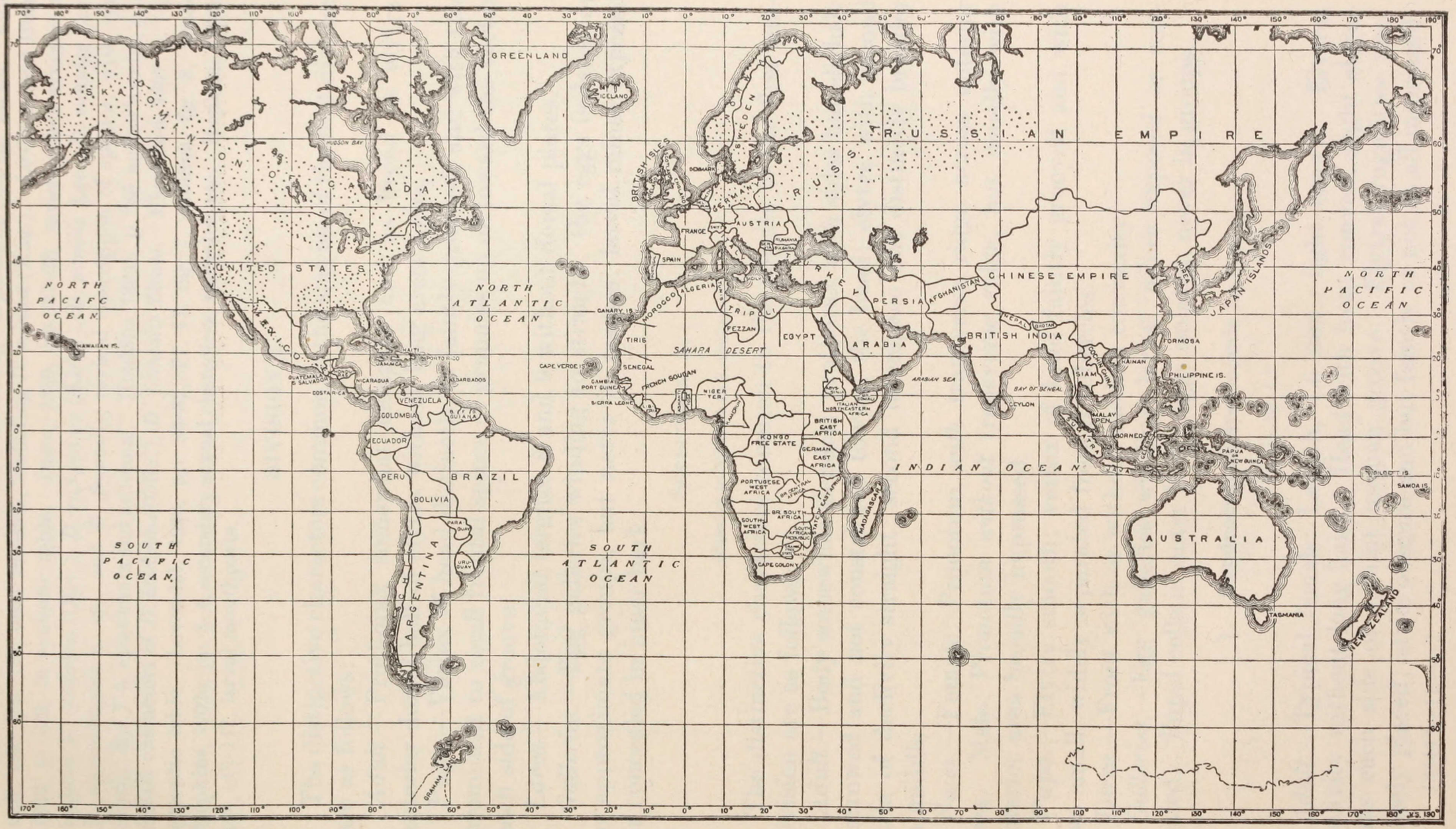
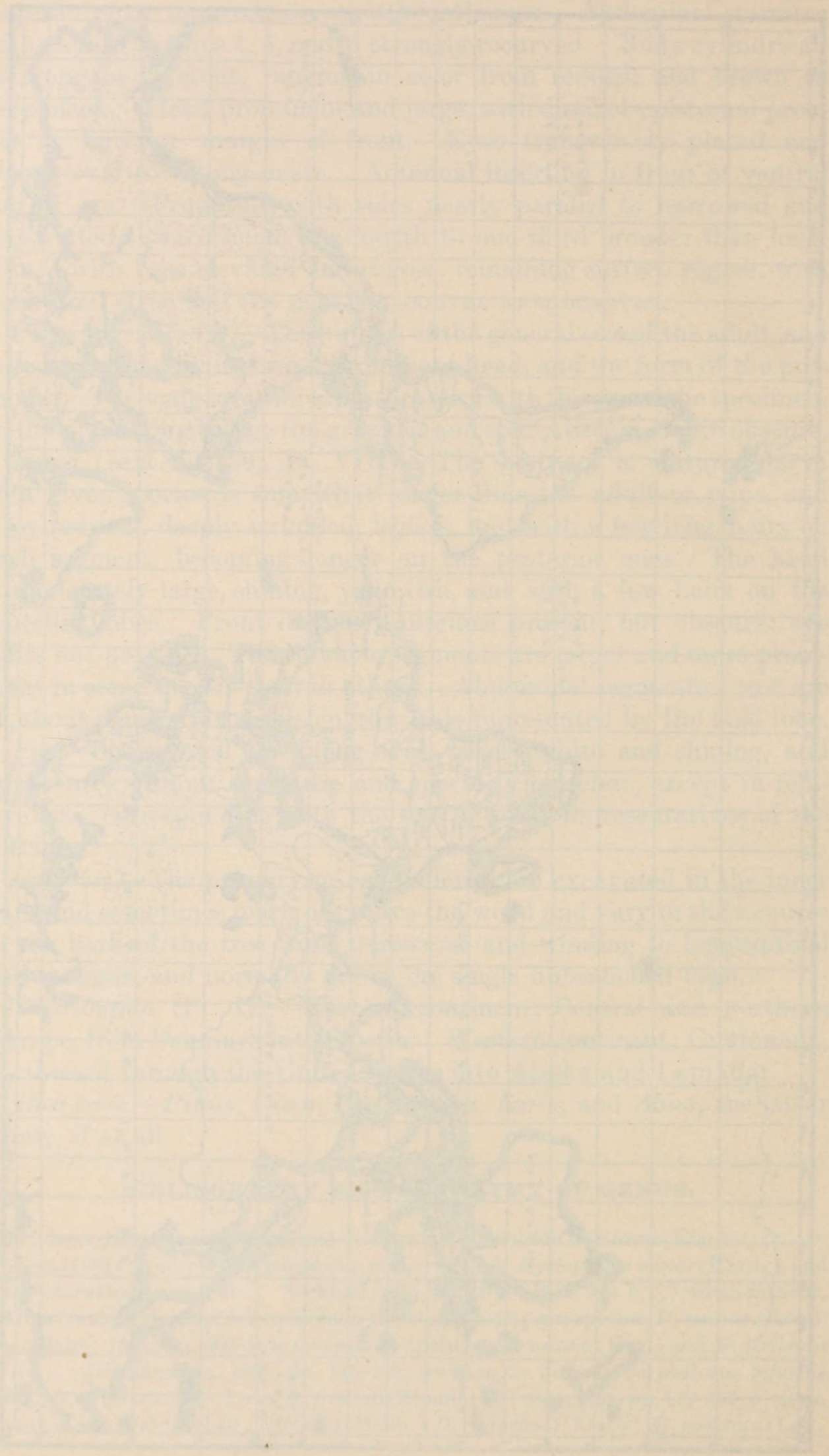


MAP OF THE WORLD SHOWING DISTRIBUTION OF THE GENUS DENDROCTONUS. (ORIGINAL.)



D. simplex Lec., *D. frontalis* Zimm., eliminating *Carphoborus bifurcus* Eichh. Eichhoff, 1881, pp. 125, brief revision, including *D. micans* (Kug.). Le Conte and Horn, 1883, p. 523, in synoptic table. Dietz, 1890, pp. 27–28, revision and synopsis to include *D. terebrans* (Oliv.), *D. rufipennis* (Kirby), *D. similis* Lec., *D. simplex* Lec., *D. approximatus* n. sp., and *D. frontalis*; revised description of species, with synonymy, figs. 1–6, epistomata and antennæ. Hopkins, 1894b, p. 280, author's extra, p. 7, sexual characters of *D. terebrans* (Oliv.), *D. frontalis* Zimm. Blandford, 1897, p. 143, synoptic table. Lovendal, 1898, pp. 86–87, Pl. II, fig. 7, antenna, fig. 8, tarsus. Hopkins, 1902a, pp. 3–4, secondary sexual characters, statistics, etc. Hopkins, 1906b, pp. 143–147, larval mouthparts.

DIVISION I.

The distinctive characters common to the species of the first division are as follows:

Adult.—Prothorax somewhat elongate and as broad as elytra; anterior dorsal half of elytra without long erect hairs.

Pupa.—Vertex of head distinctly to faintly grooved, and with two prominent to small frontal spines or granules on or toward the vertex each side of groove.

Larva.—Abdominal tergites 8 and 9 without dorsal plates.

Galleries.—Egg galleries winding to straight; the eggs isolated or in approximate groups, but never in masses; larval mines exposed or concealed in inner bark.

Subdivision A.

(Species numbers 1 to 8, inclusive.)

The distinctive characters common to the species of the first subdivision are as follows:

Adult.—Body somewhat slender; prothorax with sides but slightly narrowed and not constricted toward the head; elytra with second stria of declivity straight; second interspace not distinctly broader in middle:

Sexes.—Female: Pronotum *with* transverse ridge across anterior area. Male: Pronotum *without* transverse ridge, but usually with anterior area broadly impressed.

Pupa.—Elytra smooth; vertex of head faintly grooved and with two small, widely separated frontal tubercles.

Larva.—Front with or without median convexity.

Galleries.—Egg galleries winding; larval mines exposed or concealed. Pupal cells in outer bark; eggs isolated, never in groups.

1. **Dendroctonus brevicomis** Le Conte.

(Pl. III, fig. 1.)

Adult.—Typical female: Length, 4.6 mm.; light brown. Elytral declivity without long hairs. Head with front convex, slight elevations each side of a faint median groove. Elytral rugosities fine, densely placed; striæ obscure and but faintly or not at all impressed.

Pronotum with a few reclining long hairs on the anterior half, remaining areas with very few and stout pubescence. Secondary sexual characters: Pronotum with transverse ridge extending across the anterior area to near the sternum. Elytral declivity moderately smooth and shining; interspaces finely and densely punctured; striæ fine, with punctures scarcely visible.

Typical female labeled "type of revision," name label, "Hopk. 4/18/02," second name label, "Hopk. Jan 16/08, *Pinus ponderosa*, Hopkins, collector, 3/24/99, Grant's Pass, Or., ♀, Hopk. U. S. 34."

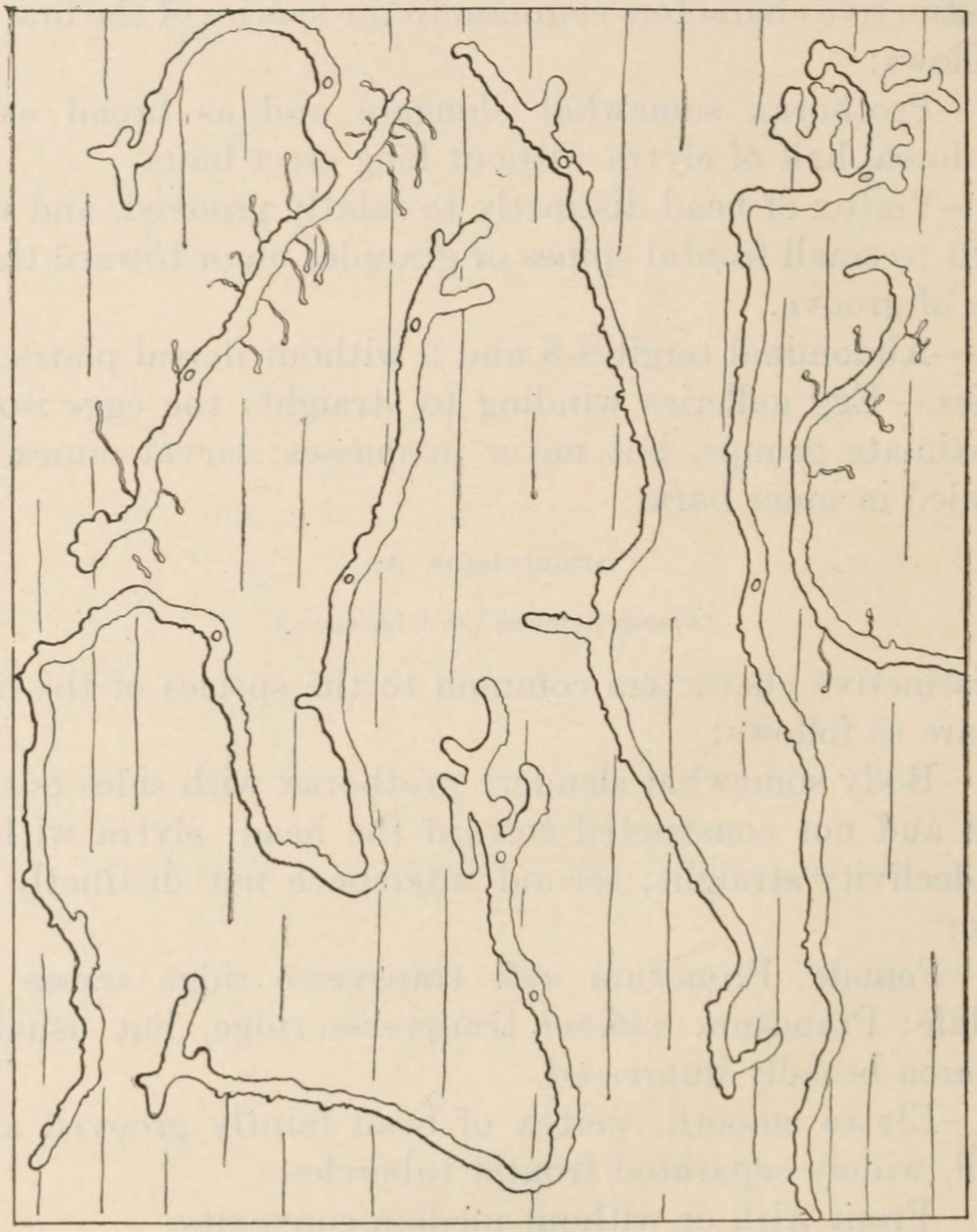


FIG. 44.—*Dendroctonus brevicomis:* Egg galleries. (Original.)

Type male in Le Conte collection, labeled "Cal.," examined by writer.

Typical male: Length 4.6 mm. Agrees with female, except in the more prominent frontal tubercles each side of a distinct groove and a transverse impression instead of an elevation across the anterior area of the pronotum, and the elytral declivity slightly less shining.

Typical male labeled "type of drawing," name label, "Hopk. 1/16/08, *Pinus ponderosa*, Hopkins, collector, 3/24/99, Grant's Pass, Or., ♂, Hopk. U. S. 34."

Variations.—Length, 3 to 5 mm.; color light brownish to nearly black; punctures of pronotum ranging from moderately coarse to very fine, elytral striæ not at all impressed in some examples, in others the impression and punctures more distinct, but never as distinct as in the majority of *D. barberi.* The elytral rugosities also vary from very fine to moderately coarse. The front varies greatly, from convex without tubercles to deeply grooved and with prominent tubercles. The epistomal process varies from the normal concave form with angles elevated and lateral margins strongly oblique to flat with rounded apex and lateral margin suboblique.

Distinctive characters.—The adults of this species are at once distinguished from its nearest ally, *D. barberi,* by the finer rugosities of the elytral interspaces and the much less distinctly impressed striæ.

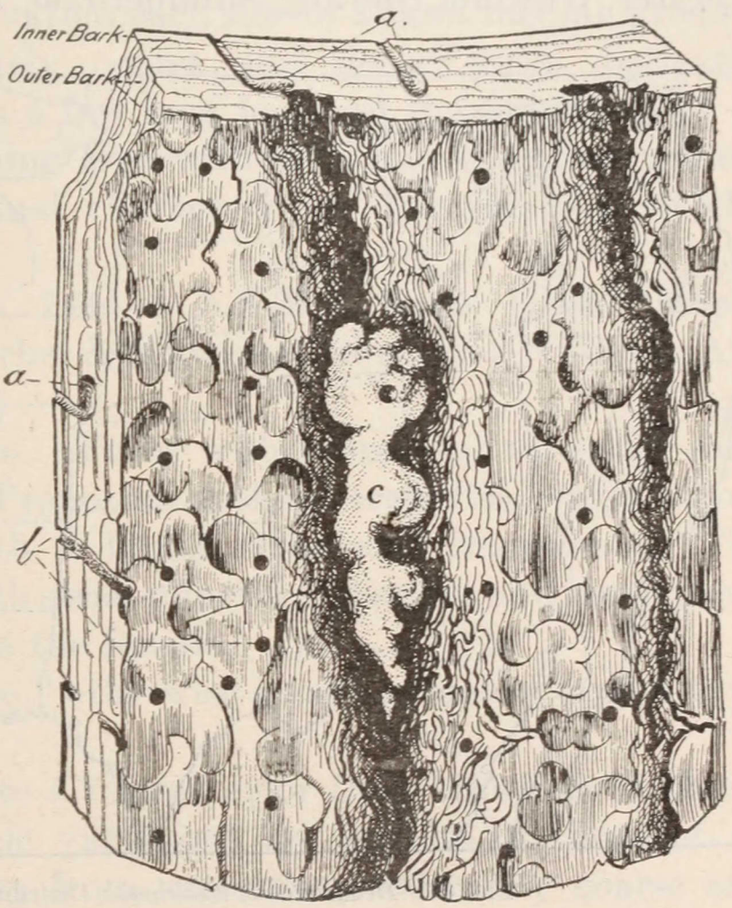


FIG. 45.—*Dendroctonus brevicomis:* Bark showing, *a*, pupal cells; *b*, exit burrows; *c*, pitch tubes. (From Webb.)

Revisional notes.—The labeled type in the Le Conte collection agrees with the description, except that the prothorax is not nearly twice as broad as long. It is certainly distinct from *D. frontalis.* The specimens in the Horn collection under *D. frontalis* that evidently represent part of the material on which Doctor Dietz based his revision, include one specimen of *D. frontalis* labeled with red disk, one specimen of *D. brevicomis* labeled "Cal.," one specimen of *D. barberi* labeled "Williams, Ariz. 7. 28," one specimen of *D. arizonicus*(?) "Williams, Ariz. 7. 28," and one specimen without locality label. One specimen was also received from Dietz, under *D. frontalis,* labeled "Arizona," which proved to be *D. barberi.* In 1898 *D. brevicomis* Lec. was not represented in the U. S. National Museum. Therefore it appears that up to 1899 there were only two specimens of the species in the large collections of the country.

Pupa.—In addition to the divisional and subdivisional characters, the pupæ range in length about the same as adults; the apices of the front and middle femora are smooth; abdominal tergites 3, 4, 5, and

6 with small pleural spines, 1 and 2 without distinct dorsal and lateral spines. Pupal type labeled "Hopk. U. S. 34."

Larva (Pl. VIII, fig. 1).—In addition to the divisional and subdivisional characters the larvæ range slightly longer than the pupæ. Epistoma distinctly elevated. Front without median convexity; clypeus with apex subacutely emarginate; thoracic segments with prominent sternal lobes; the sternellar lobes with distinct foot calli; apex of abdomen subtruncate. Larval type labeled "Hopk. U. S. 25a."

Galleries (figs. 44, 45).—Egg galleries subtransversely winding; eggs isolated; larvæ concealed in inner bark; pupal cells in outer bark.

Distribution (fig. 46).—(Hopk. U. S.) *California:* McCloud, Badger, Chester, Wawona, Sterling, Summerdale, Yosemite, Ballard. *Montana:*

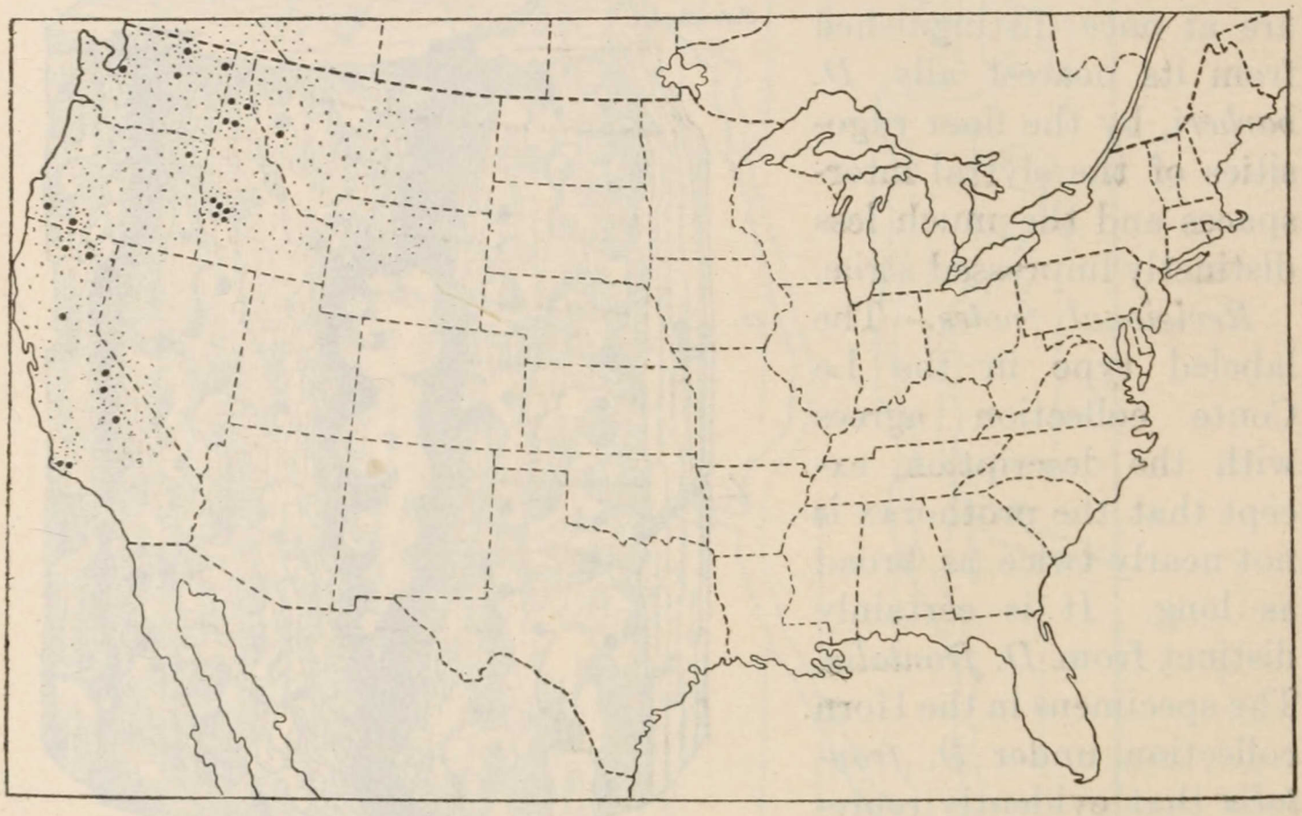


FIG. 46.—*Dendroctonus brevicomis:* Distribution map. (Original.)

Missoula. *Oregon:* Grants Pass, Joseph. *Washington:* Buckeye (near Spokane), Chelan. *Idaho:* Moscow, Smiths Ferry, Centerville, Stites, Kooskia (Harris Ridge), Pioneer (Grimes Pass), Garden Valley, Placerville, Cedar Mountains, Troy.

Host trees.—Pinus ponderosa and *P. lambertiana.*

Identified specimens.—Le Conte, 1; Horn, 1; Hopk. U. S., several hundred, including all stages and work.

BIBLIOGRAPHY AND SYNONYMY.

Dendroctonus brevicomis Le Conte, 1876, p. 386, original description, synopsis, localities. Packard, 1887, p. 177, Le Conte quoted. Packard, 1890, p. 722, Le Conte quoted. Hopkins, 1899a, p. 395, reference. Hopkins, 1899b, pp. 13, 20, 26, first records of habits, hosts, etc. Hopkins, 1901b, p. 66, habits, galleries, etc. Hopkins, 1902a, p. 3, name restored. Hopkins, 1902c, p. 21, note. Hop-

kins, 1903b, p. 281, mentioned. Hopkins, 1904, p. 18, habits, distribution, etc. Webb, 1906, bulletin, Pls. II, III, figs. 7–12, stages and work illustrated, full account of habits, life history, etc. Hopkins, 1908, pp. 162–163, depredations.

Dendroctonus frontalis (not of Zimm.) Dietz, 1890, p. 32 (in part), California.

Dendroctonus brevicornis Dietz, 1890, p. 32 (in part), California.

2. Dendroctonus barberi n. sp.

(Pl. III, fig. 2.)

Adult.—Type of species, female: Length, 4.5 mm.; very dark brown. Elytra and elytral declivity without long hairs. Head with front convex, with slight elevation each side of a faint median groove. Elytral rugosities moderately coarse and dense; striæ distinctly impressed. Pronotum with a few long hairs on the anterior half of the lateral area, the remaining area with very fine and short pubescence. The secondary sexual characters are the same as in the preceding species.

Type labeled "Type No. 7444, U.S.N.M.," name label, "Hopk. 1/15/08, ♀, individual *f*, Barber & Schwarz, Coll[ectors], Williams, Ar., 7.6" (=June 7).

Male type: Length, 4 mm. Front with prominent tubercles each side of a distinct groove. Pronotum without transverse ridge across the anterior area, but with a broad transverse impression. The elytral declivity shining, with strial punctures distinct and interspaces slightly more rugose than in the female.

Male type labeled "♂ type," otherwise same as female, except type number.

Variations.—Length 2.5 to 4.7 mm., color from brownish to black. The frontal and prothoracic variations are similar to those of *D. brevicomis*. The elytra vary from rugosities moderately coarse and obtuse to distinctly coarse and acute, and striæ from moderately to very distinctly impressed, and the punctures from obscure to distinct.

Distinctive characters.—The adults of *D. barberi* are at once distinguished from the next species by the absence of long hairs on the elytral declivity, and from *D. brevicomis*, to which it is closely allied, by the prevailing coarser rugosities of the elytral interspaces and the distinctly impressed striæ. Some systematists might concede these characters of no more than subspecific or varietal value, but it must be remembered that in this genus there is a close general resemblance of allied species and that the characters which in other genera would be of special value in specific distinction are so variable and inconstant in this as to be of no value. Therefore any constant or prevailing character of distinction, even if it does seem insignificant, is of vastly higher value than would otherwise be allowable, especially when it is supported by differences in physiological characteristics.

Revisional note.—This species is not represented in the Le Conte collection. One specimen labeled "Williams, Ariz., 7.28, 151," and one without label found in the Horn collection, both under *D. frontalis*, and one specimen labeled "Ariz.," received from Doctor Dietz under *D. frontalis*, all belong to *D. barberi*. These were evidently before Doctor Dietz when he prepared his revision of *D. frontalis, ibid.*

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apex of the front and middle femora is smooth; abdominal tergites 3 to 6 with very small dorsal, lateral, and pleural spines; 1 and 2 without dorsal or lateral spines; 3 to 6 with minute dorsal and lateral spines; 7 and 8 smooth, and 9 with small pleural spines. Pupal type, labeled "Hopk. U. S. 5030" (in alcohol), differs from pupa of *D. brevicomis* in the absence of lateral spines on abdominal tergites 3 and 4; but these, with other pupal characters, are so variable that

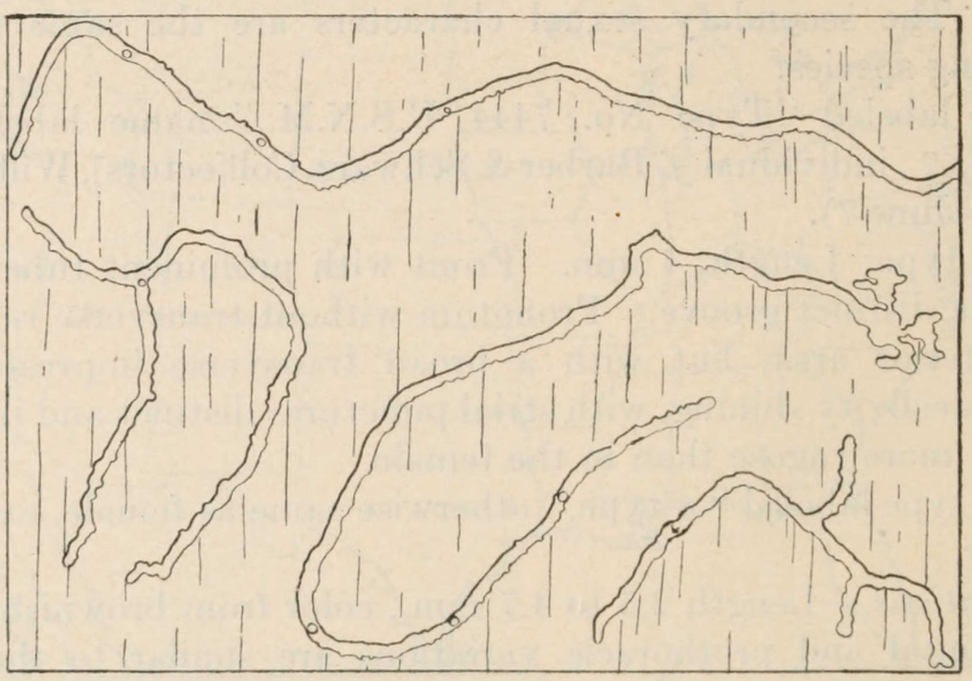


FIG. 47.—*Dendroctonus barberi:* Egg galleries. (Original.)

not much reliance can be placed on any of them to separate closely allied species.

Larva.—In addition to the generic, divisional, and subdivisional characters, the clypeus has the apex broadly emarginate instead of subacutely emarginate, as in *D. brevicomis*. It also differs in the more rounded apex of the labrum and in the more distinctly rugose mandibles. Larval type labeled "Hopk. U. S. No. 5129" (mounted and alcoholic).

Galleries (fig. 47).—In addition to the divisional and subdivisional characters, the egg galleries are usually distinctly transversely winding, thus differing from *D. brevicomis;* otherwise there is little difference.

Distribution (fig. 48).—(Hopk. U. S.) *Arizona:* Williams, Flagstaff, San Francisco Mountains, Grand Canyon, Walnut Canyon, Dead Man's

Flat, Show Low, Santa Catalina Mountains. *New Mexico:* Vermejo, Santa Fe, Meeks, Capitan (Mountains), Cloudcroft. *Texas:* Davis Mountains. *Colorado:* Fort Garland and Monte Vista. *Utah:* Escalante and Panguitch. *Additional localities from other collections.* (H. & S.) Chiricahua Mountains, Ariz.

Host trees.—Pinus ponderosa var. *scopulorum* (very common), *P. edulis* (rare), and *Pseudotsuga taxifolia* (rare, probably abnormal).

Identified specimens.—Horn collection, 2; Dietz, 1; U. S. N. M., H. & S., 2, B. & S., 62; Hopk. U. S., more than 400, including all stages and work.

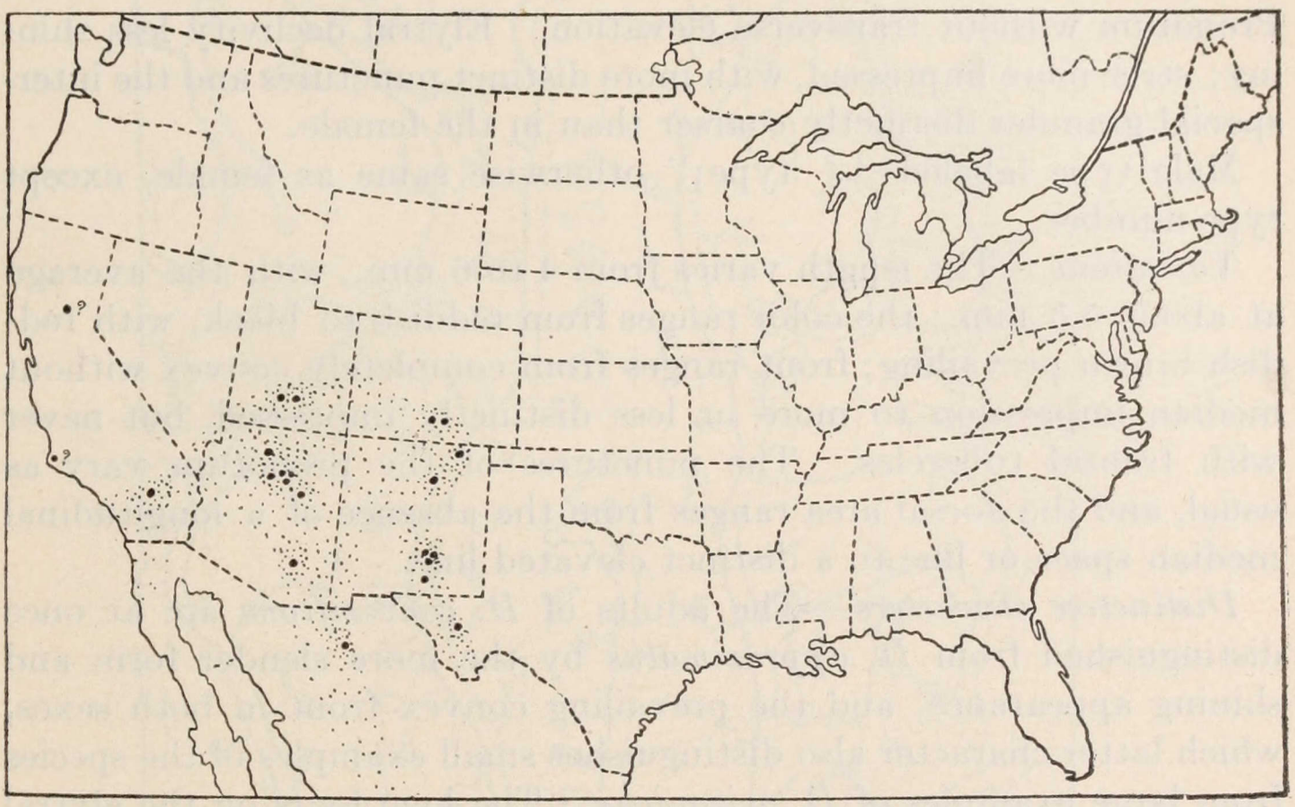


FIG. 48.—*Dendroctonus barberi:* Distribution map. (Original.)

BIBLIOGRAPHY AND SYNONYMY.

Dendroctonus frontalis (not of Zimm.) Dietz, 1890, p. 32 (in part), Arizona.
Dendroctonus arizonicus Hopkins, 1902a, p. 3 (in part), manuscript name only.
Dendroctonus n. sp. Hopkins, 1904, pp. 42, 44, habits, host, distribution, etc.
Dendroctonus brevicomis var. *barberi* Hopkins, 1906b, p. 147, Pl. IV, fig. 9, anatomy of larval head, manuscript name.

3. Dendroctonus convexifrons n. sp.

(Pl. III, fig. 3.)

Adult.—Type of species, female: Length, 6 mm.; reddish-brown, shining. Elytral declivity with long hairs. Head with front convex; without median frontal groove or tubercles, but with posterior impression. Elytral rugosities moderately coarse, but not densely placed, except toward the base; striæ faintly impressed and with rather coarse, indistinct punctures. Pronotum with long, erect hairs on the entire

lateral area, the remaining area with short, erect, and sparse pubescence. Secondary sexual characters: Pronotum with transverse ridge across the anterior area, extending to the sternum. Elytral declivity shining; striæ very slightly impressed; punctures obscure; interspacial granules sparse and small, but distinct.

Type labeled "Type No. 7445 U.S.N.M.," name label, "Hopk. 1/16/08, *Pinus ponderosa*, Hopkins, Colr., 9/8/02, Williams, Ariz., ♀, Hopk. U. S. 1109."

Male type: Length, 5.6 mm. Front convex and with faint anterior and posterior impressions, but without frontal groove or tubercles. Pronotum without transverse elevation. Elytral declivity less shining; striæ more impressed, with more distinct punctures and the interspacial granules distinctly coarser than in the female.

Male type labeled "♂ type;" otherwise same as female, except type number.

Variations.—The length varies from 4 to 6 mm., with the average at about 5.5 mm.; the color ranges from reddish to black, with reddish-brown prevailing; front ranges from completely convex without median impression to more or less distinctly impressed, but never with frontal tubercles. The punctures of the pronotum vary as usual, and the dorsal area ranges from the absence of a longitudinal median space or line to a distinct elevated line.

Distinctive characters.—The adults of *D. convexifrons* are at once distinguished from *D. approximatus* by the more slender form and shining appearance, and the prevailing convex front in both sexes, which latter character also distinguishes small examples of the species from large examples of *D. arizonicus*. The long hairs on the elytral declivity render it absolutely distinct from *D. barberi*, to which it appears to be more closely allied on account of pupal characters.

Revisional notes.—This species is not represented in the Le Conte collection, but among the three specimens in the Horn collection, under *D. approximatus* Dietz, there was one labeled "N. M.," which certainly must be referred to it.

Pupa.—In addition to the divisional and subdivisional characters, the front and middle femora are smooth or with minute apical granule; abdominal tergites 1 and 2 without dorsal spines but with one or two lateral granules; 2 to 6 with very small lateral spines, and 3 to 6 with very small dorsal and lateral spines, becoming more prominent toward the sixth; 7 and 8 smooth and 9 with widely separated caudal spines. Pupal type labeled "Hopk. U. S. No. 5090."

Larva.—In addition to the divisional characters, the front has a median smooth, shining convexity; mandibles distinctly rugose on lateral area toward base; labrum with apex broadly rounded and

clypeus with apex broadly emarginate. Sternellar lobes of thoracic segment without foot calli. Larval type labeled "Hopk. U. S. No. 5078."

Galleries (fig. 49).—Egg galleries longitudinally winding; eggs isolated; larval mines exposed in inner bark; pupal cells in outer bark.

The galleries of this species are at once distinguished from those of *D. barberi* and *D. approximatus* by the exposed larval mines.

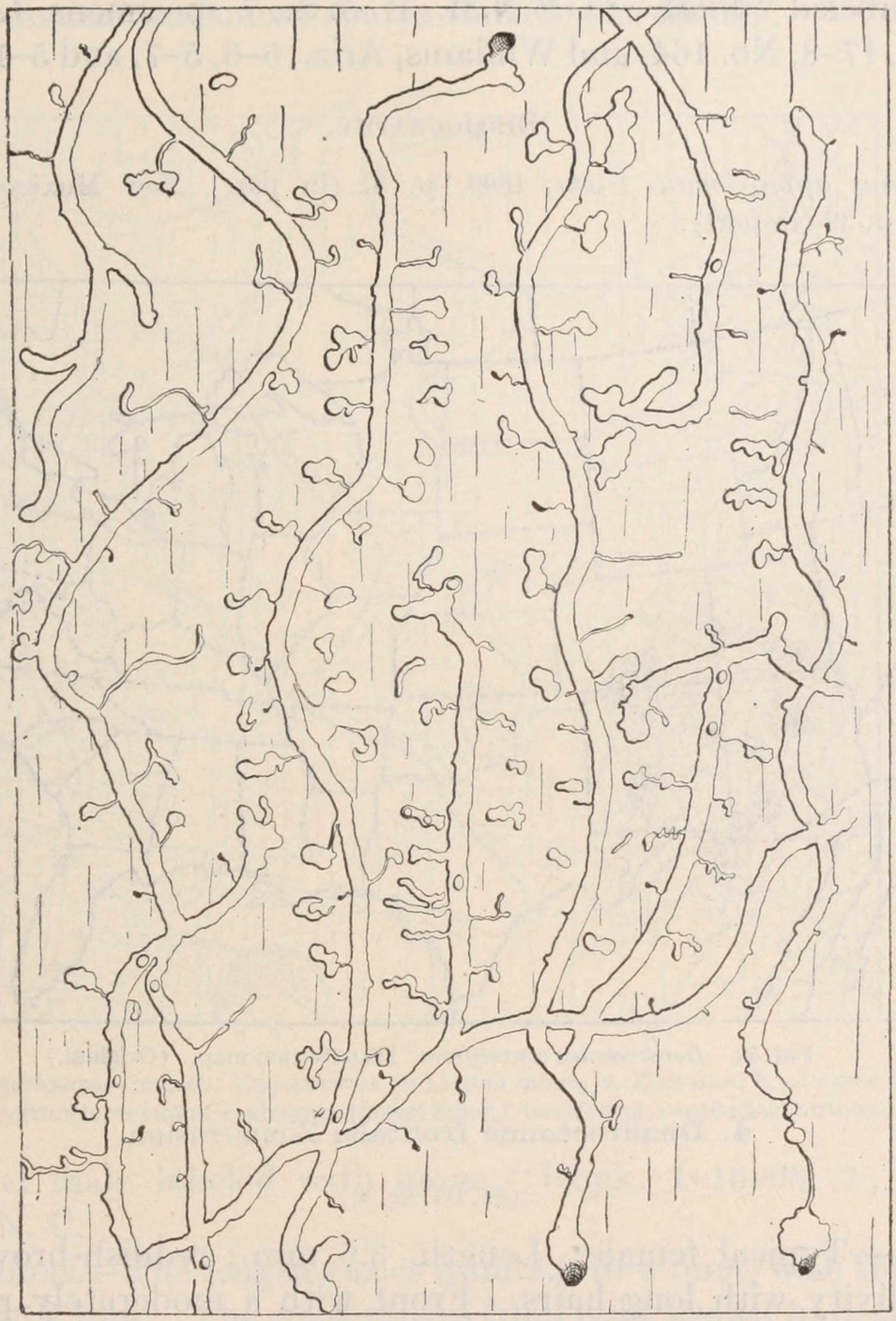


FIG. 49.—*Dendroctonus convexifrons:* Egg galleries and larval mines. (Original.)

These three species usually infest the same tree, and often all of their galleries are represented in a piece of bark.

Distribution (fig. 50).—(Hopk. U. S.) *Arizona:* Williams, Flagstaff, Show Low, Paradise, Santa Catalina Mountains, and Chiricahua Mountains. *Colorado:* Las Animas County, La Veta, Fort Garland, and Monte Vista. *New Mexico:* Cloudcroft, Meeks, Capitan, Fort

Wingate Military Reservation, Vermejo, Lincoln National Forest, and Sierra Blanca Mountains. *Utah:* Escalante, La Salle National Forest, and Panguitch Lake. *Additional locality from other collections:* (B. & S.) Las Vegas, N. Mex.

Host trees.—Pinus ponderosa var. *scopulorum* (very common) and *P. chihuahuana* (rare).

Identified specimens.—Hopk. U. S., more than 100 specimens, including all stages and work; Horn, 1 specimen under *D. approximatus*, labeled "N. M."; U.S.N.M., B. & S., 7 specimens, Las Vegas, N. Mex., 17–8, No. 164, and Williams, Ariz., 5–6, 5–7, and 5–10.

Bibliography.

Dendroctonus approximatus Dietz, 1890, p. 31 (in part), New Mexico. Schwarz, 1902, p. 32 (in part).

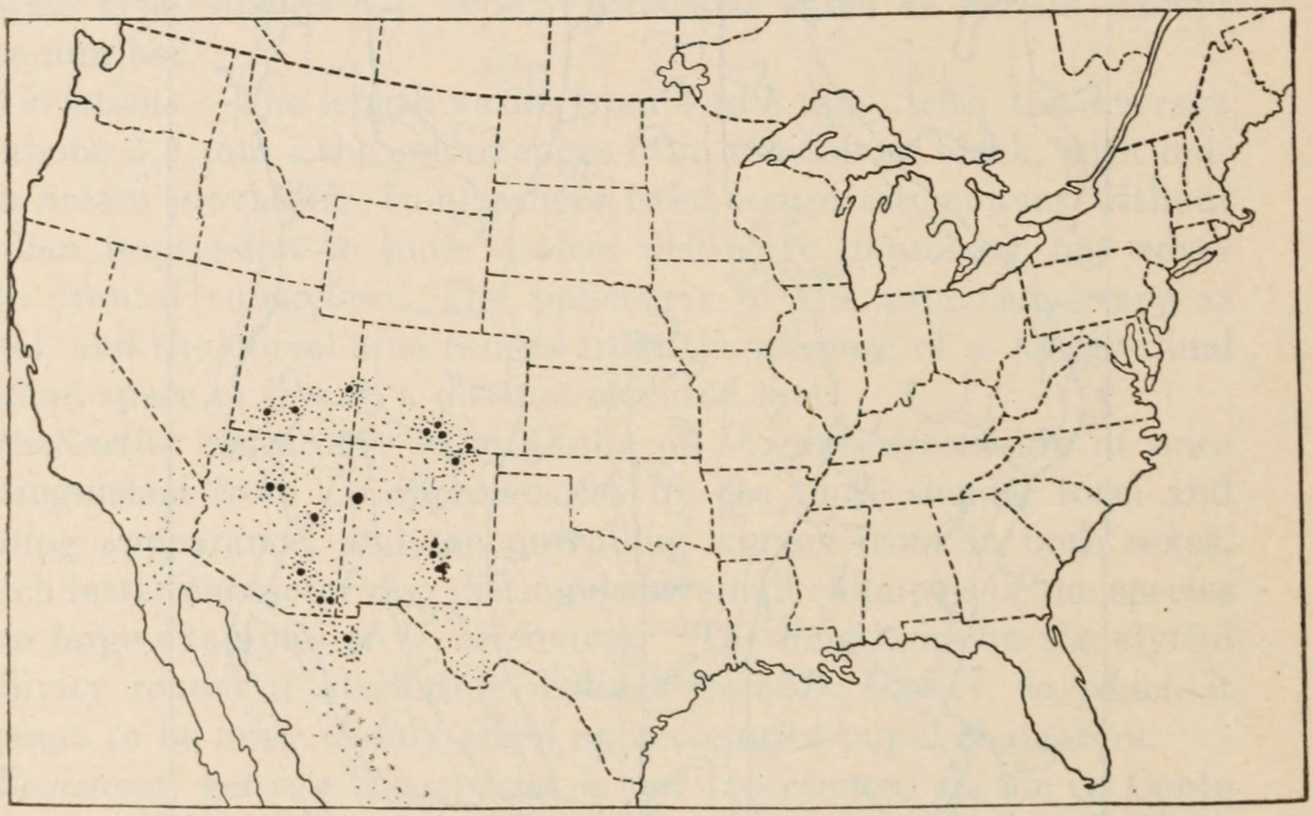


Fig. 50.—*Dendroctonus convexifrons:* Distribution map. (Original.)

4. Dendroctonus frontalis Zimmermann.

(Pl. III, fig. 4.)

Adult.—Typical female: Length, 3.6 mm.; reddish-brown. Elytral declivity with long hairs. Front with a moderately prominent tubercle each side of a distinct median groove. Elytral striæ distinctly punctured; interspacial rugosities moderately coarse, obtuse, not very densely placed, and not very distinctly coarser toward the base and vertex. Pronotum with a few long hairs on the anterior section of the lateral area. Secondary sexual characters: Pronotum with transverse ridge across the anterior area, the elytral declivity shining and with finely granulate interspaces, the striæ distinctly impressed, but the punctures obscure.

Typical female labeled "type of revision, type of drawing," name label, "Hopk. 4–18–02, ♀, H. S. 58, S. C."

Type in Le Conte collection labeled "Type 1, *D. frontalis* (Fab.) Zimm.," red disk (= Carolinas).

Male type: Length, 3.5 mm. Front with prominent frontal tubercle each side of a broad, deep frontal groove. Pronotum without transverse elevation or impression across the anterior area. Elytral declivity with striæ more impressed and the interspacial granules coarser and more sparse than in the female.

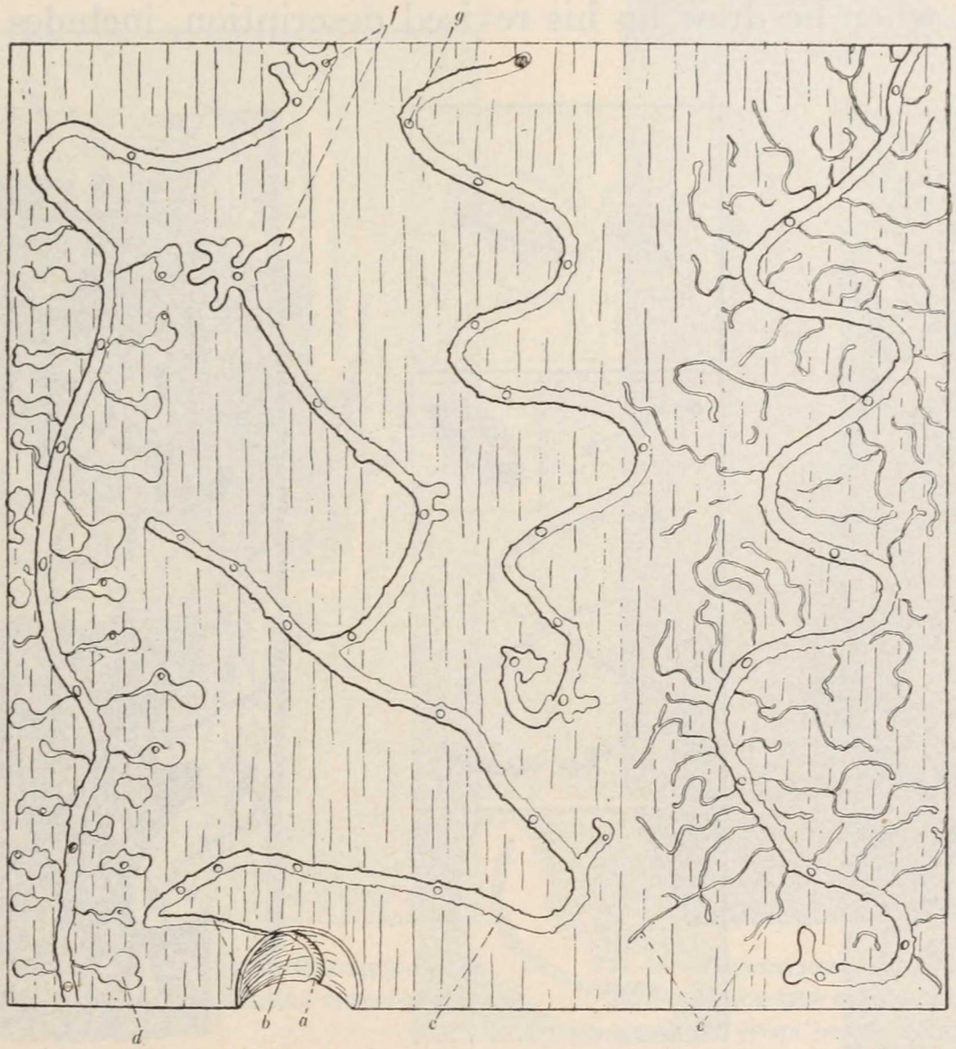


FIG. 51.—*Dendroctonus frontalis:* Egg galleries and larval mines. *a*, Entrance; *b*, entrance burrow; *c*, egg gallery; *d*, normal larval mine; *e*, abnormal larval mine; *f*, terminal; *g*, ventilating burrows. (Original.)

Typical male labeled with name, "Hopk. 1–16–08, ♂, U.S.N.M. 37, sp., N. C."

Variations.—The length varies from 2.5 to 4 mm., with the average at about 3.2 mm. The color ranges from light brown to nearly black; the epistoma, front, prothoracic punctures, and elytral rugosities vary as usual. The anterior area of the pronotum, which is glabrous in the typical females and males, usually has a few long hairs.

Distinctive characters.—This species is distinguished from *D. arizonicus*, its nearest ally, by its smaller size, broader pronotum, with finer punctures, and finer and less acute rugosities of the elytra.

Revisional notes.—The type series in the Le Conte collection is represented by three specimens—one labeled "Type 1, *D. frontalis* (Fab.)

Zimm.," red disk (=Carolinas), which should stand as the type, and the other two labeled "Type 2" and "Type 3," same locality. There are also two specimens, one labeled "Specimen 4, Lake Superior," and the other labeled "Specimen 5, Va." Both of these agree with the West Virginia form. In addition, there are three specimens labeled with an orange disk (=Georgia), one with light green disk (=Middle States), all of which were doubtless before Le Conte when he drew up his revised description.

The series in the Horn collection, which was evidently before Doctor Dietz when he drew up his revised description, includes but one

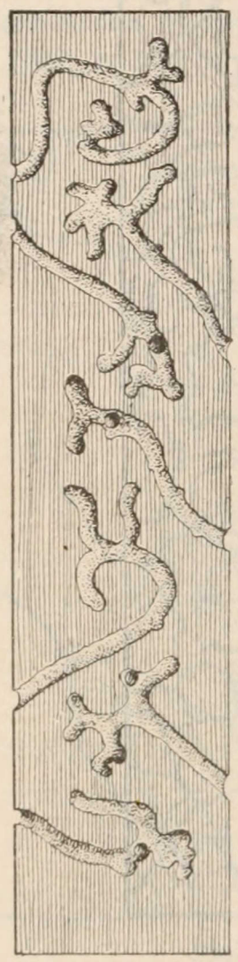


FIG. 52.—*Dendroctonus frontalis:* Termination of egg galleries. (Original.)

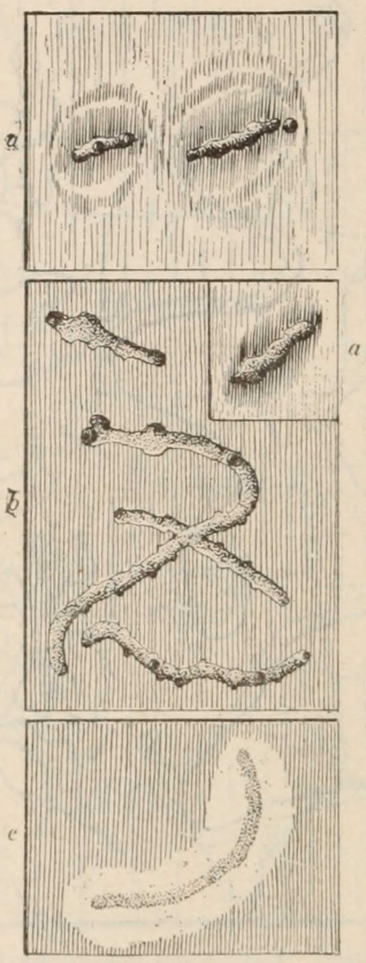


FIG. 53.—*Dendroctonus frontalis:* Beginning of egg galleries; *a*, in living bark; *b*, in dying bark; *c*, marked on surface of wood (white area represents normal appearance of wood preserved by resin). (Original.)

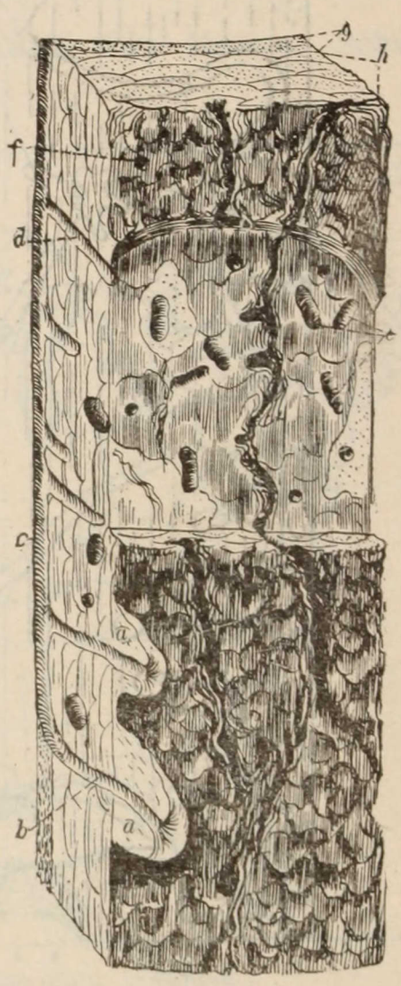


FIG. 54.—*Dendroctonus frontalis:* Bark showing, *a*, pitch tubes; *b*, entrance burrow; *c*, egg gallery; *d*, ventilating burrow; *e*, pupal cells; *f*, exit burrows; *g*, inner bark; *h*, outer bark. (Original.)

specimen labeled with red disk (=Carolinas). The specimens mentioned, together with two or three specimens in the United States National Museum, were probably all that were in the larger collections of the country up to 1890.

The form which in 1891 and 1892 extended northward from the normal range of the species into Virginia and West Virginia is represented in the revision series by specimens labeled "Hopk. W. Va. ♀ individual 1" and "Hopk. W. Va. ♂ individual 1." The West Virginia female differs from the typical South Carolina female in a more

rugose front, prothorax slightly narrow in front, with a few short and long hairs on sides and the punctures of anterior dorsal surface coarser toward base and fine toward anterior margin; elytral rugosities more acute; strial punctures coarser and more distinct; elytral declivity with longer and more numerous hairs. The West Virginia male differs from the typical North Carolina male type in the more shining front, with punctures more distinct, while the pronotum and elytra show the corresponding differences mentioned under the female individual 1. At one time it seemed to the writer that this

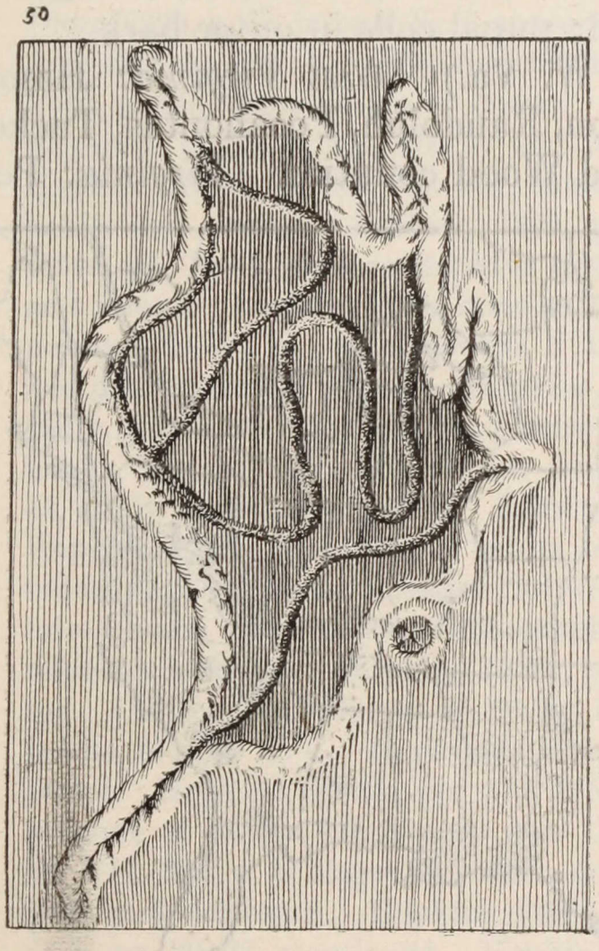


FIG. 55.—*Dendroctonus frontalis:* Old egg galleries in living tree, with surrounding callus of new wood. (Original.)

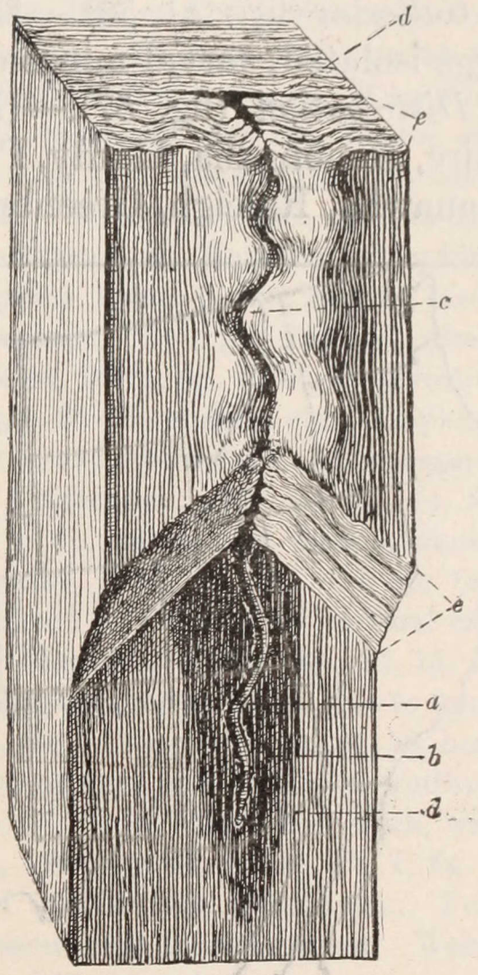


FIG. 56.—*Dendroctonus frontalis:* Egg gallery in living tree marked on surface of wood six years before block was cut from tree. *a*, Mark of gallery on original surface; *b*, resinous wood; *c*, surface scar six years later; *d*, original surface or 7-year-old annual layer of wood; *e*, six subsequent annual layers of wood formed over original wound. (Original.)

northern form was worthy of specific distinction, and the manuscript name of *D. pinicida* was proposed for it, but it was later found that some southern examples showed the same, and even greater, variations from the type. Therefore, since the species had disappeared from its northern range, it was decided that it would not be advisable to recognize it as specifically distinct.

Pupa.—In addition to the divisional and subdivisional characters the apices of the front and middle femora are armed with small apical spines or granules. Abdominal tergites 1 to 6 without pleural spines; 1, 2, and 3 without distinct dorsal and lateral spines; 4 to 6 with a pair of dorsal spines and one or two lateral ones; 7 and 8 with

a few dorsal granules, and 9 with medium-sized caudal spines. Pupal type labeled "Hopk. U. S. No. 2968."

Larva.—In addition to the divisional characters, the front has a distinct, median, smooth, shining convexity produced toward vertex; clypeus short, broad, with apex deeply emarginate; prothoracic segments very large and sternellar lobes with distinct foot calli. Apex of abdomen truncate. Larval type labeled "Hopk. W. Va. No. 5976."

The frontal convexity is more rugose in some specimens than in others.

Galleries (figs. 51–56).—Egg galleries sublongitudinal, winding; the eggs isolated; larval mines exposed; pupal cells in outer bark.

Distribution (fig. 57).—(Hopk. W. Va.) *West Virginia:* Hampshire, Monongalia, Hardy, Pendleton, Randolph, Pocahontas, Tucker, Kanawha, Raleigh, Greenbrier, and Wood counties. *Virginia:* Port

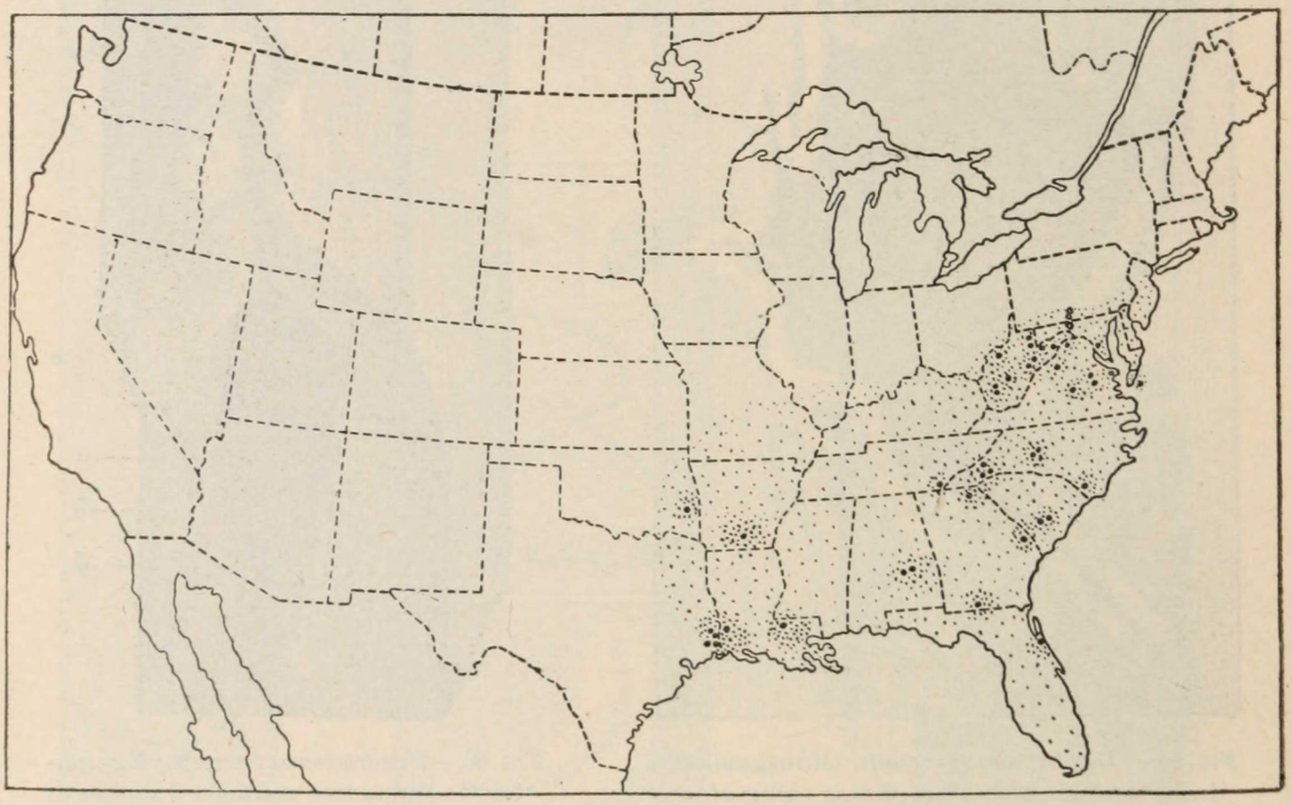


FIG. 57.—*Dendroctonus frontalis:* Distribution map. (Original.)

Republic. Work observed in southern Pennsylvania, Maryland, and Virginia (author). (Hopk. U. S.) *Alabama:* Calhoun, Montgomery. *Arkansas:* Hampton. *Georgia:* Clyo, Thomasville, Demorest. *Louisiana:* Singer, Wilson. *Maryland:* Near Cumberland. *North Carolina:* Tryon, Pisgah Ridge, Fletchers, Boardman, Pink Beds, Biltmore. *South Carolina:* Chicora (Pregnalls). *Tennessee:* Ducktown. *Texas:* Call, Deweyville, Kirbyville, Beaumont. *Virginia:* Green Bay, Glen Allen, Auburn Mills, Virginia Beach. *District of Columbia:* Washington. *Additional localities represented in other collections:* (Le Conte) Lake Superior, Michigan. (There may have been some mistake in regard to the labeling of this specimen, since it is not likely the species will ever be found that far north.) (H. & S.) Haw Creek, Florida; Cobbs Island, Virginia; (A. M. N. H.) Black Mountains and Mount Graybeard, North Carolina; (Barber) "western Indian territory" [Oklahoma].

Host trees.—*Pinus strobus, P. tæda, P. rigida, P. virginiana, P. pungens, P. echinata, P. glabra, P. palustris, Picea rubens,* and *P. excelsa.*

Identified specimens.—Le Conte collection, 9; Horn, 1; U.S.N.M., H. & S., 5; D. A., 7; Barber, 2; Hopk. W. Va., 68; Hopk. U. S., more than 150, including all stages and work.

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Bostrichus frontalis (not of Fab.) Zimmermann, 1868, p. 149, synonymical reference. Le Conte, 1868, p. 173.

Dendroctonus pinicida Hopkins, 1902a, p. 3, manuscript name only.

Dendroctonus frontalis Zimm. var. *destructor* Hopkins, 1902b, p. 21, note. Hopkins, 1902c, p. 20, habits, etc.

Dendroctonus brevicornis Dietz, 1890, p. 32 (in part).

5. Dendroctonus arizonicus n. sp.

(Pl. III, fig. 5.)

Adult.—Type of species, female: Length, 3.7 mm., dark brown. Elytral declivity with long hairs confined to declivity and posterior lateral areas. Head with front convex, shining, and with distinct frontal tubercle each side of a broad median groove. Elytral striæ distinctly punctured; the interspaces with subacute, moderately coarse rugosities, distinctly coarser toward the base and vertex. Pronotum with long erect hairs on the anterior half of the lateral area. Secondary sexual characters same as in *D. frontalis.*

Type labeled "Type No. 7446, U.S.N.M.," name label, "Hopk. 1/15/05, ♀, Barber & Schwarz Coll[ectors], Williams, Ar., 7.6" (=June 7).

Male type: Length, 3.3 mm. Front with prominent tubercles each side of a deep median groove. Pronotum with transverse impression and faint transverse elevation across anterior area. Elytral declivity less shining; striæ more distinctly impressed and punctured and the interspaces more convex and distinctly rugose than in the female.

Male type labeled, name label, "Hopk. Jan. 15/08, *Pinus ponderosa*, Webb, Collr., 8–22–04, Flagstaff, Ariz., ♂, Hopk. U. S. No. 5118."

Variations.—Length 3.5 to 3.9 mm., average about 3.6 mm.; color from light brown to black. The short hairs of the lateral area of the elytra range from obscure to distinct, and the long hairs of the elytral declivity range from short and sparse to very long and numerous. The variation in the size of the punctures of the pronotum is less marked than in other species.

Distinctive characters.—The coarse punctures of the pronotum, and especially the very coarse shallow rugose ones, together with the coarser rugosities of the elytra, serve to distinguish specimens of this species from *D. barberi*, and the absence of short reclining hairs on the pronotum with the more distinctly impressed elytral striæ and less evident short and long hairs on the elytra serve to distinguish it from *D. mexicanus*, which is its nearest ally. It is also distinguished from *D. frontalis* by its larger size, coarser punctures of the pronotum, and coarser rugosities of the elytra, as it is from small examples of *D. convexifrons* by the grooved front, and from small examples of *D. approximatus* by the impressed elytral striæ and the shorter, more yellow, and less numerous hairs of the declivity.

Revisional notes.—This species is not represented in the Le Conte collection and not in the Horn collection unless it is one specimen found under *D. frontalis* labeled "Williams, Ariz., 7.28, 152," which the writer has not seen since *D. arizonicus* has been recognized as a distinct species. If this specimen is *D. arizonicus*, it was evidently before Doctor Dietz when he prepared his revised description of *D. frontalis*.

Pupa.—In addition to the generic and divisional characters, the apices of the front and middle femora have each a small spine. Abdominal tergites 2 to 6 with small pleural spines and 4 to 6 with small dorsal, lateral, and pleural spines, increasing in size toward 6; 7 and 8 with a pair of dorsal granules, coarser on 7. Pupal type labeled "Hopk. U. S. No. 3129."

Larva.—In addition to the divisional characters, the front has a median transverse and rugose convexity produced toward apex; clypeus with apex broadly emarginate; labrum broad, with apex broadly rounded. Thoracic segments with foot calli on sternellar lobes. Larval type labeled "Hopk. U. S. No. 5156."

Galleries.—While the galleries of this species have not been definitely recognized from those of *D. barberi*, with which they are nearly always present, it is evident that they are quite similar in general character to those of *D. barberi*, especially in the concealed larval mines.

Distribution (fig. 58).—(Hopk. U. S.) *Arizona:* Williams, Flagstaff, Santa Catalina Mountains (rare).

Host tree.—*Pinus ponderosa* var. *scopulorum.*

Identified specimens.—Horn collection, 1 (?), B. & S., 2; Hopk. U. S., more than 50 specimens, including adults, larvæ, and pupæ.

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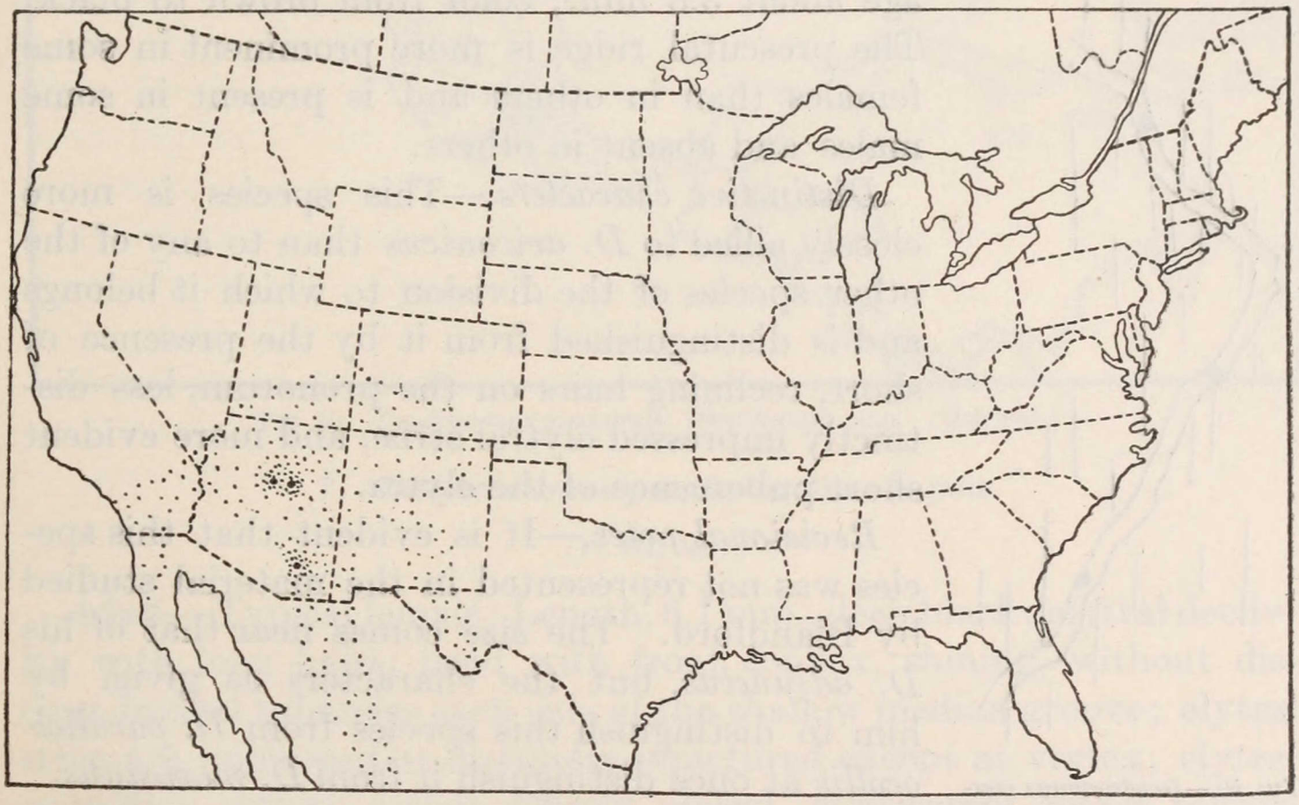

FIG. 58.—*Dendroctonus arizonicus:* Distribution map. (Original.)

6. **Dendroctonus mexicanus** Hopkins.

(Pl. III, fig. 6.)

Adult.—Type of species, female: Length, 4 mm.; dark brown. Elytra with long hairs on posterior half and declivity. Head with front convex, shining, with small frontal tubercles each side of the short, shallow groove; elytral striæ distinctly impressed, but not distinctly punctured; elytral rugosities distinctly coarser toward the base and vertex, and with an evident row of acute rugosities on the first interspace. Pronotum clothed with short reclining hairs on entire lateral area. Secondary sexual characters: Pronotum with transverse ridge across the anterior area; elytral declivity shining, striæ distinct, obscurely punctured; interspaces roughened with sparsely exposed granules, becoming coarser toward the vertex in lateral area.

Type labeled "Type No. 7518, U.S.N.M., individual 1," name label, "n. sp., Hopk., 4/18/02," name label, "1/15/08, A. L. Herrera, collector, ♀, Sacramento, Amecameca, Mexico."

Male type: Length, 4 mm.; front with moderately prominent frontal tubercles each side of the distinct groove. Pronotum with rather distinct transverse elevation across the entire area similar to that of the female; elytral declivity more uniformly convex; striæ more impressed and deeply punctured and interspaces more convex and distinctly rugose.

Male type labeled "Type No. 7518, U.S.N.M., individual 5," remaining labels same as on female except sex label.

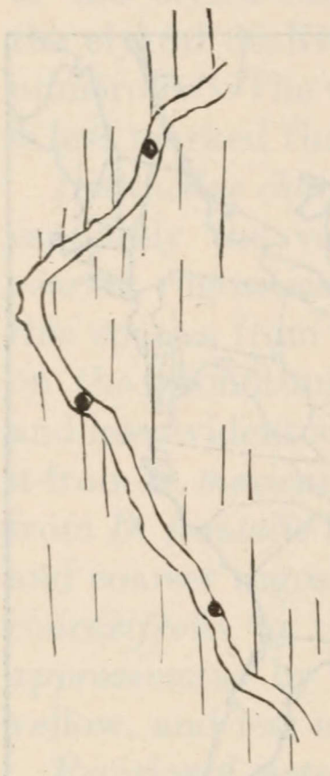

FIG. 59.—*Dendroctonus mexicanus:* Section of egg galleries. (Original.)

Variations.—Length from 3 to 4.5 mm.; average about 3.8 mm.; color from brown to black. The prescutal ridge is more prominent in some females than in others and is present in some males and absent in others.

Distinctive characters.—This species is more closely allied to *D. arizonicus* than to any of the other species of the division to which it belongs and is distinguished from it by the presence of short, reclining hairs on the pronotum, less distinctly impressed elytral striæ, and more evident short pubescence of the elytra.

Revisional notes.—It is evident that this species was not represented in the material studied by Blandford. The size comes near that of his *D. adjunctus*, but the characters as given by him to distinguish this species from *D. parallelocollis* at once distinguish it from *D. mexicanus*.

The pupa and larva have not been seen.

Gallery (fig. 59).—A small section of the gallery, evidently of this species, was received with the specimens of adult from Prof. A. L. Herrera. This indicates a winding egg gallery, with the eggs isolated, the larval mines concealed in the inner bark, and the pupal cells in the outer bark.

Distribution (fig. 60) *and host trees.*—The specimens received at different times from Prof. A. L. Herrera and Dr. S. J. Bonansea were evidently from *Pinus teocotl, P. lejophilla,* and *P. ayacahuite* in Amecameca, Michoacan, and Tacubaya, Mexico.

Identified specimens.—Thirty-six specimens of adults and one specimen of work were identified for Professor Herrera and Doctor Bonansea, a set of which were returned to them and the remainder retained for the forest insect collection of the Bureau of Entomology.

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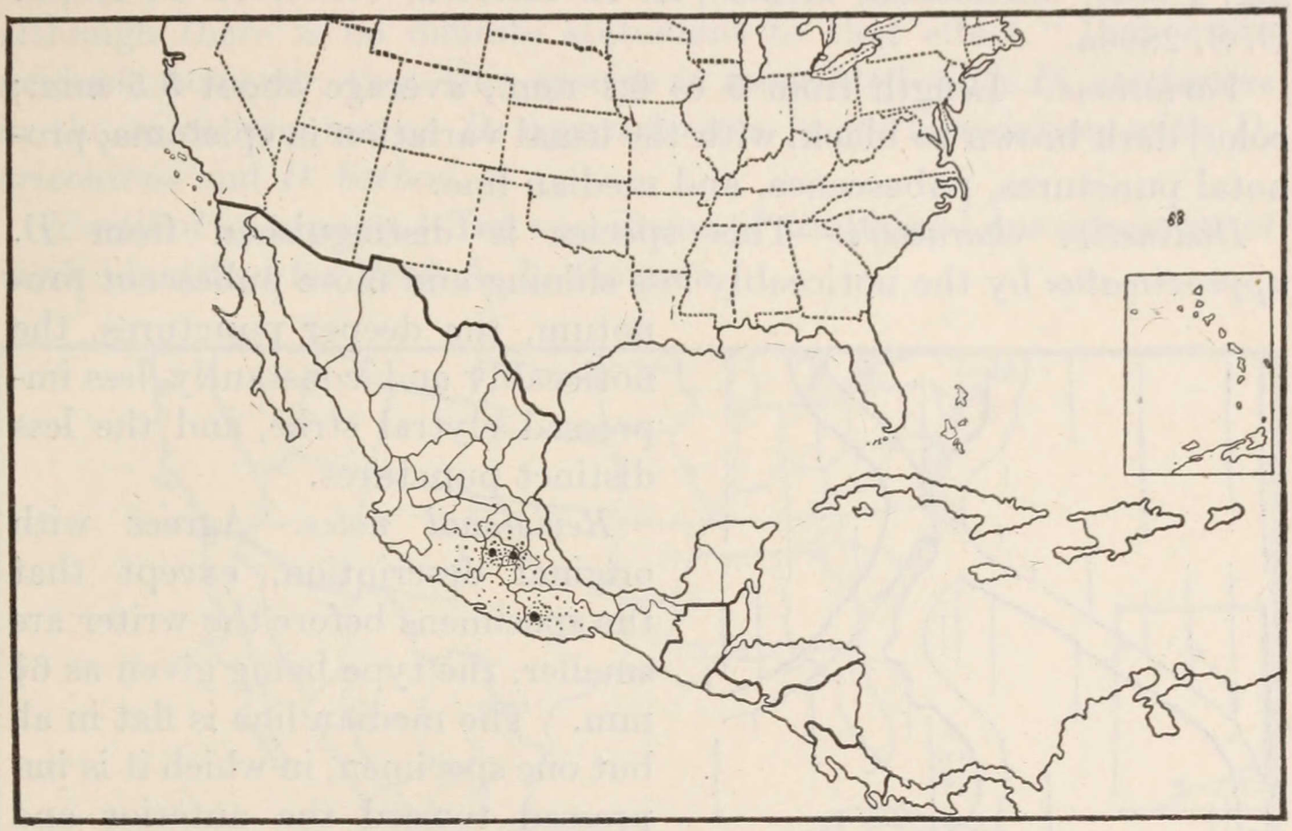

FIG. 60.—*Dendroctonus mexicanus:* Distribution map. (Original.)

7. **Dendroctonus parallelocollis** Chapuis.

(Pl. III, fig. 7.)

Adult.—Typical female: Length, 6.1 mm., deep black; elytral declivity with long hairs; head with front convex, shining, without distinct frontal tubercles each side of the shallow median groove; elytral striæ not impressed or distinctly punctured except at vertex; elytral rugosities obtuse, rather densely placed, moderately coarse toward suture, fine and less evident toward and on the lateral area; striæ obscure, especially on the lateral area. Pronotum with numerous short, reclining hairs and with very long, erect hairs on the entire lateral area, punctures distinct. Secondary sexual characters: Pronotum with transverse ridge across the anterior area; elytral declivity subconvex, shining; striæ distinct, slightly impressed, punctures rather distinct; interspaces with a few granules and sparse punctures, the lateral areas more rugose and coarsely punctured.

Typical female labeled, name label, "Hopk., January 16/08, Michoacan, Mexico, A. L. Herrera, collector, ♀, Hopk. U. S. 2896b."

Typical male: Length, 6 mm. Head with front convex and with prominent frontal tubercles each side of a deep groove. Pronotum with transverse impression across anterior area; elytral declivity

subconvex; striæ distinct, slightly impressed, and the interspaces more distinctly rugose than in female.

Typical male labeled, name label, "Hopk. 1/16/08, type of drawing, *Pinus*, Michoacan, Mexico, A. L. Herrera, collector, ♂, Hopk. U. S. 2896a."

Variations.—Length from 5 to 6.1 mm., average about 5.5 mm.; color, dark brown to black, with the usual variation in epistoma, pronotal punctures, pubescence, and median line.

Distinctive characters.—This species is distinguished from *D. approximatus* by the noticeably less shining and more pubescent pronotum, the deeper punctures, the noticeably and constantly less impressed elytral striæ, and the less distinct punctures.

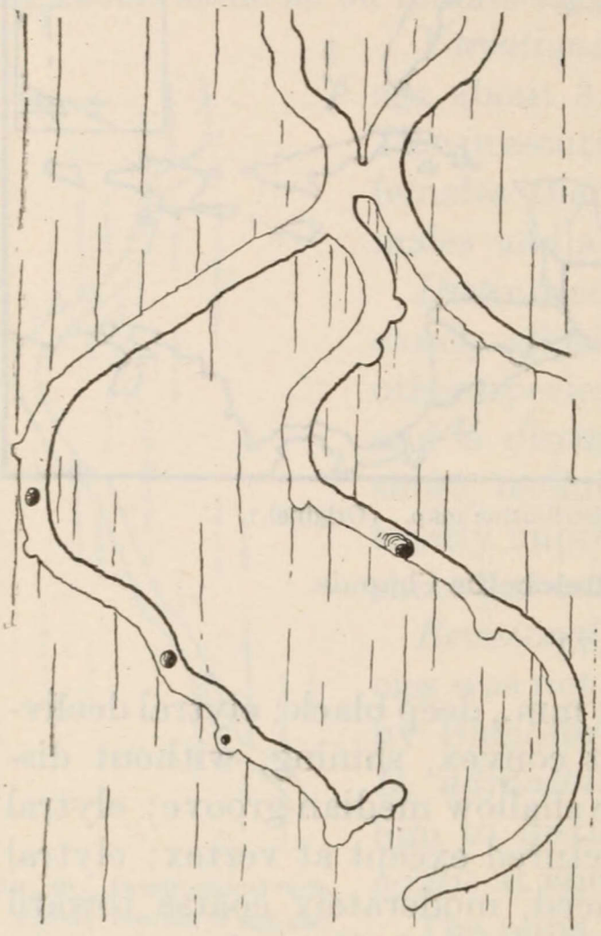

FIG. 61.—*Dendroctonus parallelocollis:* Section of egg gallery. (Original.)

Revisional notes.—Agrees with original description, except that the specimens before the writer are smaller, the type being given as 6⅔ mm. The median line is flat in all but one specimen, in which it is impressed toward the anterior and posterior margin. In Blandford's revision the length of the type is given as 6.3 mm. Blandford states that it differs from *D. approximatus* Dietz by its smaller size, more elongate shape, more shining and strongly punctured prothorax, and indistinct elytral striæ. The last difference holds, but the others do not.

In the writer's reference to this species (1905a, p. 81) it was considered to be the same as *D. approximatus* Dietz, but I am now convinced that the two are specifically distinct.

The pupæ and larvæ have not been observed.

Galleries (fig. 61).—A short section of the egg gallery, from which an adult was taken, indicates that it is quite similar, in its winding character and the absence of exposed larval mines, to that of *D. approximatus.*

Distribution (fig. 62).—Recorded from Mexico by Chapuis (1869) and Blandford (1897). Specimens were received with *D. mexicanus* from Prof. A. L. Herrera, labeled Mexico and Michoacan, Mexico, with his statement that it destroys the forests of Ionacatapec, Morelos, and many regions of Mexico.

Host trees.—According to evidence from correspondence with Professor Herrera, it would appear that this species, like *D. mexicanus*, attacks *Pinus teocotl* (?), *P. lejophylla*, and *P. ayacahuite*, although there is no definite statement to that effect. It is quite evident, however, that this species is associated with *D. mexicanus* in the same manner as *D. approximatus* in its association with *D. arizonicus* and *D. barberi*.

Identified specimens.—Ten specimens of adults and one specimen of work identified for Prof. A. L. Herrera.

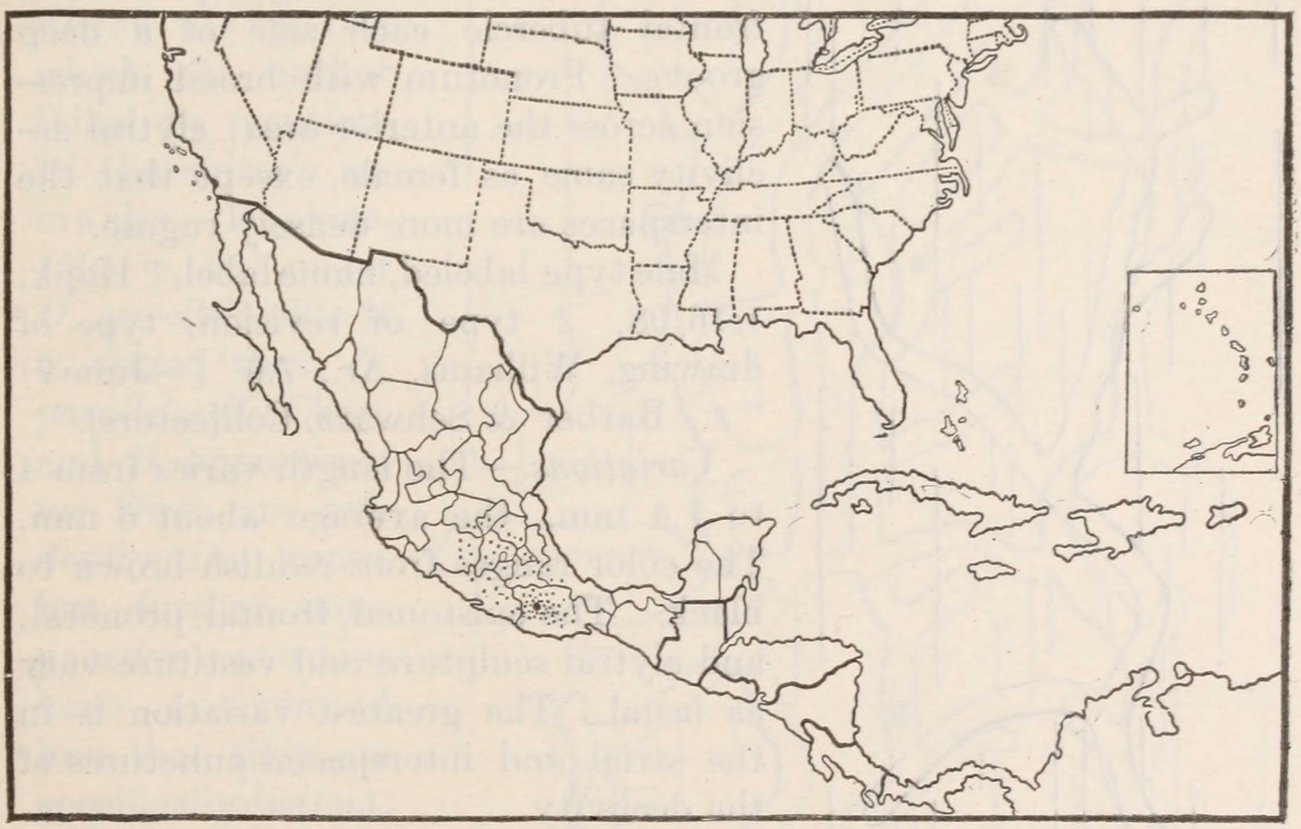

FIG. 62.—*Dendroctonus parallelocollis:* Distribution map. (Original.)

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8. **Dendroctonus approximatus** Dietz.

(Pl. IV, fig. 8.)

Adult.—Typical female: Length, 6.5 mm., reddish brown; elytral declivity with long hairs; head with front convex, shining, and with obscure frontal tubercles each side of short, median groove; elytral striæ not impressed or distinctly punctured; elytral rugosities rather coarse, sparse; striæ on lateral area rather distinct; pronotum with long hairs on anterior two-thirds of lateral area, but not on posterior section. Secondary sexual characters: Pronotum with transverse ridge across the anterior area; elytral declivity subconvex, shining;

striæ very distinct, impressed, and distinctly punctured; interspaces sparsely tuberculate, and with a few fine punctures; lateral area shining, with a few subacute tubercles, and rather coarse, distinct punctures.

Typical female labeled, name label, "Hopk. 1/16/08, ♀, individual *c*, Barber & Schwarz, Coll[ectors], Flagstaff, Ar. 2.7" (=July 2).

Type of species, ♀, in Horn collection, A.E.S., Philadelphia, labeled "Type *D. approximatus* n. sp., Col[orado]."

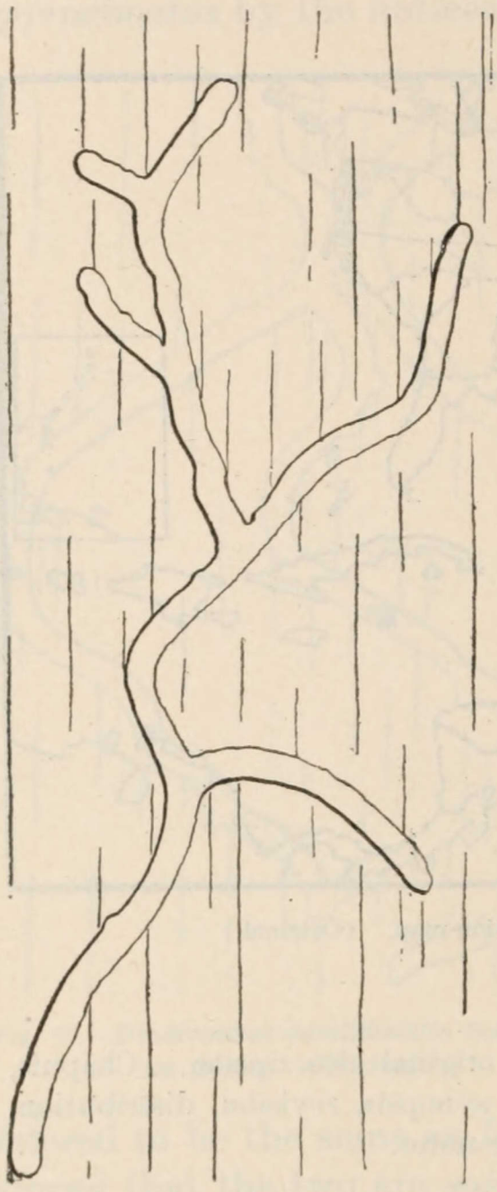

FIG. 63.—*Dendroctonus approximatus*: Single egg gallery. (Original.)

Male type: Length, 5.7 mm. Head with front convex, shining, a prominent frontal tubercle each side of a deep groove. Pronotum with broad impression across the anterior area; elytral declivity same as female, except that the interspaces are more densely rugose.

Male type labeled, name label, "Hopk. 1/16/08, ♂ type of revision, type of drawing, Williams, Ar., 7.6" (=June 7) "♂, Barber & Schwarz, Coll[ectors]."

Variations.—The length varies from 4 to 7.4 mm., the average about 6 mm. The color ranges from reddish-brown to black. The epistomal, frontal, pronotal, and elytral sculpture and vestiture vary as usual. The greatest variation is in the strial and interspacial punctures of the declivity.

Distinctive characters.—The characters which distinguish this species from *D. parallelocollis*, its nearest ally, are the noticeably more shining and less pubescent pronotum, with the punctures finer and more shallow, the elytral striæ constantly more impressed, and the punctures distinct.

Revisional notes.—The original description (Dietz, 1890, p. 31), was based on "four specimens, two males and two females, from New Mexico and Colorado in Doctor Horn's collection." The specimen labeled type in the Horn collection is a female from Colorado, and agrees with the description, but one specimen labeled "N. M." is a female of *D. convexifrons* Hopk., and one other specimen with the type, but without locality label, is quite a different thing from either of the other two. The specimen has not been examined since the more distinctive characters of *D. monticolæ* Hopk. and *D. ponderosæ* Hopk. have been recognized, but it evidently belongs to one of these species. The fourth specimen mentioned by Dietz was not in the

collection when examined by the writer on January 12, 1900. The reference in the original description to the front of the head "coarsely granulated, channeled" applies to the type, and at once distinguishes it from the other two specimens which are without a median frontal channel or groove. The "strong transverse impression about one-fourth from the anterior margin" of the prothorax is associated with the more distinct transverse elevation which the author failed to mention. In the writer's remarks (Hopkins, 1905, p. 81) under *D. parallelocollis* it is stated that *D. parallelocollis* Chap. and *D. approximatus* Dietz are evidently the same, but further comparative studies have convinced him that they are specifically distinct.

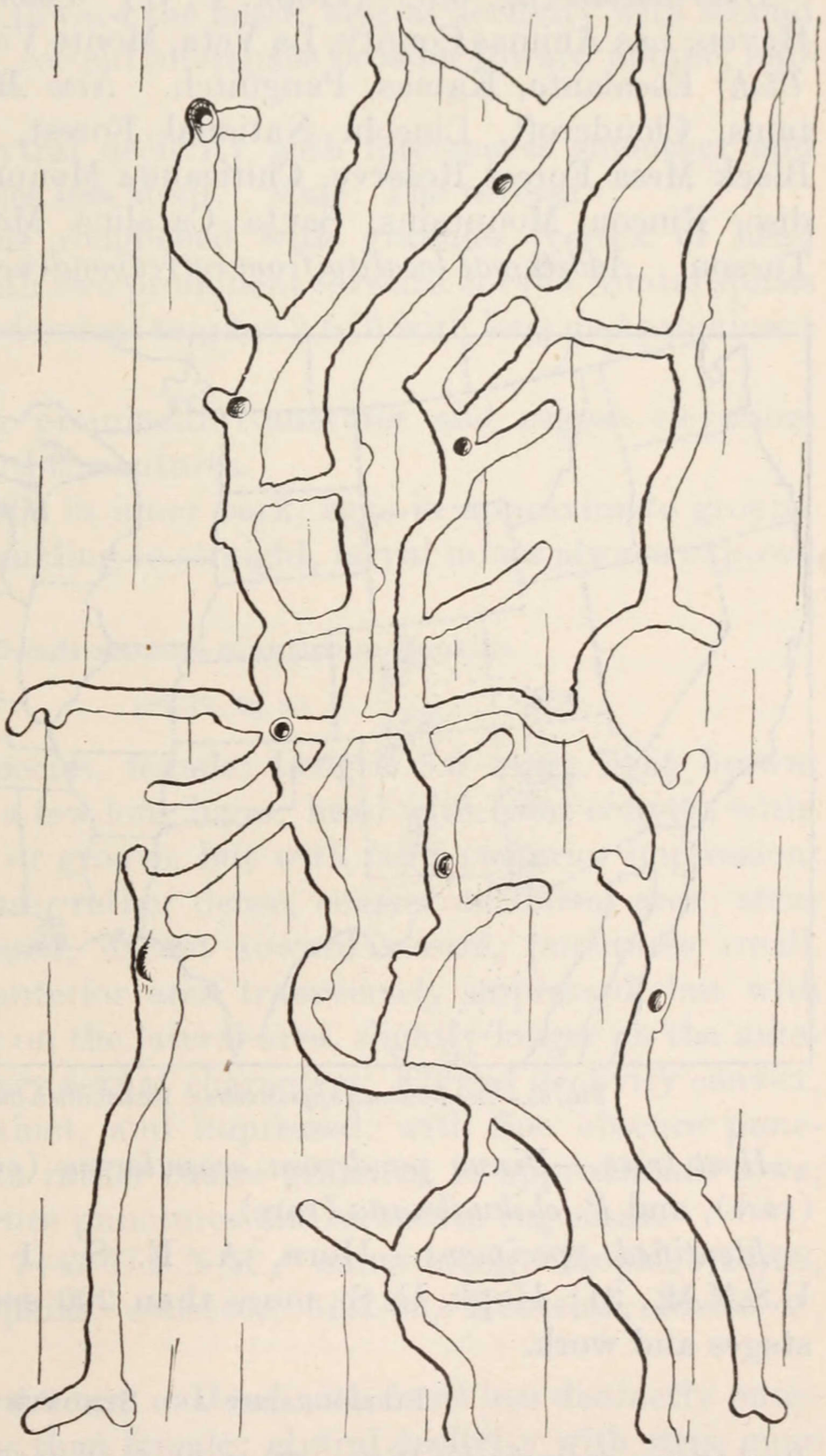

FIG. 64.—*Dendroctonus approximatus:* Egg galleries. (Original.)

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apex of the front and middle femora have each a minute subapical spine; abdominal tergites 1 to 6 with small pleural spines, 1 without distinct dorsal and lateral spines; 2 to 6 with distinct dorsal and lateral spines, increasing in length and prominence to and including tergite 6; 7 and 8 smooth; 9 with long pleural spine. Pupal type labeled "Hopk. U. S. No. 5777."

Larva.—In addition to generic and divisional characters, the front has a broad, but not prominent, median elevation; clypeus short, broad, with apex truncate; prothoracic segments with prominent

sternellar lobes, each with a distinct foot callus. Larval type labeled "Hopk. U. S. No. 5024."

Galleries (figs. 63, 64).—Egg galleries sublongitudinal, branched, slightly winding; eggs isolated; larval mines concealed; pupal cells in outer bark.

Distribution (fig. 65).—(Hopk. U. S.) *Colorado:* Brookville, Glen Haven, Las Animas County, La Veta, Monte Vista, and Palmer Lake. *Utah:* Escalante, Kamas, Panguitch. *New Mexico:* Capitan Mountains, Cloudcroft, Lincoln National Forest, Santa Fe. *Arizona:* Black Mesa Forest Reserve, Chiricahua Mountains, Flagstaff, Paradise, Rincon Mountains, Santa Catalina Mountains, Show Low, Tucson. *Additional locality from correspondence:* Glenhaven, Colo.

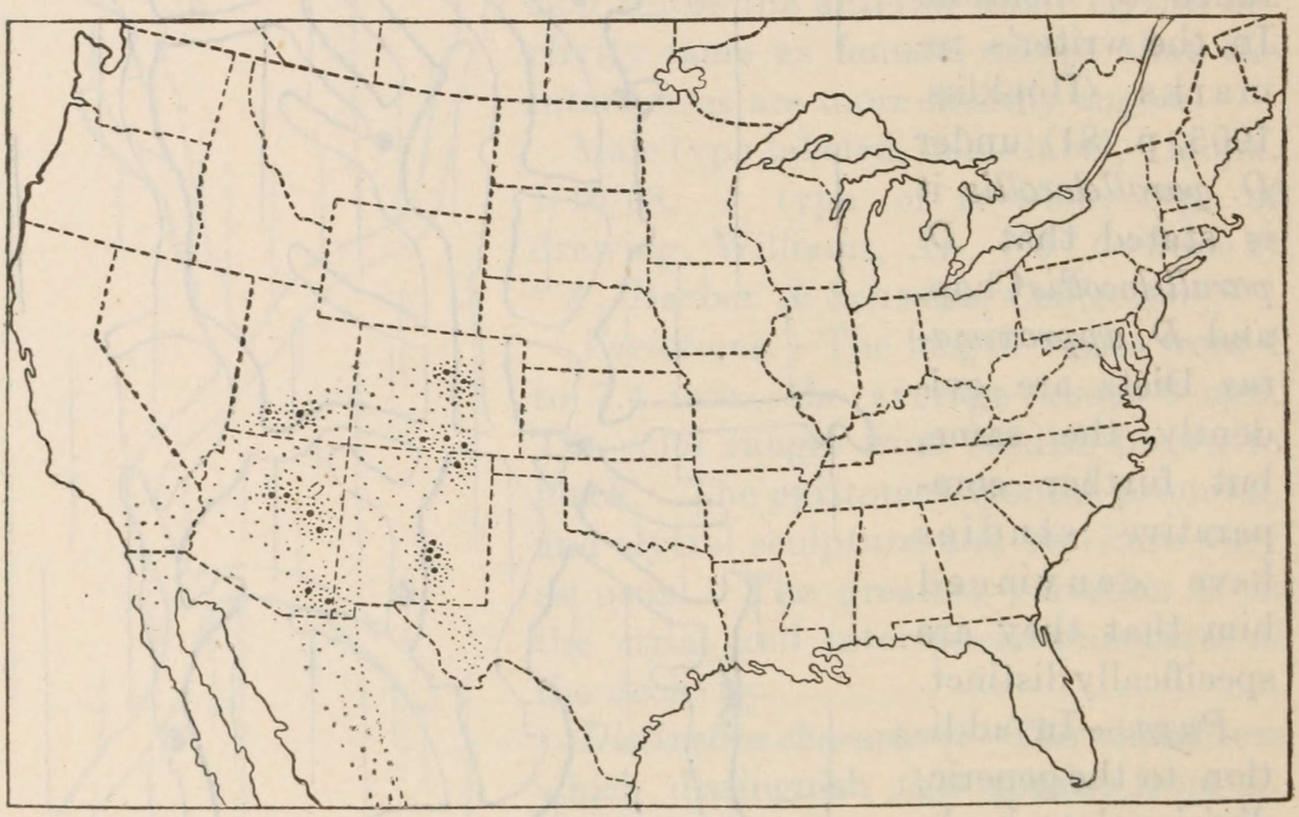

FIG. 65.—*Dendroctonus approximatus:* Distribution map. (Original.)

Host trees.—*Pinus ponderosa scopulorum* (common), *P. arizonica* (rare), and *P. chihuahuana* (rare).

Identified specimens.—Horn, A. E. S., 1 specimen, the type; U.S.N.M., 31; Hopk. U. S., more than 200 specimens, including all stages and work.

BIBLIOGRAPHY AND SYNONYMY.

Dendroctonus approximatus Dietz, 1890, p. 31, fig. 5, antenna and epistoma; original description (applies to type only). Blandford, 1897, p. 147, reference to characters. Hopkins, 1899a, p. 392, fig. LVIII, reference. Schwarz, 1902, p. 32 (in part), destructive to pine at Flagstaff, Ariz. (see also *convexifrons*). Wickham, 1902, p. 310 (in part), list, Dietz quoted. Hopkins, 1903a, p. 60, reference to habits, etc. Hopkins, 1903b, p. 281, mention. Hopkins, 1904, p. 44, habits, distribution, hosts, etc. Hopkins, 1905, p. 11, some distinctive characters. Hopkins, 1906c, p. 81, referred to *D. parallelocollis*.

Dendroctonus (*parallelocollis*) var. *approximatus* (Dietz) Fall, 1907, p. 218, list, localities.

SUBDIVISION B.

(Species numbered 9 to 11, inclusive.)

The distinctive characters common to the species of the second subdivision are as follows:

Adult.—Body somewhat stout, prothorax with sides distinctly narrowed and constricted toward the head; elytral declivity with second stria distinctly curved, second interspace broader toward middle, narrowed toward apex.

Sexes.—Female: Elytral declivity with interspaces smoother and more shining, mandibles less stout. Male: The reverse.

Pupa.—Elytral pads roughened with granules, vertex of head deeply grooved and with two prominent forward curved frontal spines toward the vertex; abdominal tergites 2 to 6 with long and prominent pleural spines.

Larva.—Front with prominent transverse and rugose elevation, more prominent toward the sutures.

Galleries.—Pupal cells in inner bark, eggs in approximate groups, egg galleries slightly winding to straight, larval mines always exposed in inner bark.

9. **Dendroctonus monticolæ** Hopkins.

(Pl. IV, fig. 9.)

Adult.—Type of species, female: Length 5.6 mm., light brown; elytral declivity with a few long hairs; head with front convex, without median elevation or groove, but with faint posterior impression; elytral rugosities coarse, rather dense, coarser on dorsal area; striæ not distinctly impressed, except toward suture, punctures small. Pronotum with the anterior area transversely impressed, but with moderately long hairs on the lateral area, slightly longer on the anterior section. Secondary sexual characters: Elytral declivity convex, subopaque; striæ distinct, and impressed, with fine obscure punctures; interspaces with rather coarse granules, in approximate rows; lateral area with obscure punctures and subacute rugosities.

Type labeled "No 7447 U.S.N.M.," name label, "Hopk. 1/16/08, *Pinus monticola*, Hopkins, collector, 5/27/99, Kootenai, Idaho, ♀, Hopk. U. S. 205."

Male type: Length 4.9 mm. Head with front less distinctly punctured and more rugose than female; elytral declivity with striæ more distinctly punctured, interspaces more opaque, and rugosities slightly coarser, the mandibles stouter than in female.

Male type labeled same as female except sex label.

Variations.—The length varies from 3.7 to 6.4 mm., averaging about 5.5 mm. The color ranges from light brown to black; the sculpture and vestiture of the epistoma, front, pronotum, and elytra vary as usual, but the character of the strial punctures is fairly constant.

The greatest variation is in size and in the presence or absence of dorsal line of the pronotum.

Distinctive characters.—The characters which distinguish this species from the next following, to which it is more closely allied, are the average smaller size and prevailing moderately impressed elytral striæ with distinct but moderately coarse punctures. While the strial punctures vary in size in different individuals, they are never so coarse as in the average *D. ponderosæ*. It is also distinguished from *D. jeffreyi* by the much smaller average length of body and the prevailingly coarser punctures of the pronotum.

Revisional notes.—A brief description (Hopkins, 1905, p. 11) was published under the name *D. monticola,* but the name should read *D. monticolæ,* which, as the manuscript name indicates, was originally intended. The species is represented by three specimens from California in the Le Conte collection, with the type series, under *D. similis,* bearing specimen numbers 4, 12, and 13, and therefore may have been included in the revision by Le Conte (1876, p. 385), although the locality (California) is not given in that correction. There is also one specimen in the Horn collection, labeled "Cal.," under *D. similis.* It is probable that the one under *similis* was before Dietz when he prepared his revision (1890, pp. 30–31) under the name *similis.* These specimens are evidently the only ones which may have been involved in Le Conte's or Dietz's revisions on the literature previous to Hopkins, 1899b, pp. 14 and 26.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apex of the front and middle femora is armed with two small apical spines; abdominal tergites 2 to 6 with long and prominent pleural spines, 1 is without distinct dorsal and lateral spines, but 2 to 6 have distinct dorsal and lateral ones, 2, 3, and 6 with a pair, and 4 and 5 with three lateral spines each side of the dorsal ones; 7 has two dorsal spines, while 8 is smooth and the pleural spines of 9 are long and prominent. Pupal type labeled "Hopk. U. S. No. 196."

There is the usual variation in the arrangement and number of minor spines, and one specimen from Yosemite National Park is quite different in the widely separated frontal spines, with the dorsal ones of the abdominal tergites coarser and tergite 7 with a pleural spine. It is possible that this may be a pupa of an unrecognized species. The characters of the pupa of *D. monticolæ,* which serve to distinguish it from that of *D. ponderosæ,* are the less coarse spines of the abdominal segments, the less densely granulated elytral pads, and the presence of two apical spines on the front and middle femora.

Larva.—In addition to the generic and divisional characters, the front has the posterior angle subacute and a moderately stout, rugose elevation situated in the middle, becoming slightly thickened and elevated toward the suture. Clypeus shining, with faint median

groove and usual elevation; apex broadly emarginate, labrum with apex broadly rounded, and the sternellar lobes of the thoracic segments with distinct foot calli. Larval type labeled "Hopk. U. S. No. 196."

There is some variation in the frontal elevation, but generally it is situated slightly anterior to the middle or in the middle, while the posterior angle of the front is distinctly subacute. These serve as

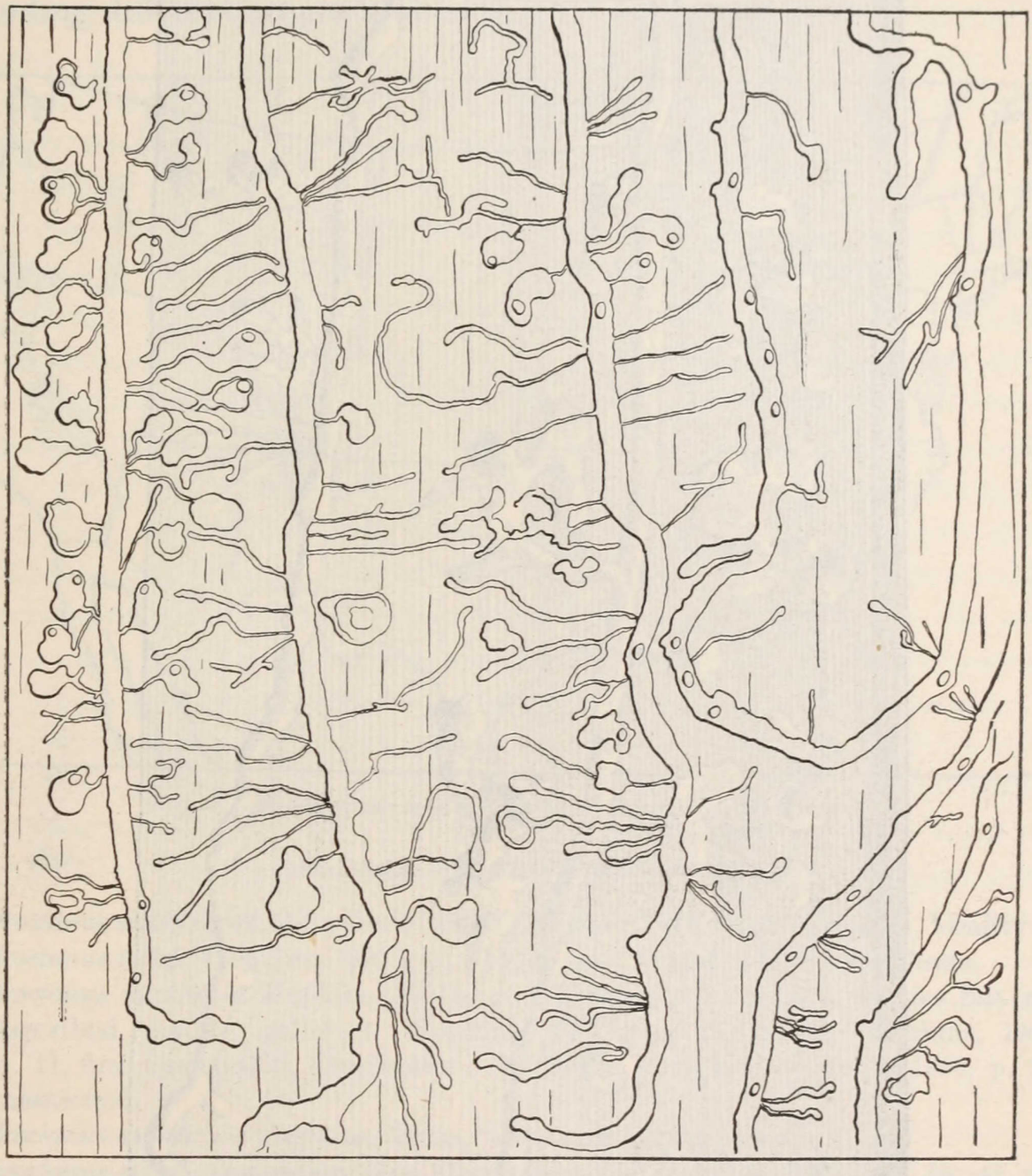

FIG. 66.—*Dendroctonus monticolæ:* Egg galleries and larval mines in bark. (Original.)

the most distinctive characters to separate the larva of this species from that of *D. ponderosæ*.

Galleries (figs. 66, 67).—The egg galleries are longitudinal, distinctly to slightly winding or straight, usually grooved on the surface of the wood and deeply grooved in the bark, the larval mines and pupal cells exposed in the inner bark; the eggs are placed in approximate groups, and the larval mines are short and broad. The egg galleries differ from those of *D. ponderosæ* in smaller size, more winding form, and are often of a much greater length.

Distribution (fig. 68).—(Hopk. U. S.) *California:* Alder Creek, Chester, Fulda, Lake Tenaya, Mariposa Grove, Millwood, Siskiyou County, Soda Springs, Summerdale, Tioga Road, Wawona. *Idaho:* Boise County, Cedar Mountain, Centerville, Coeur d'Alene National

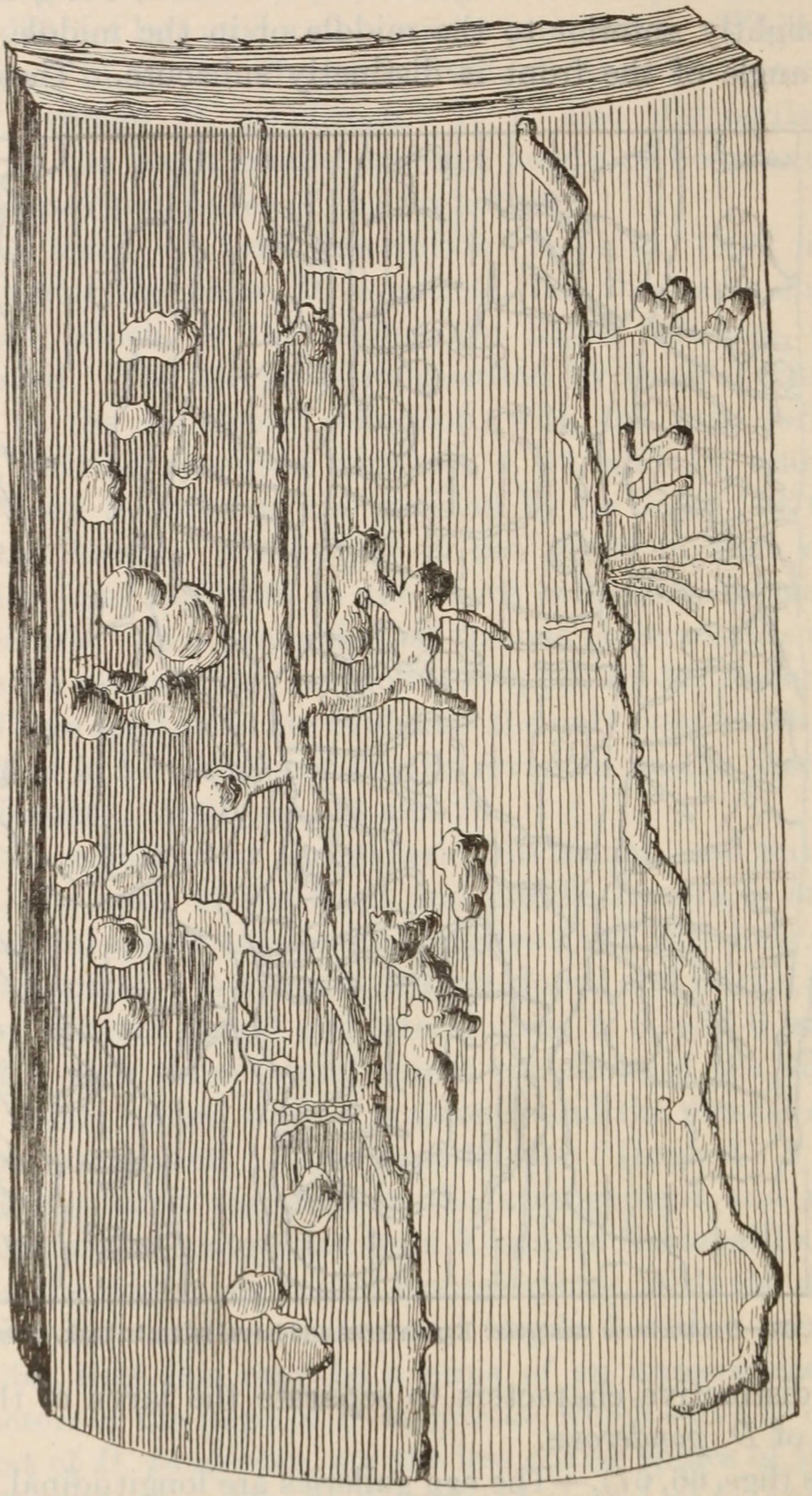

FIG. 67.—*Dendroctonus monticolæ:* Egg galleries and larval mines grooved in surface of wood. (Original.)

Forest, Collins, Helena, Kootenai, Moscow Mountains, Sand Point, Smith's Ferry, Weiser. *Montana:* Big Fork, Columbia Falls, Iron Mountain, Lolo, Lewis and Clark National Forest, Missoula, Saltese. *Oregon:* Ashland, Grants Pass, Joseph, Pokegama, Wallowa. *Washington:* Longmires Springs, Mount Rainier National Forest, Pialschie,

Washington National Forest. *Wyoming:* North Fork Shoshone River, Wapiti. *Additional localities from other collections:* (A. M. N. H.) Millwood, Cal.; (U.S.N.M.) Columbia Falls, Mont.

Host trees.—Pinus lambertiana, P. monticola, P. murrayana and *P. ponderosa* (common); *Picea engelmanni* (rare).

Identified specimens.—Le Conte, M. C. Z., 3; Horn, A. E. S., 1; A. M. N. H., Webb collection, 1; Henry Edwards collection, 1; U.S.N.M., 2; D. A., 11; Webb collection, 14; Hopk. U. S., over 500, including different stages and work.

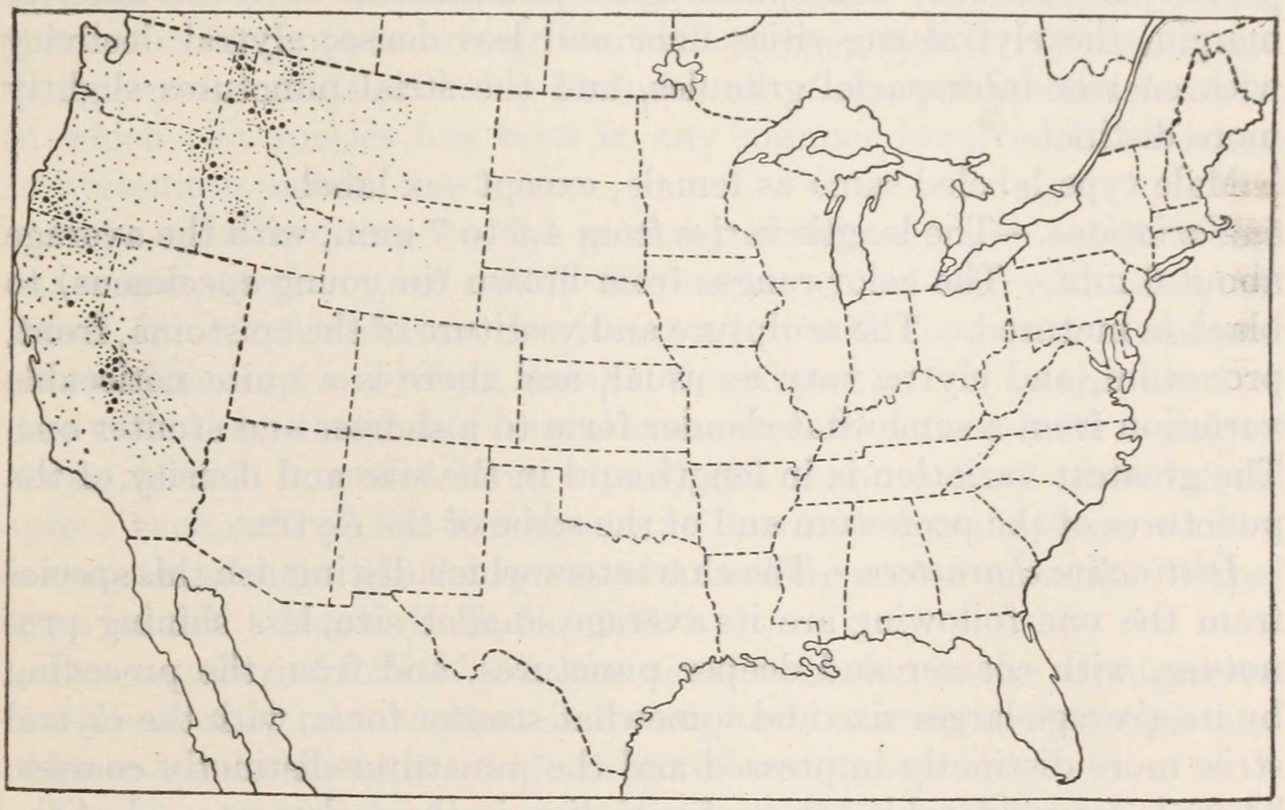

FIG. 68.—*Dendroctonus monticolæ:* Distribution map. (Original.)

BIBLIOGRAPHY AND SYNONYMY.

Dendroctonus similis (not of Le Conte, 1860) Le Conte, 1876, p. 385 (in part), locality.

Dendroctonus n. sp. Hopkins, 1899b, pp. 14, 26, first record of habits and hosts.

Dendroctonus monticola Hopkins, 1901b, p. 67, referred to as new species but not described, habits, galleries. Hopkins, 1902c, p. 21, notes. Hopkins, 1905, p. 11, first description, distribution, characters, very brief. Webb, 1906, p. 22, mentioned.

Dendroctonus monticolæ Hopkins, 1902a, p. 3, manuscript name.

Dendroctonus n. sp. (mountain pine *Dendroctonus*). Hopkins, 1904, pp. 19, 42, 45, habits, hosts, distribution, etc.

Mountain pine beetle. Hopkins, 1908, p. 162.

10. **Dendroctonus ponderosæ** Hopkins.

(Pl. IV, fig. 10.)

Adult.—Type of species, female: Length, 6 mm., black; elytral declivity with a few long hairs. Head with front convex, without median elevation or groove, but with faint posterior impression; elytral rugosities moderately coarse and moderately dense, becoming

much finer on the lateral area and coarser toward and on the vertex. Pronotum with moderately long, erect hairs on the lateral area, considerably longer toward the anterior section; punctures of elytral striæ distinct and coarse. Secondary sexual characters same as in preceding species.

Type labeled "Type No. 7448 U.S.N.M.," name label, "Hopk. 1/16/08, *Pinus ponderosa*, Spearfish, S. D., 7/1/00, A. D. Hopkins, collector, ♀, Hopk. U. S. 434."

Male type: Length 5.5 mm. Characters same as in female, except pronotum with very dense, subrugose punctures toward the anterior margin, the elytral rugosities finer and less dense; elytral declivity with coarser interspacial granules, and the strial punctures slightly more distinct.

Male type labeled same as female, except sex label.

Variations.—The length varies from 4.5 to 7 mm., with the average about 6 mm. The color ranges from brown (in young specimens) to black in matured. The sculpture and vestiture of the epistoma, front, pronotum, and elytra vary as usual, and there is a quite noticeable variation from a somewhat slender form to a shorter and stouter one. The greatest variation is in length and in the size and density of the punctures of the pronotum and of the striæ of the elytra.

Distinctive characters.—The characters which distinguish this species from the one following are its average smaller size, less shining pronotum, with coarser and deeper punctures, and from the preceding by its average larger size and somewhat stouter form, with the elytral striæ more distinctly impressed and the punctures distinctly coarser. There is a considerable range of variation in these characters, but the specimens with less distinctly impressed striæ and finer punctures which might be mistaken for *D. monticola* are exceptional, and should cause no confusion as long as the range of distribution of the two species is so distinct.

Revisional notes.—In March, 1902, the writer (Hopkins, 1902a, p. 3) published the manuscript name, *D. ponderosæ*, without description of any kind, and in April of the same year (Hopkins, 1902b, p. 10) he gave a brief description under *D. ponderosa*, but, as indicated by the manuscript name, it was intended that the name should relate to the host tree, *Pinus ponderosa*, therefore the name *D. ponderosæ*, under which it is here fully described, should stand. The species is represented in the Le Conte collection by one immature example, which, in 1900, was in the *D. rufipennis* series, labeled "Specimen 8, Col." In March, 1907, this specimen was again examined by the writer, and identified as *D. ponderosæ*. It is evident that it was in Le Conte's collection when he prepared his latest revision (1876), but there is

evidence that the characters and locality were not involved in the revised description under *D. rufipennis*. It is probably represented in the Horn collection (A. E. S.) by one specimen, without locality label, found by the writer in 1900 as the third specimen in the type series, under *D. approximatus*. Two other specimens, labeled "Colo.," were found in the Horn collection and one specimen in the general Academy of Natural Sciences collection under *D. rufipennis*. The two in the Horn collection were evidently before Dietz when he prepared his revision under *D. rufipennis* and included in the Colorado locality if not in the revised description. The writer (1902, p. 10) refers in a footnote to wrong identifications under *D. rufipennis* and *D. terebrans*. This probably includes all of the published references in which this species has been in any manner involved in revisions or systematic notes.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the front and middle femora are armed each with one small apical spine. Abdominal tergites 2 to 6, with long and prominent pleural spines; 1 is without distinct dorsal and lateral spines, but 2 to 6 have distinct dorsal and lateral ones, and all of them have a pair of dorsal, and 2, 3, and 6 have a pair, and 4 and 5 have three lateral spines each side of the dorsal ones; 7 has two dorsal spines, while 8 is smooth, and the pleural spines of 9 are long and prominent. Pupal type labeled "Hopk. U. S. No. 623."

In a number of individuals, the usual variation in the arrangement and number of minor spines is found, and between the younger and older examples there is a wide range of variation.

The characters which seem to distinguish the pupa of this species from that of *D. monticolæ* are the coarser spines of the abdominal tergites, the more densely granulate elytral pads, and the presence of but one apical spine on the front and middle femora.

Larva.—In addition to the generic and divisional characters, the front has the posterior angle subobtuse, and a stout prominent rugose transverse elevation situated slightly behind the middle and elevated and broad toward the sutures; clypeus with the base shining and bearing a faint median elevation, and the apex broadly emarginate; labrum less than half as long as broad, with the apex truncate; sternellar lobes of the thoracic segments with indistinct foot calli. Larval type labeled "Hopk. U. S. No. 755."

There is some variation in the frontal elevation, but generally it is situated behind the middle, and the posterior angle of the front is more obtuse than in the preceding, which latter serves as the most distinctive character separating the larva of this species from that of *D. monticolæ*.

Galleries (figs. 69, 70).—The egg galleries are longitudinal, and usually nearly straight. They are usually grooved on the surface of the wood and deeply grooved in the inner bark, with the larval mines and pupal cells exposed. The eggs are placed in approximate groups,

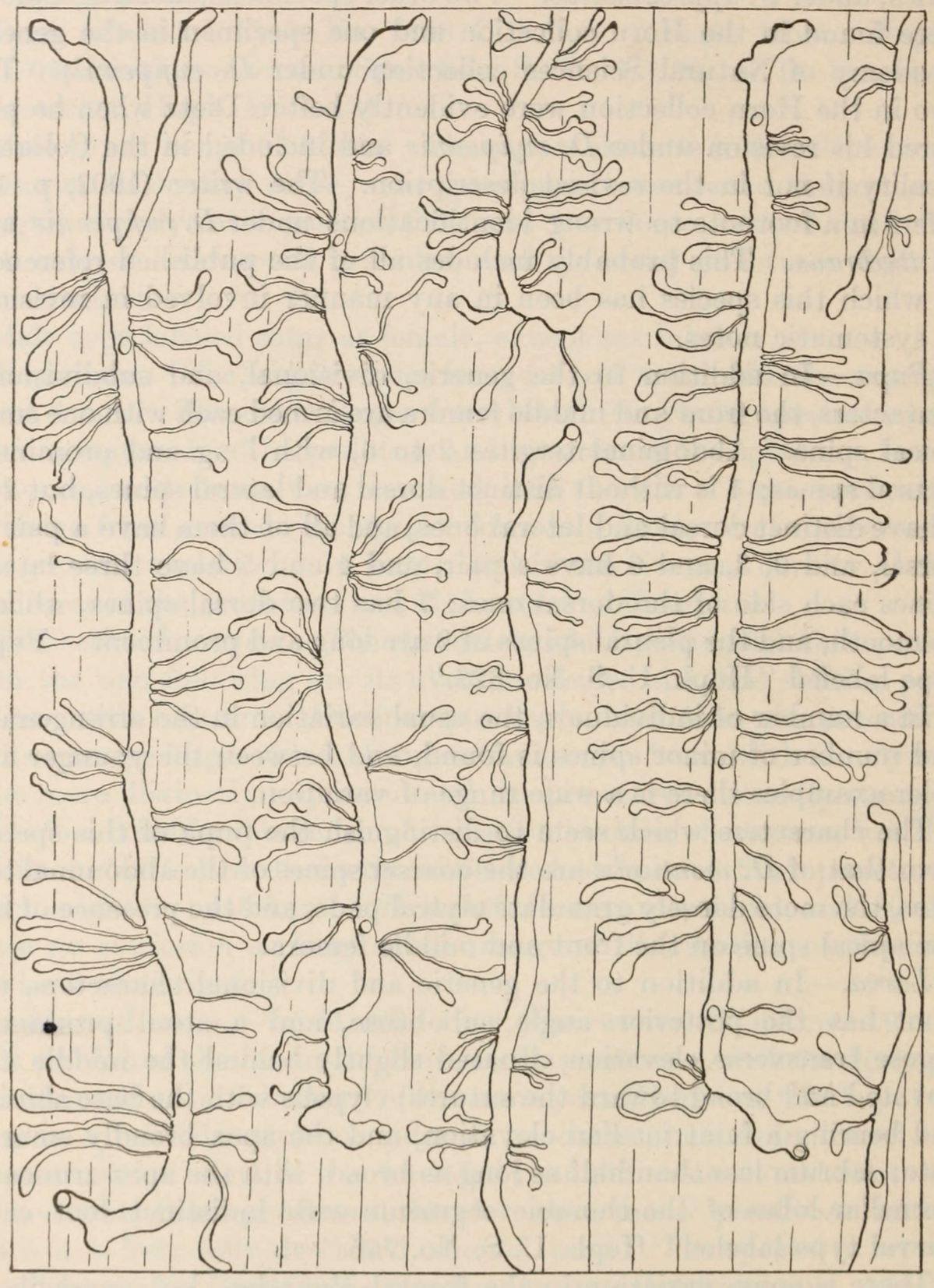

FIG. 69.—*Dendroctonus ponderosæ:* Egg galleries and larval mines. (Original.)

and the larval mines are short. The egg galleries differ from those of *D. monticolæ* in the larger diameter and straighter, shorter form.

Distribution (fig. 71).—(Hopk. U. S.) *Arizona:* Chiricahua National Forest, Flagstaff, Fredonia, San Francisco Mountains. *Colorado:* Bailey, Brookvale, Cascade, Cat Mountain, Cochetopa, Colo-

rado Springs, Fort Garland, Glenwood Springs, Gunnison National Forest, Green Mountain Falls, Hahns Peak, Husted, Indian Creek, Larkspur, La Veta, Manitou, Medicine Bow National Forest, Meeker, Monte Vista, Ouray National Forest, Palmer Lake, Pikes Peak, Pine, Poncha Springs, San Isabel National Forest, San Juan National Forest, Sequache, Uncompahgre National Forest, White River National Forest. *New Mexico:* Gila National Forest, Vermejo. *South Dakota:* Custer, Elmore, Hill City, Lead, Nemo, Piedmont, Sylvan Lake. *Utah:* Escalante, Kamas, Kanab, La Salle National Forest, Panguitch, Provo. *Wyoming:* Downington, Encampment, Keystone. *Additional locality from other collectors*: (Brown) Las Animas County, Colo. *Localities reported by correspondents:* Eagle, Florissant, Idaho Springs, Kennedy Station, La Veta, Montrose, Pagosa Springs, Porter, San Juan, Ute Pass, and West Cliff, Colo.

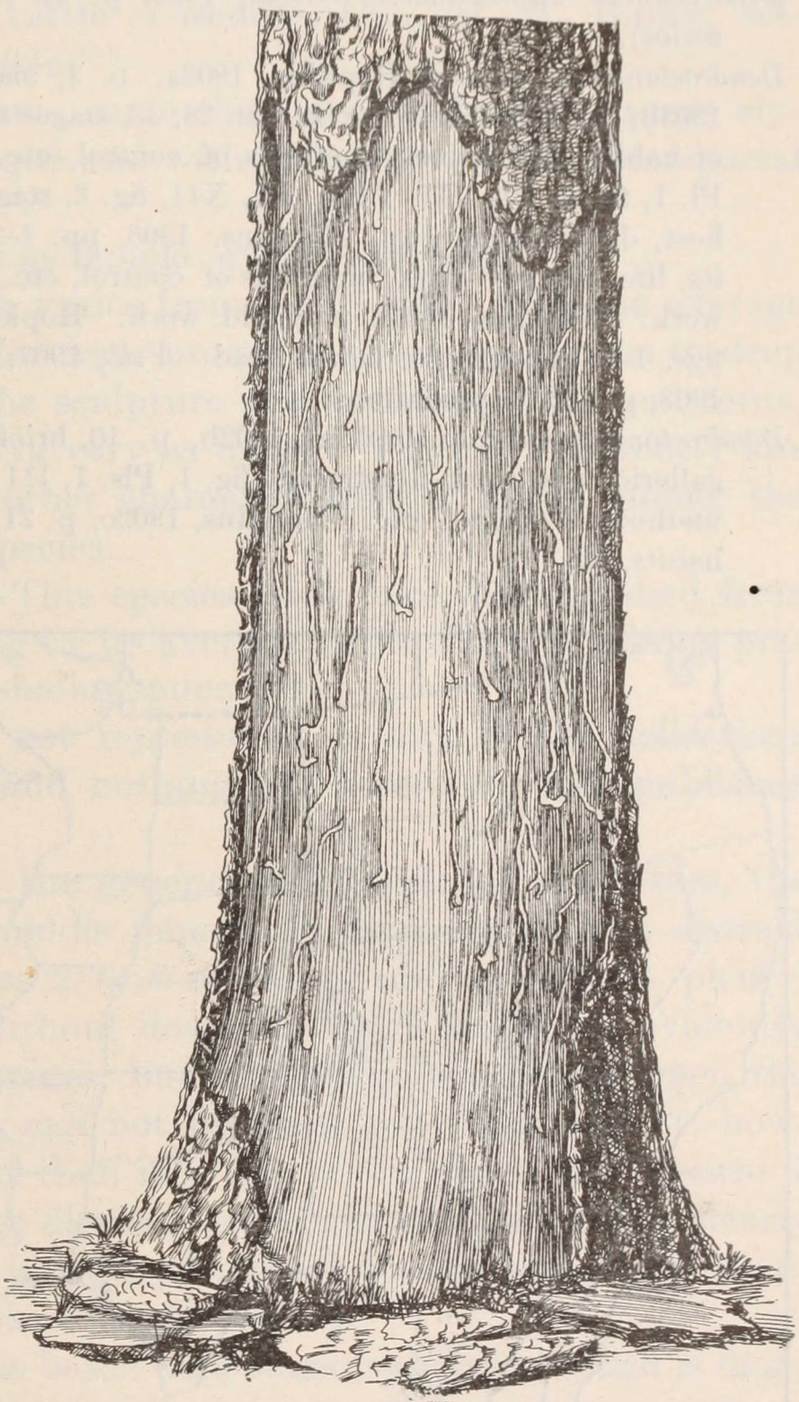

FIG. 70.—*Dendroctonus ponderosæ:* Tree with bark removed, showing egg galleries grooved and marked on surface of wood. (Original.)

Host trees.—*Pinus ponderosa scopulorum*, *P. flexilis*, *P. murrayana*, *P. strobiformis*, and *Picea engelmanni*.

Economic relation to forests.—This species is exceedingly destructive to the pine forests of the central and southern Rocky Mountain region, having caused a loss of forest resources worth many millions of dollars. The rock pine, or bull pine (*Pinus ponderosa* var. *scopulorum*), is its favorite host tree, but it attacks and kills the other pines and infests the spruce, though apparently not destructive to the latter.

Identified specimens.—Le Conte (M. C. Z.), 1 specimen; Horn (A. E. S.), 2 specimens; A. N. S., 2 specimens; U.S.N.M., 1 specimen;

D. A., 14 specimens; Gillette, 2 specimens; Hopk. U. S., more than 10,000 specimens, including all stages and work.

BIBLIOGRAPHY AND SYNONYMY.

Dendroctonus similis (not of Le Conte, 1860) Le Conte, 1876, p. 385 (in part) (in collection 1890).

Dendroctonus approximatus Dietz, 1890, p. 31 (in part?) (specimen with type series).

Dendroctonus ponderosæ Hopkins, 1902a, p. 3, manuscript name only. Hopkins, 1903b, pp. 275, 282, p. xxix, figs. 28, 32, stages and work figured, and full account of habits, life history, methods of control, etc. Hopkins, 1904, pp. 41, 43, 44, Pl. I, fig. 1, Pls. III, VIII, IX, XII, fig. 2, stages and work illustrated, habits, host, distribution, etc. Hopkins, 1905, pp. 1–24, full account of history, habits, life history, work, methods of control, etc., Pls. I, II, figs. 1–6, stages and work. Hopkins, 1906a, p. 4, old work. Hopkins, 1906b, p. 147, Pls. IV, V, figs. 1–5, anatomy of larval head. Fall, 1907, p. 218, list, locality. Hopkins, 1908, p. 162, depredations.

Dendroctonus ponderosa Hopkins, 1902b, p. 10, brief original description, adult, etc., galleries and work illustrated, fig. 1, Pls. I, III, IV, VII, full account of habits, methods of control, etc. Hopkins, 1902c, p. 21, habits. Hopkins, 1903a, p. 59, habits, etc.

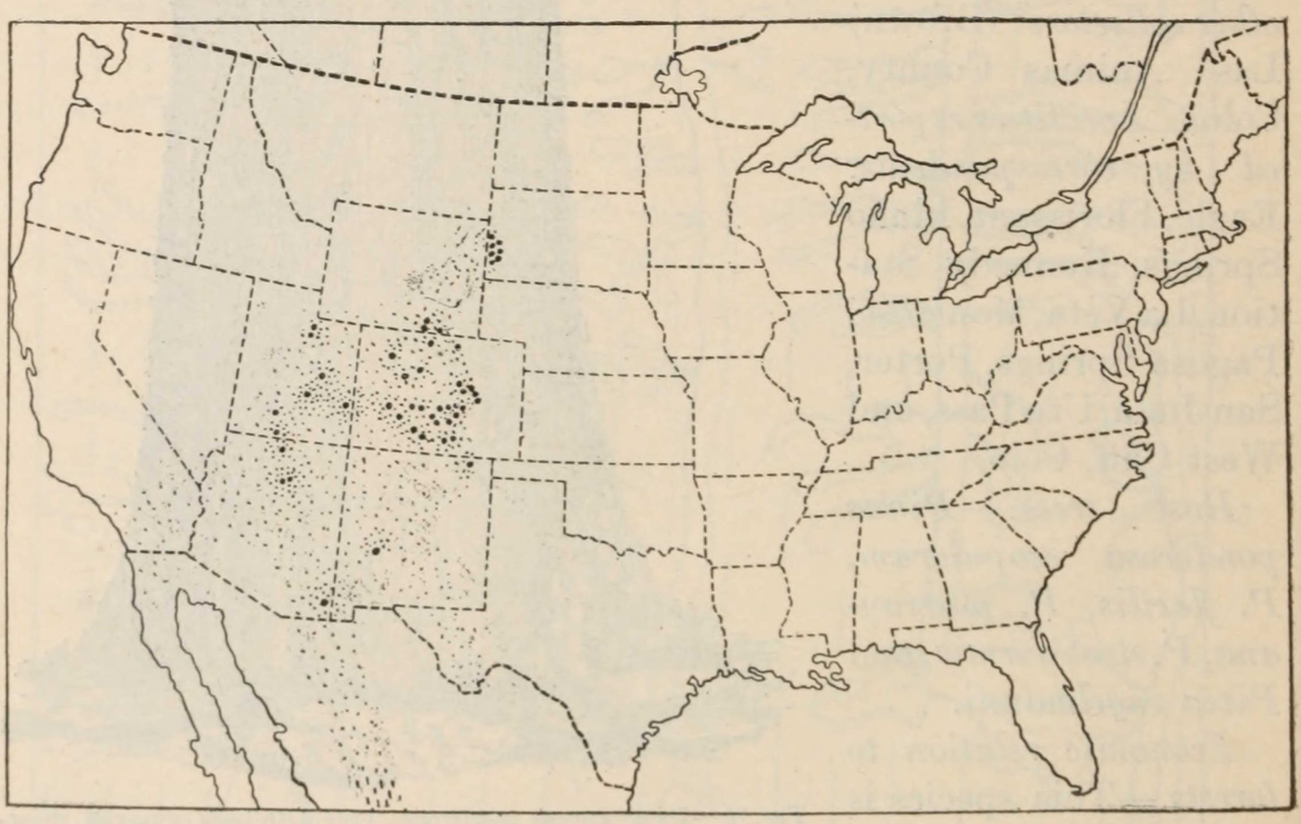

FIG. 71.—*Dendroctonus ponderosæ:* Distribution map. (Original.)

11. Dendroctonus jeffreyi n. sp.

(Pl. IV, fig. 11.)

Adult.—Type of species, female: Length 7.5 mm., black; elytral declivity with a few long hairs. Head with front convex, with slight anterior and posterior impressions, without frontal elevations; elytral rugosities moderately coarse and dense, becoming much finer on lateral area and coarser toward the vertex. Pronotum shining, sides

distinctly constricted toward the head, with moderately long, erect hairs on the lateral area, longer and denser on the anterior surface; punctures of elytral striæ distinct and coarse, the striæ more distinctly impressed on the dorsal area. Secondary sexual characters same as in preceding species.

Type labeled "Type No. 7449 U.S.N.M.," name label, "Hopk. 1/22/08, *Pinus jeffreyi*, Little Yosemite, Cal., H. E. Burke, collector, ♀, Hopk. U. S. 4394a."

Male type: Length 7 mm., same characters as female, except elytral declivity is more opaque and with distinctly coarser interspacial rugosities.

Male type labeled same as female, except sex label.

Variations.—The length varies from 6 to 8 mm., with the average about 7 mm., and the color from brown in young specimens to deep black when matured. The sculpture and vestiture of the epistoma, front, pronotum, and elytra vary as usual. There is apparently less variation in size and in other characters than is found among the individuals of the other species.

Distinctive characters.—This species is at once distinguished from either of the two preceding by its average larger size and shining pronotum, with its fine and shallow punctures.

Note.—This species is not represented in any of the collections examined by the writer, and nothing has heretofore been published about it.

Pupa.—In addition to the generic and divisional characters, the apices of the front and middle femora are armed with two distinct spines; abdominal tergites 2 to 6 with long and prominent pleural spines; 1 is apparently without dorsal spines, 2 and 6 are evidently with dorsal and lateral spines, but in the single poor specimen the relative size and number can not be made out; they appear, however, to be less prominent than in either of the preceding species; 7 has two small dorsal, three distinct lateral spines, and a small pleural one; 8 is smooth, and 9 is with prominent pleural spines, as usual. Pupal type labeled "Hopk. U. S. No. 4412a."

The above description is based on a single specimen, which is damaged, therefore is subject to revision when more specimens are examined. It seems to be quite different from the unique pupa mentioned under *D. monticola.*

Larva.—In addition to the generic, divisional, and subdivisional characters, the front has the posterior angle subacute, and a narrow transverse elevation situated in the middle and not broadened or more elevated toward the sutures; clypeus shining, with median groove toward the base and with the apex broadly emarginate; labrum with apex broadly truncate; sternellar lobes of the thoracic segments

with obscure foot scars. Larval type labeled "Hopk. U. S. No. 6204b."

There is very little variation in the four specimens before the writer, and the narrow smoother frontal elevation, not elevated and broadened toward the suture, is the most distinctive character separating the larva of this species from those of the two preceding species.

Galleries.—The egg galleries are longitudinal, nearly straight, grooved on surface of the wood, and deeply grooved in the inner bark, with the larval mines and pupal cells exposed. The eggs are placed singly and in approximate groups. The egg galleries and larval mines of this species differ from those of the two preceding in

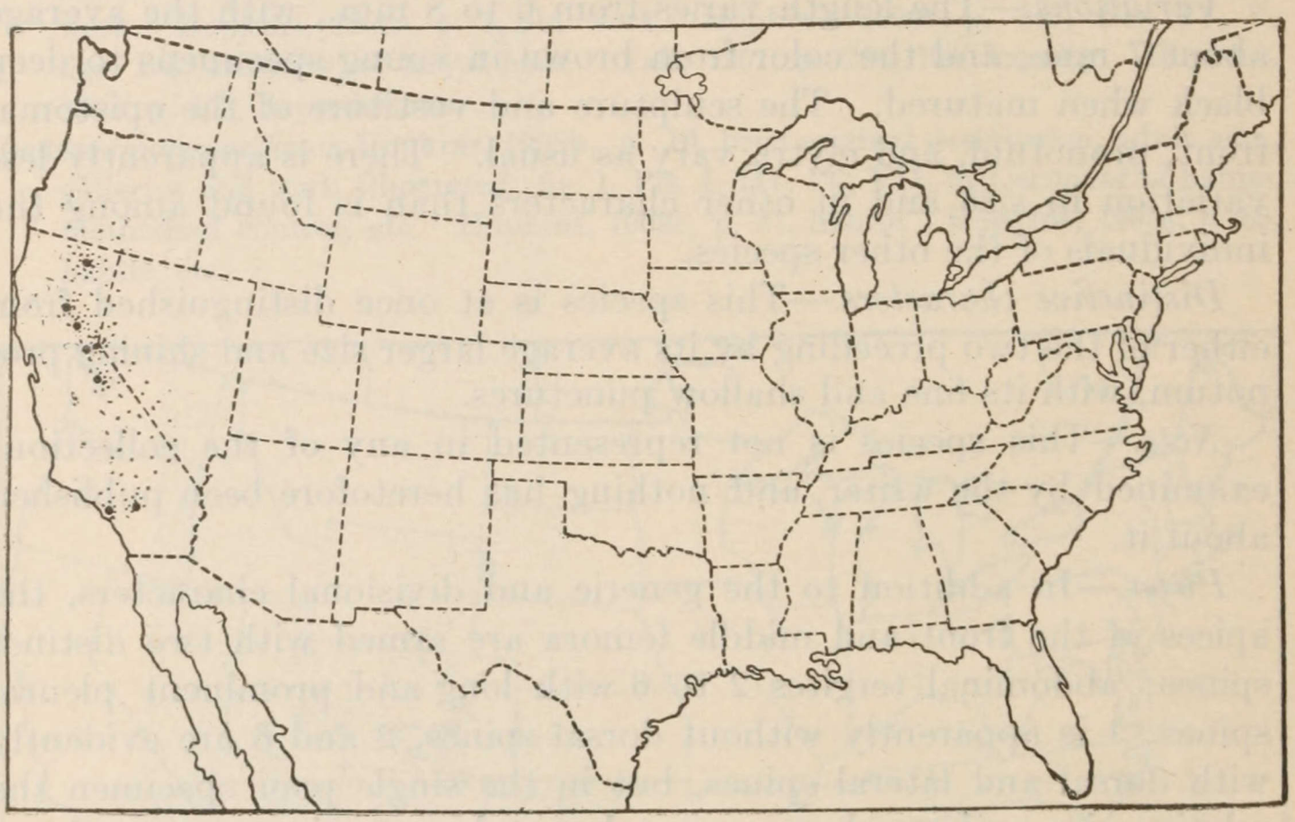

FIG. 72.—*Dendroctonus jeffreyi:* Distribution map. (Original.)

being much coarser; otherwise they appear to be more like those of *monticolæ.*

Distribution (fig. 72).—(Hopk. U. S.) *California:* Chester, Little Yosemite, Nevada City, Pinogrande, Sterling, Tallac, Yosemite (Yosemite National Park), and Seven Oaks (San Bernardino National Forest).

Host trees.—*Pinus jeffreyi. P. ponderosa,* and *P. lambertiana.*

Identified specimens.—Hopk. U. S., over 160 specimens, including adults, pupæ, and larvæ.

DIVISION II.

The distinctive characters common to the species of the second division are:

Adults.—Prothorax stout, usually narrower than elytra, distinctly narrowed or constricted toward head; elytra with anterior dorsal

half bearing long hairs, except in *D. terebrans* and badly rubbed specimens.

Pupa.—Vertex of head faintly impressed, flat or convex, and with two small widely separated frontal granules toward vertex.

Larva.—Abdominal tergites 8 and 9 with dorsal plates except in *simplex* and *pseudotsugæ*, and 8 without plate in *micans*.

Galleries.—Egg galleries longitudinal, straight to slightly winding; eggs in groups or masses; larval mines and pupal cells exposed in inner bark.

Subdivision C.

(Species Nos. 12 to 21, inclusive.)

The distinctive characters common to the species of this third subdivision are:

Adults.—Front usually with posterior impression, pronotum with large and small punctures intermixed. Pronotum with long hairs on dorsal and lateral areas.

Sexes.—Female: Interspaces of elytral declivity more roughened and the striæ more distinctly impressed. Male: The reverse.

Pupa.—Vertex of head flattened or faintly impressed; apices of front and middle femora smooth; abdominal tergites with moderately prominent pleural and dorsal spines.

Larva.—Abdominal tergites 8 and 9 without dorsal plate in *simplex* and *pseudotsugæ* and with unarmed dorsal plate in the remaining species.

Galleries.—Egg galleries slightly winding to straight; eggs in groups, but larval mines separated from the beginning, or beyond the middle, except in *D. micans*.

12. **Dendroctonus simplex** Le Conte.

(Pl. V, fig. 12.)

Adult.—Typical female: Length, 3.9 mm., dark reddish-brown. Head with front distinctly convex, with faint posterior impression. Pronotum with distinctly coarse and fine punctures intermixed; elytral declivity with striæ deeply impressed; epistomal process narrow, flat, the sides nearly parallel, apex not extending beyond the anterior frontal margin; elytral rugosities moderately coarse, becoming finer on the lateral areas, sparse, coarser, and more acute on the dorsal area and vertex; striæ toward suture impressed, not impressed on lateral area; strial punctures coarse and distinct. Pronotum with moderately long reclining hairs on lateral area. Secondary sexual characters: Elytral declivity with interspaces more rugose and the striæ more distinctly impressed.

Typical female labeled, name label, "Hopk. 1/22/08, H. S. 41, ♀, Grand Ledge, Mich., 21.4" (= April 21).

Typical male: Length, 3.8 mm.; elytra more shining, less rugose; declivity shining, interspaces convex and smooth, with fine, distinct

punctures and with striæ distinctly impressed and finely punctured; otherwise as in female.

Typical male labeled, name label, "Hopk. 1/22/08, H. S. 40, ♂, Grand Ledge, Mich., 20.5" (= May 20).

Variations.—The length varies from 3.5 to 5 mm., with the average about 4.7 mm. The color varies from reddish to reddish-brown, with the head and thoracic segments ranging from light to dark brown, and nearly black. The epistomal characters are more constant in this and the next species, otherwise the usual variation in the sculpture and vestiture of the head, pronotum, and elytra prevails. The greatest variation, other than size, is found in the punctures of the pronotum and in the strial punctures and interspacial rugosities of the elytra.

Distinctive characters.—The characters which distinguish this species from the following, to which it is more closely allied, are the much smaller average size of the individual and the coarser and deeper punctures of the pronotum.

Revisional notes.—The original description was based on two male specimens labeled "Canada," which have been examined by the writer and found to agree with the common species which lives in the eastern larch. The comparison in the description with *D. obesus* must refer to *D. pseudotsugæ* Hopk., representatives of which were then confused with the true *D. obesus* (Mann.). The smooth intervals on the declivity referred to is a male character. The reference to a much deeper sutural stria relates to what is now recognized as stria 1. The revision relates to the type specimens. With our present knowledge of the specific characters, those given in Le Conte's tables are only partially applicable. It is evident that no other species were confused with this one in Le Conte's description and revision, but it was involved in the revision under *D. obesus* (1868) and *D. similis* (1873). In 1900 it was in Le Conte's collection under *D. rufipennis*, labeled "Lake Superior" and "Tex.," and under *D. similis*, labeled "Lake Superior" and "Can." In Dietz's revision, the specimens from Colorado and California were evidently *D. pseudotsugæ*, but did not involve any confusion in the description, except in the length, 6.2 mm., which was evidently based on a specimen of *D. pseudotsugæ*.

The species was found to be represented in the Horn collection by one specimen, under *simplex*, labeled "Can.," and two specimens under *D. similis*, labeled "Can."

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apex of the front and middle femora has a minute subapical granule. Abdominal tergite 1 with very small and 2 to 6 with stout, prominent pleural spines, 1 without dorsal or lateral, 2 without dorsal, 3 to 6 with prominent dorsal spines, becoming larger toward 6, 2 to 6 with two lateral spines each side, becoming more

prominent toward the latter, 7 with two minute dorsal hairs, 8 smooth, 9 with prominent widely separated spines. Pupal type, labeled "Hopk. U. S. No. 6444b."

The usual variation in arrangement and number of minor spines prevails, but the pupa of this species is easily distinguishable from that of the following by its smaller size and the more prominent dorsal, lateral, and pleural spines.

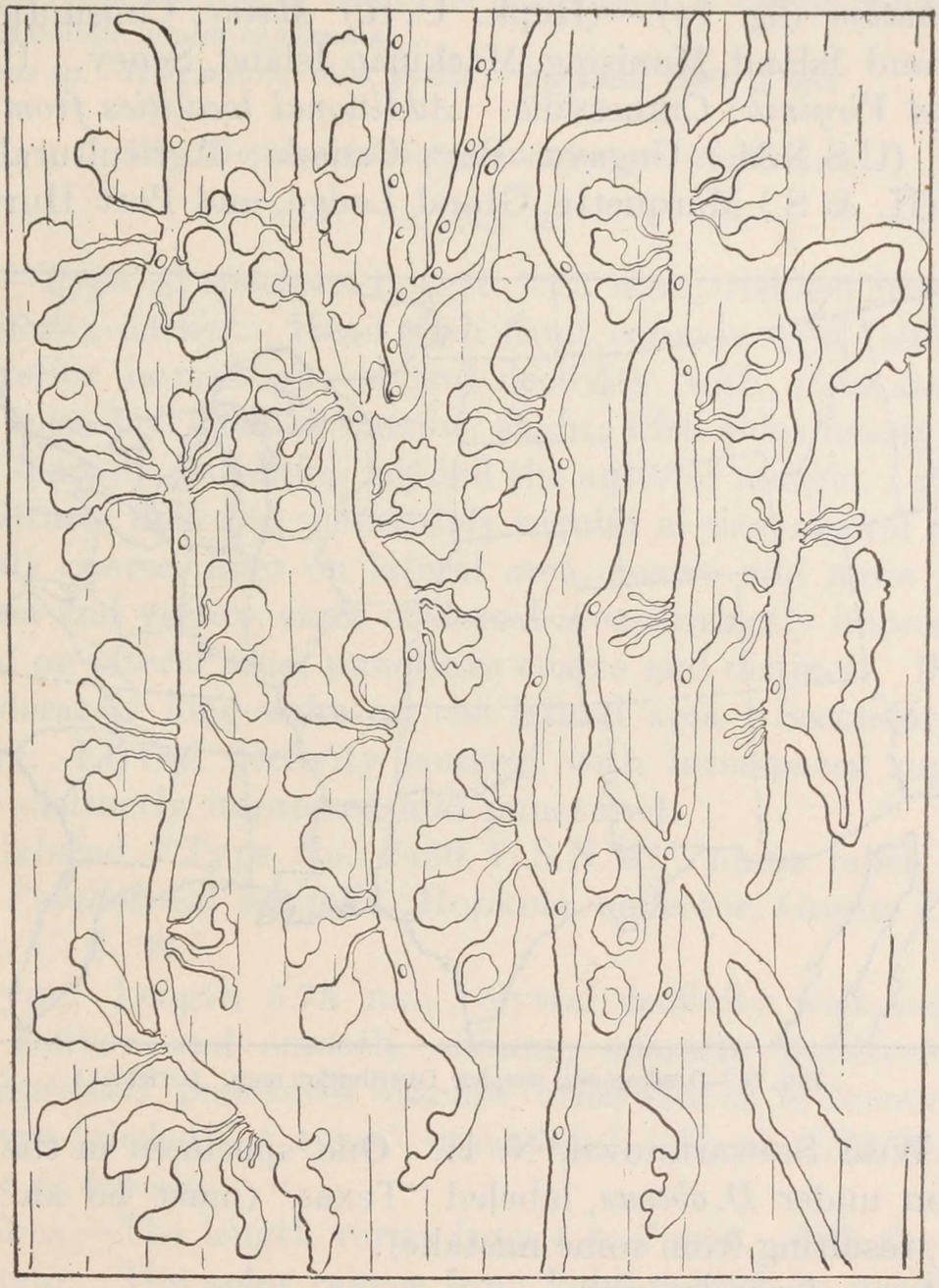

FIG. 73.—*Dendroctonus simplex:* Egg galleries and larval mines. (Original.)

Larva.—In addition to the generic and divisional characters, the front is convex, opaque, with the posterior angle obtuse, and the middle with an indistinct transverse elevation, and transversely rugose. The clypeus is prominent, shining, with a distinct median impressed line and the apex broadly emarginate; the labium is short, with the apex broadly rounded. The sternellar lobes of the thoracic segments are prominent and with distinct foot calli. Larval type labeled "Hopk. U. S. No. 6444b."

Galleries (fig. 73).—Egg galleries longitudinal, slightly winding, and sometimes branched and grooved on the surface of the wood, as

well as deeply grooved in the inner bark; larval mines and pupal cells exposed in the inner bark. Eggs are placed in groups of three to five or more, and the larval mines, which are short, are separated from the start. The galleries differ from those of the next species by their smaller size, more elongate and winding form of the egg galleries, and the much shorter larval galleries arranged in much smaller groups.

Distribution (fig. 74).—(Hopk. U. S.) *Maine:* Cupsuptic. *Michigan:* Grand Island, Munising, Mackinac Island, Seney. (Hopk. W. Va.) *West Virginia:* Cranesville. *Additional localities from other collections:* (U.S.N.M.) Ungava Bay, Canada; Agricultural College, Mich. (H. & S.) Marquette, Grand Ledge, and Port Huron, Mich.

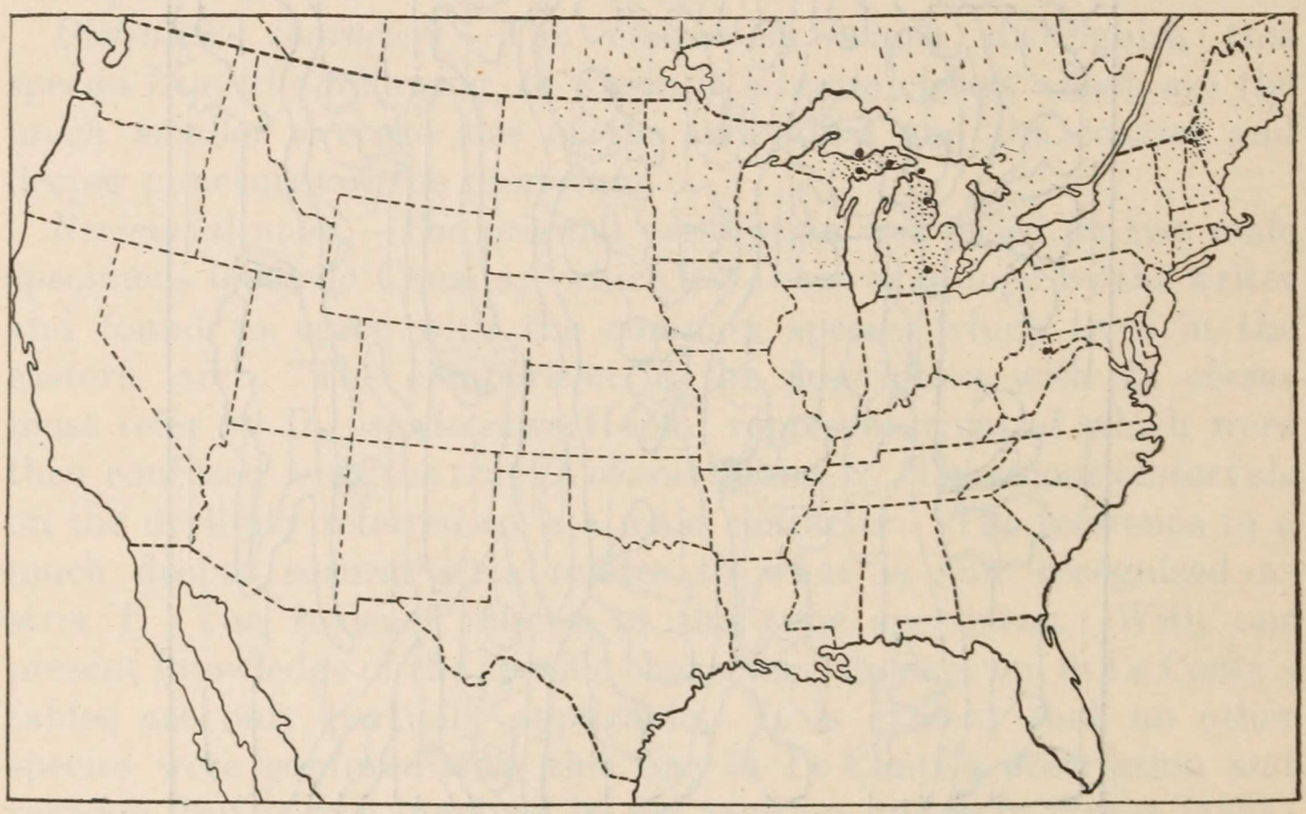

FIG. 74.—*Dendroctonus simplex:* Distribution map. (Original.)

(D. A.) West Stewartstown, N. H. One specimen in the Le Conte collection under *D. obesus*, labeled "Texas" (must be an erroneous locality, resulting from some mistake).

Host tree.—Larix laricina.

Identified specimens.—Le Conte, 10 specimens (2 under *D. simplex*, 3 under *D. rufipennis*, and 5 under *D. similis*); Horn, 3 specimens (2 under *simplex*, 2 under *similis*); U.S.N.M., 6; H. & S., 10; D.A., 5 specimens; Hopk., W. Va., 157, and Hopk. U. S., over 150 specimens.

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Dendroctonus simplex. Le Conte, 1868, p. 173, original description, synopsis, localities. Le Conte, 1876, p. 385, revision, synopsis, bibliography, localities. Packard, 1887, p. 177 (Le Conte quoted). Schwarz, 1888, p. 175, synonymy, habits in larch. Packard, 1887, p. 177, Le Conte quoted. Packard, 1890, p. 722

(ibid). Dietz, 1890, p. 31 (in part), Michigan and Lake Superior, fig. 4, antenna and epistoma. Harrington, 1891, p. 27, habits and host. Hopkins, 1898a, p. 69, distinct from *rufipennis* (*piceaperda*). Hopkins, 1898b, in larch in W. Va. Hopkins, 1899a, p. 392, etc., fig. lviii, adult, revisional notes, etc., host, distribution. Hopkins, 1899c, p. 343, good species, habit, host, etc. Felt, 1906, p. 752 (in part), bibliography.

Dendroctonus similis (not of Le Conte, 1860) Le Conte, 1876, p. 385 (in part), revision, synonymy, bibliography, localities. Dietz, 1890, p. 31, Canada.

Dendroctonus rufipennis (not of Kirby) Le Conte, 1876, p. 385 (in part) (in collection 1900–1907, under *rufipennis*).

Dendroctonus sp. Harrington, 1884, p. 218. Packard, 1890, p. 903.

13. Dendroctonus pseudotsugæ Hopkins.

(Pl. V, fig. 13.)

Adult.—Type of species: Length 5.75 mm.; reddish brown, with the prothorax darker. Head with front convex, with faint median and posterior impression; elytral declivity with striæ deeply impressed; epistomal process narrow, slight, with sides nearly parallel, the apex scarcely projecting beyond the anterior margin. Pronotum with punctures fine, and moderately regular in size; elytral rugosities moderately coarse, finer on lateral area, coarse and more acute on dorsal area and vertex; striæ of dorsal area distinctly impressed, not impressed on lateral area; punctures coarse and distinct. Pronotum with moderately long hairs on the lateral area. Secondary sexual characters: Elytral declivity convex, with interspaces rugose and the striæ distinctly impressed and punctured.

Type labeled "Type No. 7450 U.S.N.M.," name label, "Hopk. 1/22/08, *Pseudotsuga taxifolia*, Hopkins, collector, Grants Pass, Or., ♀, Hopk. U. S. 39."

Male type: Length 5.75 mm.; elytral declivity with interspaces strongly convex and smooth, shining, sparsely punctured; striæ deeply impressed, punctures obscure, otherwise as in female.

Male type labeled "♂ type," name label, "Hopk. 1/22/08," otherwise same as female.

Variations.—The length varies from 4 to 7 mm., with the average about 6 mm. The color ranges from light reddish to nearly black. The usual variation in sculpture, vestiture, etc., prevails. The greatest variation is in the size and color, and in the size of the punctures of the pronotum. The epistomal process varies considerably, so that in some specimens it extends beyond the epistomal margin, while in others it does not.

Distinctive characters.—This species and the one preceding are at once distinguished from all of the other species of the genus by the characters of the epistoma and from each other by the sculpture of the pronotum and the difference in average size of representative individuals. *D. pseudotsugæ* is distinguished especially by the shining and finely punctured pronotum.

Revisional notes.—This species has been an element of much confusion in descriptions, revisions, and identifications, under the names *D. similis*, *D. obesus*, *D. rufipennis*, etc. It is represented in the type series in Le Conte's collection under *D. similis*, but the specimen which bears the name label, and therefore the type of *D. similis*, is a true *D. obesus* (Mann.). Le Conte (1868, p. 173) referred *D. similis* to *obesus* on account of the intervals of the elytra being "rough for their whole extent," which is the case in the type of *D. similis*, and in all females of *D. obesus*. Later he evidently com-

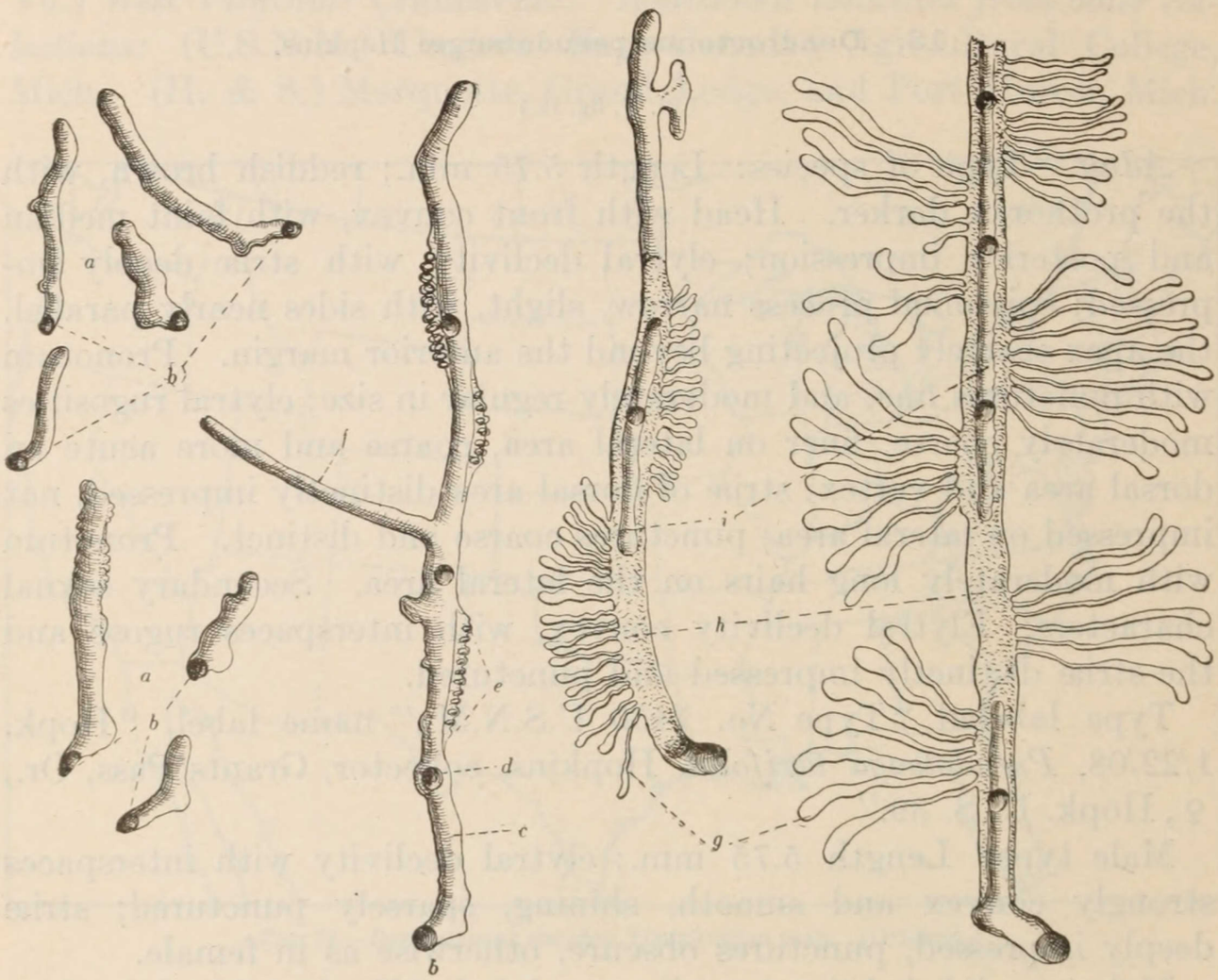

FIG. 75.—*Dendroctonus pseudotsugæ:* Egg galleries and larval mines. *a*, Beginning or basal sections of egg galleries in bark; *b*, entrance; *c*, egg gallery; *d*, ventilating hole; *e*, egg nest; *f*, abnormal branch; *g*, larval mines; *h*, egg gallery packed with borings; *i*, subsequent passage or inner gallery through borings. (Original.)

pared the type of *D. similis* with a single male specimen of *D. obesus* in his collection, which, according to Mr. Henshaw, is from the Mannerheim collection, and finding that this differed from his *D. similis* in the smooth elytral declivity he restored *D. similis* (Le Conte, 1876, p. 385) and called attention to the roughened interspaces of the declivity as a distinctive character; all of which makes it quite clear that he considered the specimen bearing the name label as the type of his *D. similis* and that therefore this name must fall as a synonym of *D. obesus* Mann. Thus the other specimens of the type series are left to represent a distinct species as here described. In 1900 it was

represented in the Le Conte collection by two specimens labeled "Or." and three specimens labeled "Van." under *D. similis*, and one specimen labeled "Garland Pass, Col.," under *D. rufipennis*. In 1900 it was represented in the Horn collection by one specimen labeled "Col." and one specimen labeled "Cal.," and in the A. E. S. collection by three specimens from Oregon under *D. similis* and two specimens labeled "Col." under *D. rufipennis*. Dietz's revision under *D. similis* (1890, pp. 30–31) includes the characters of *D. pseudotsugæ*, as represented by the Oregon, Colorado, and California speci-

FIG. 76.—*Dendroctonus pseudotsugæ:* Egg gallery and larval mines. *a*, Egg gallery in bark and grooved in surface of wood; *b*, larval mines in bark; *c*, larval mines marked and slightly grooved on surface of wood. (Original.)

mens, while the specimens from Canada represented *D. simplex*, and one from California referred to in the note is *D. monticolæ*.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apices of the front and middle femora are smooth; abdominal tergite 1 is without a pleural spine, 2 with small, and 3 to 6 with rather stout ones; 1 and 2 are without dorsal and lateral spines, while 3 to 6 have a pair of dorsal and a pair of lateral ones each side; 7 and 8 are smooth, and 9 has the usual prominent pleural spines. Pupal type labeled "Hopk. U. S. No. 2298."

The usual variation in number and arrangement of minor spines prevails in other specimens, but they are easily distinguished from those of *D. simplex* by their larger size and less prominent dorsal, lateral, and pleural spines.

Larva.—In addition to the generic and divisional characters, the front is opaque, except toward the apex, where it is more shining, and the apex is subacute; the middle has a transversely rugose elevation, slightly more elevated and broader toward the suture. The clypeus is prominent, shining, and with an impressed line from the middle to the anterior margin, which is broadly emarginate; labium short, with the apex broadly rounded; the sternellar lobes are moderately prominent, with indistinct foot calli. Larval type labeled "Hopk. U. S. No. 2289."

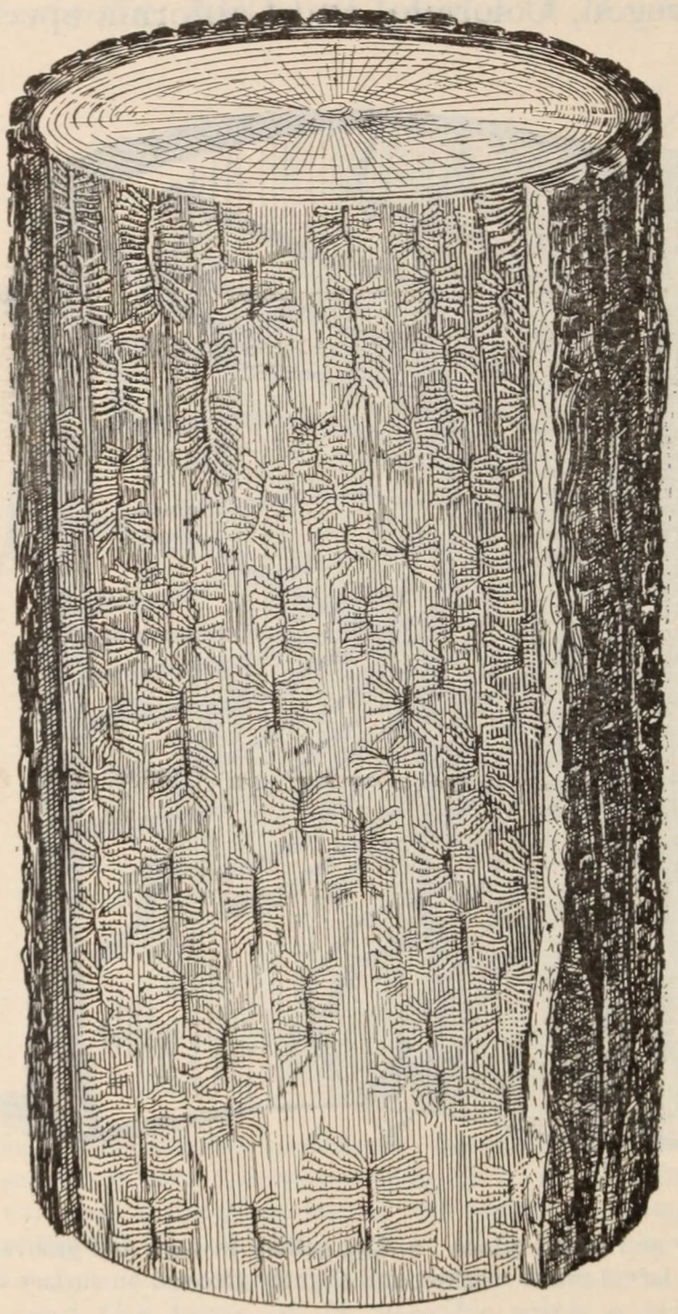

FIG. 77.—*Dendroctonus pseudotsugæ:* Section of log with bark removed, showing brood galleries marked and grooved on surface of wood. (Original.)

Galleries (figs. 75–77).—The egg gallery is longitudinal, short, but slightly winding, sometimes branched, slightly grooving the surface of the wood, and deeply grooved in the inner bark. The larval mines and pupal cells are exposed in the inner bark, and the eggs are rather closely placed in groups of three to ten or more, but the larval mines are separated from the start and are usually extended for some distance from the egg gallery. The galleries of this species differ from those of the one preceding by their larger size and shorter form of the egg gallery and the much larger larval mines, which are arranged in larger groups.

Distribution (fig. 78).—(Hopk. U. S.) *Arizona:* Chiricahua National Forest, Flagstaff, San Francisco Mountains, Santa Catalina National Forest. *California:* Fieldbrook, Guerneyville, McCloud, San Mateo County (Big Basin). *Colorado:* Colorado Springs, Fort Garland, Gunnison National Forest, Indian Creek, Leavenworth Valley, Moffat,

Ouray, Palmer Lake, San Isabel National Forest, San Juan National Forest, Saguache. *Idaho*: Beaver Canyon, Centerville, Bailey, Henrys Lake National Forest, Kooskia, Kootenai, Pioneerville, Priest River, Sand Point, Smiths Ferry, Stites. *Montana:* Belton, Bozeman, Middle Creek (Gallatin County), Ovando. *New Mexico:* Capitan, Cloudcroft, Sacramento National Forest, Santa Fe, Vermejo. *Oregon:* Corvallis, Detroit, Grants Pass, Newport, Slate Creek, St. Helena. *Utah:* Panguitch. *Washington:* Ashford, Buckeye, Des Moines, Dole, Gray's Harbor City, Hoquiam, Junction, Kent, Keyport, Meredith, New London, North Bend, Orting, Pialschie, Port Angeles, Port Williams, Pullman, Puyallup, Rock

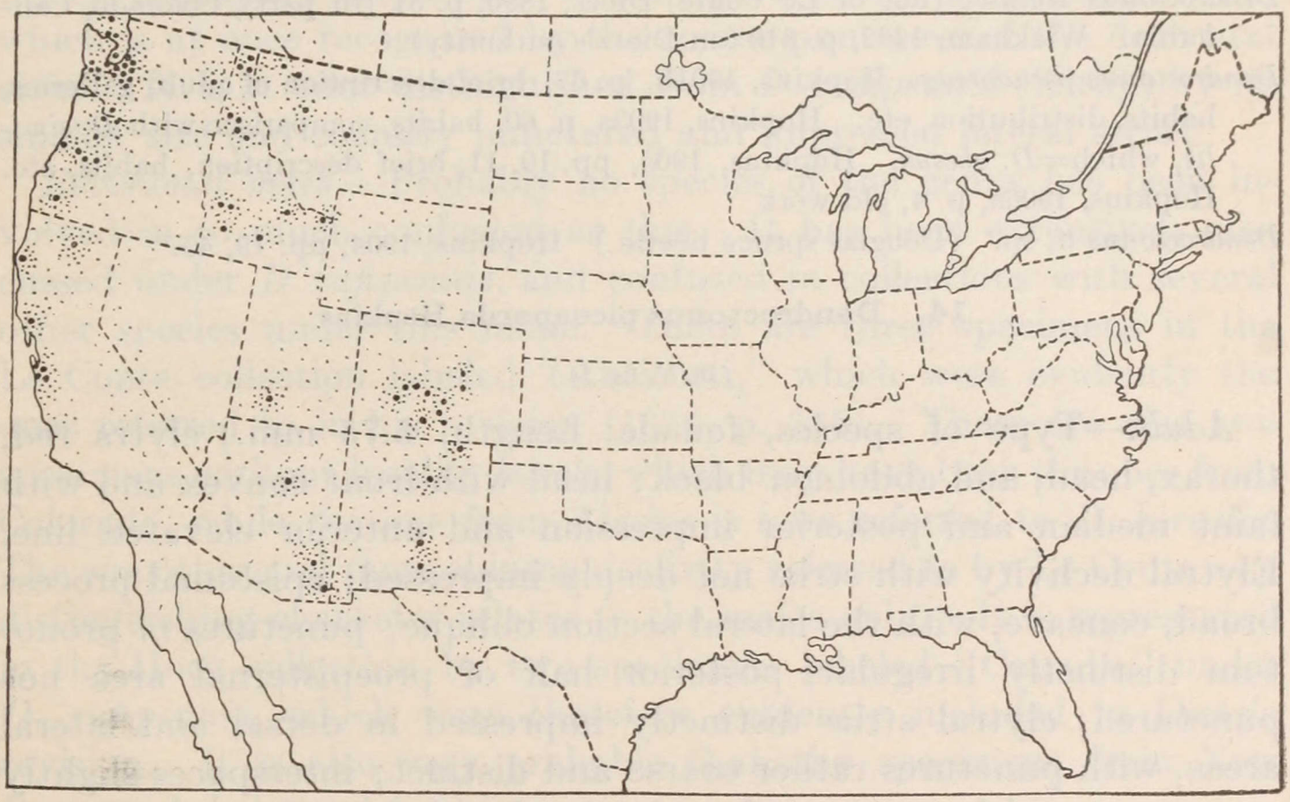

FIG. 78.—*Dendroctonus pseudotsugæ:* Distribution map. (Original.)

Creek, Satsop. *Additional localities from other collections:* (Le Conte) Vancouver, B. C. (U.S.N.M.) Easton, Wash. (H. & S.) Hood River, Oreg; Beaver Canyon, Idaho. (D. A.) Mount Angel, Oreg. (Soltau) Seattle, Wash. (Wickham) Leavenworth Valley and Kalispell, Mont.

Host trees.—Pseudotsuga taxifolia, P. macrocarpa, and *Larix occidentalis.*

Identified specimens.—Le Conte, 6 specimens (1 under *rufipennis,* 5 under *D. similis);* Horn, 2; A. E. S., 5; Dietz, 2; U.S.N.M., 7; H. &. S., 2; Soltau, 3 ; Webb, 21; Wickham, 2; Laurent, 1; D. A., 5; Hamilton, 1; Hopk. U. S., over 700 specimens, including all stages and work.

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Dendroctonus rufipennis (not of Kirby) Le Conte, 1876, p. 385 (in part) (in collection 1900–1907, under *rufipennis*). Le Conte, 1878, p. 469 (in part). Packard, 1887, pp. 177, 243 (in part?). Hopkins, 1899b, p. 15, localities, note. Hopkins, 1904, p. 19, reference.

Dendroctonus simplex (not of Le Conte) Dietz, 1890, p. 31 (in part), Colorado, California. Wickham, 1902, p. 310 (on Dietz's authority).

Dendroctonus pseudotsugæ Hopkins, 1901b, p. 67, brief description of adult, galleries, habits, distribution, etc. Hopkins, 1903a, p. 60, habits, comparison with *D. similis*, which=*D. obesus*. Hopkins, 1905, pp. 10, 11, brief description, habits, etc. Hopkins, 1906a, p. 4, old work.

Dendroctonus n. sp. (Douglas spruce beetle.) Hopkins, 1904, pp. 19, 45.

14. **Dendroctonus piceaperda** Hopkins.

(Pl. V, fig. 14.)

Adult.—Type of species, female: Length, 5.75 mm.; elytra red, thorax, head, and abdomen black; head with front convex and with faint median and posterior impression and anterior elevated line. Elytral declivity with striæ not deeply impressed; epistomal process broad, concave, with the lateral section oblique; punctures of pronotum distinctly irregular; posterior half of proepisternal area not punctured; elytral striæ distinctly impressed in dorsal and lateral areas, with punctures rather coarse and distinct; interspaces slightly convex; rugosities acute, rather closely placed, irregular. Secondary sexual characters: Declivity convex; striæ very faintly impressed, with fine indistinct punctures; interspaces nearly flat, shining, with approximate row of fine granules.

Type labeled "Type No. 7451 U.S.N.M.," name label, "Hopk. 4/23/02, compared with Kirby type *rufipennis*, does not agree, *Picea canadensis*, Hopkins, collector, Camp Caribou, Me., ♀ type, Hopk. U. S. 326."

Male type: Length, 5.6 mm.; elytra dark reddish-brown; thorax and head darker; elytral declivity convex; striæ not impressed; punctures obscure; interspaces flat, shining, and finely punctured, with very small granules toward vertex.

Type labeled, "♂ type, type of drawing," name label, "Hopk. 1/22/08, *Picea canadensis*, Hopkins, collector, Camp Caribou, Me., ♂ type, Hopk. U. S. 326."

Variations.—The length varies from 4.7 to 6 mm., with the average about 5.5 mm. The color ranges from uniform light red to black, to the head, thorax, and abdominal sternites dark to black, with the ely-

tra lighter or red. The sculpture and vestiture of the epistoma, front, pronotum, and elytra vary as usual. The greatest variation is in size and color.

Distinctive characters.—The characters which distinguish this species from the next are its smaller average size, slightly less elongate form, less shining elytra, with the striæ more distinctly impressed on the sides and the interspaces slightly more convex and more acutely rugose. The difference is not so perceptible in comparing single individuals as when many individuals of both species are compared. It differs from *D. borealis* by the noticeably more elongate and narrower pronotum, and from species 17 to 21 it is distinguished by the distinctly impressed lateral striæ of the elytra, except *D. punctatus* Lec., which is at once recognized by the coarse punctures of the declivital striæ. It is at once distinguished from *D. rufipennis* (Kirby) by its smaller size and coarsely punctured and impressed lateral striæ.

Revisional notes.—Probably no species of the genus has been involved in so much confusion as this. It has been extensively discussed under *D. rufipennis*, and confused in collections with several other species under this name. There are three specimens in the Le Conte collection labeled "Anticosti," which were evidently the ones referred to in his revision (1876, p. 385). There are also two specimens without locality labels, which may have been the ones from Colorado, while the one from Alaska is here referred to *D. borealis*. The smoother and more shining declivity referred to by Le Conte as a distinguishing character relates to the males only. It is represented in the Horn collection by two specimens labeled "Canada," under *D. rufipennis*, which were therefore evidently included in Dietz's revision. It is also very probable that the specimens from New Brunswick belonged to this species.

It is very evident that the barkbeetle referred to under *D. rufipennis* by Peck, Packard, Hough, and other authors as depredating on the spruce of New Brunswick, Canada, New England, New York, and Pennsylvania was *D. piceaperda*.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apices of the front and middle femora are smooth; abdominal tergites 2 to 6 with very small pleural spines; 1 without distinct dorsal or lateral spines; 2 to 3 without dorsal, but with two small lateral spines each side; 4 to 6 with a pair of very small dorsal and three or four small lateral spines each side; 7 and 8 smooth; 9 with usual pleural spines. Pupal type labeled "Hopk. U. S. 377."

The usual variation in minor details prevails. It is distinguished from the pupa of *D. engelmanni* by the less impressed vertex of the head and the generally smaller spines and the absence of dorsal spines on the third abdominal tergite.

Larva.—In addition to the generic, divisional, and subdivisional characters, the front has a slight transverse, rugose elevation situ-

ated slightly in front of the middle, the anterior surface, including the elevation, opaque. The area behind the elevation is impressed and shining; clypeus short, broad, with median groove and its apex subacutely emarginate (in dried specimens); labrum prominent, its anterior margin subtruncate; mandibles opaque, with slight dorsal impression or elevation; sternellar lobes of thoracic segments moderately

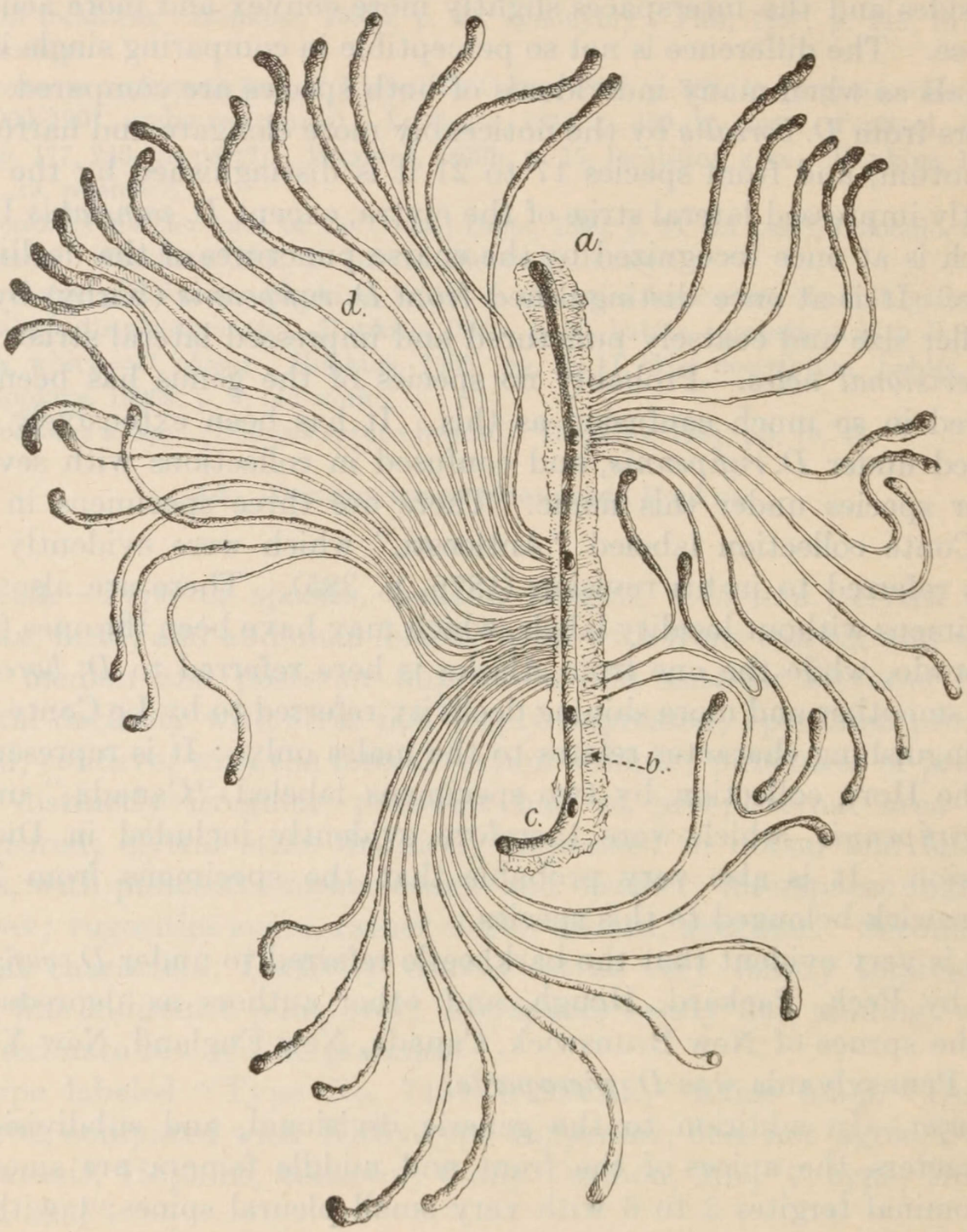

FIG. 79.—*Dendroctonus piceaperda:* Egg gallery and larval mines. *a*, Egg gallery; *b*, boring dust packed in gallery; *c*, entrance and subsequent or inner gallery; *d*, larval mines. (Author's illustration.)

prominent and with distinct foot calli. Larval type labeled "Hopk. U. S. No. 318."

The most distinctive characters are the opaque mandibles with moderate impression and elevation, and the distinctly elevated anterior margin of the epicranium.

Galleries (fig. 79).—The egg galleries are short, broad, longitudinal, grooving the surface of the wood and deeply grooved in the inner

bark, the larval mines exposed and the pupal cells partially to entirely exposed. The eggs are closely placed in large groups, and the larval mines are at first contiguous or nearly so, near the egg gallery, but soon become separated and when completed are often as long as the egg gallery or longer. The egg galleries differ from those of all of the species of subdivisions A and B in being very much broader than the diameter of the beetle's body. This broad groove is packed with borings, through which a central gallery is excavated by the parent beetle after the eggs have been deposited.

Distribution (fig. 80).—(Hopk. U. S.) *Maine:* Beaver Pond, Camp Caribou, Cupsuptic, Meadows. *Michigan:* Grand Island, Munising. *New Hampshire:* Waterville. *Additional localities from specimens*

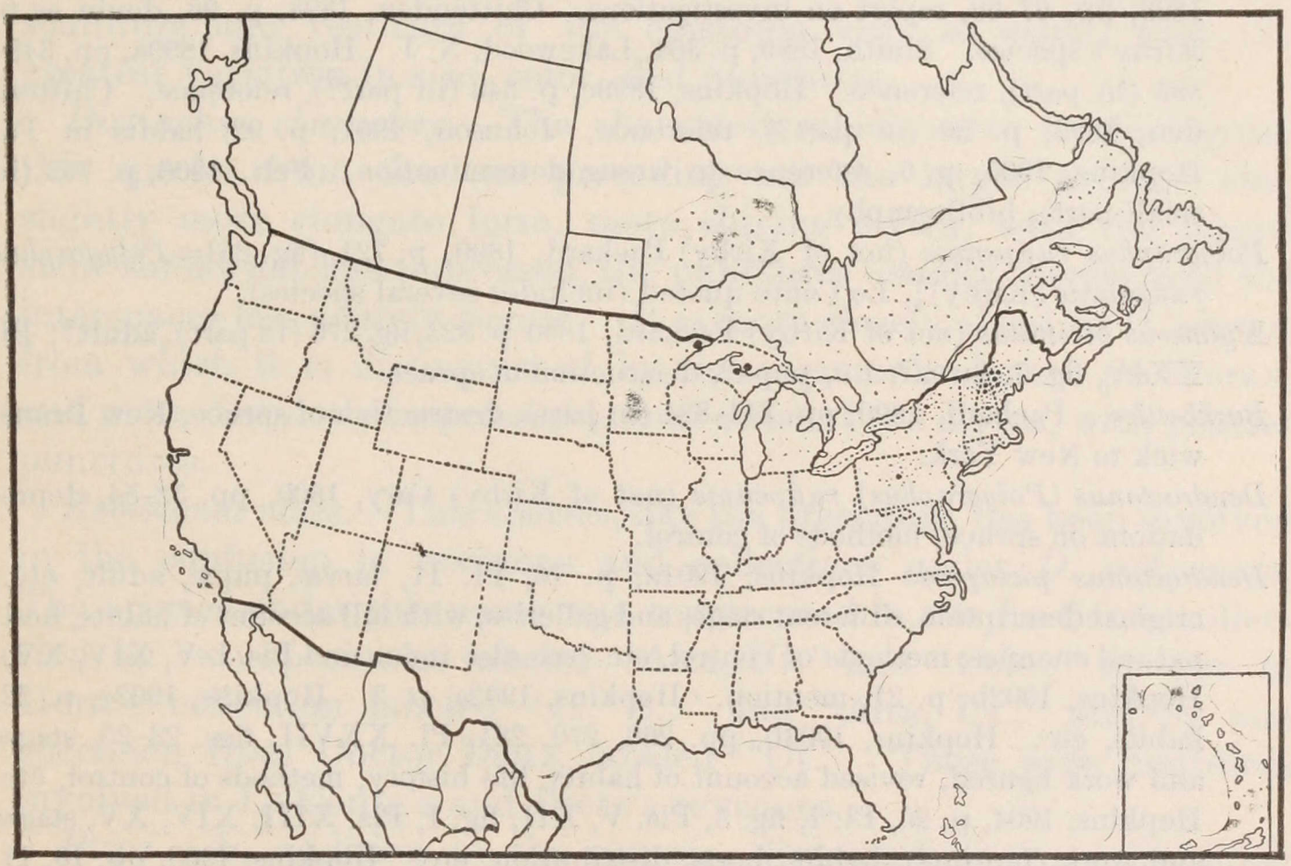

FIG. 80.—*Dendroctonus piceaperda:* Distribution map. (Original.)

identified in other collections: (Le Conte) Anticosti, Canada. (Horn) Canada. (U.S.N.M., H. & S.) Isle Royale, Mich. (D. A.) Colebrook and West Stewartstown, N. H. (Wenzel) Ricketts, Pa.

It is evident that this species follows the distribution of the spruce from the higher mountains of central Pennsylvania northward and eastward into New York, New Hampshire, Maine, New Brunswick, and Canada, and westward to the Lake Superior region.

Host trees.—Picea rubens, P. canadensis, and *P. mariana.*

Identified specimens.—Le Conte, 3 specimens from Anticosti, 2 without label, under *D. rufipennis,* 1 labeled "N. Y." under *D. punctatus* (Mar. 11, '07), 2 specimens without locality labels doubtfully referred to this species; Horn, 2 specimens labeled "Can.," under *D. rufipennis;* U.S.N.M., H. & S., 1 specimen labeled "Isle Royale;" Weed and

Fiske, 12 specimens; Hopk. U. S., over 300 specimens, including all stages and work.

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Dendroctonus rufipennis (not of Kirby) Le Conte, 1876, p. 385, revision, synopsis, localities. Lintner, 1885, p. 54, destruction of spruce in New York. Fletcher, 1887, pp. 39–40, habits. Dietz, 1890, p. 30 (in part), Canada and New Brunswick. Packard, 1887, pp. 177–243 (in part). Packard, 1890, p. 722 (in part), quotes Le Conte. Harvey, 1898, p. 176, depredations on spruce in Maine; p. 98, host, distribution, etc. Hopkins, 1898a, p. 69, distinct from *simplex*. Weed and Fiske, 1898, pp. 67–69, report on investigations. Chittenden, 1898, p. 96, doubt as to Kirby's species. Smith, 1899, p. 364, Lakewood, N. J. Hopkins, 1899a, pp. 349–393 (in part), reference. Hopkins, 1899c, p. 343 (in part?), reference. Chittenden, 1899, p. 56 (in part?), reference. Johnson, 1901, p. 92, habits in Pa. Hopkins, 1905, p. 6, reference to wrong determination. Felt, 1906, p. 753 (in small part), bibliography.

Polygraphus rufipennis (not of Kirby) Packard, 1890, p. 721, [fig. 251=*Polygraphus rufipennis* (Kirby)], Le Conte quoted (includes several species).

Xyloterus bivittatus (not of Kirby) Packard, 1890, p. 823, fig. 276 (in part), adult?; Pl. XXIV, fig. 1, larva?, 1 *a*, pupa?, destruction of spruce.

Barkbeetles. Packard, 1890, pp. 811–824 (in part), destruction of spruce, New Brunswick to New York.

Dendroctonus (*Polygraphus*) *rufipennis* (not of Kirby) Cary, 1900, pp. 52–54, depredations on spruce, methods of control.

Dendroctonus piceaperda Hopkins, 1901a, p. 16, Pl. II, larvæ, pupæ, adult, etc., original description, different stages and galleries, with full account of habits, host, natural enemies, methods of control, etc. (see also index and Pls. I–V, XIV, XV). Hopkins, 1902b, p. 21, mention. Hopkins, 1902a, p. 3. Hopkins, 1902c, p. 22, habits, etc. Hopkins, 1903b, pp. 266, 270, 281, Pl. XXVII, figs. 23–25, stages and work figured, revised account of habits, life history, methods of control, etc. Hopkins, 1904, p. 26, Pl. I, fig. 3, Pls. V, XII, fig. 1, Pls. XIII, XIV, XV, stages and work (reprints), habits, hosts, distribution, etc. Hopkins, 1905, pp. 10, 11, distinctive characters, brief. Felt, 1905, pp. 6, 7, habits and work. Felt, 1906, pp. 379–385, fig. 85 *b*, history, habits, etc. Hopkins, 1908, pp. 160–161, depredations.

15. **Dendroctonus engelmanni** n. sp.

Adult.—Type of species, female: Length 6.2 mm., black. Head with front convex, faint median and posterior impression and faint anterior line. Elytral declivity with striæ not deeply impressed; punctures of pronotum distinctly irregular; posterior half of proepisternal area not punctured; punctures of prothorax and elytra rather coarse; striæ moderately impressed; interspaces moderately convex, and scarcely rugose, except on dorsal area. Secondary sexual characters: Declivity convex; striæ rather distinctly but not deeply impressed; punctures distinct; interspaces with rows of granules.

Type labeled "Type No. 7452 U.S.N.M.," name label, "Hopk. 1/22/08, *Picea engelmanni*, Capitan, N. M., W. F. Fiske, collector, ♀, Hopk. U. S. 3958."

Male type: Length 5.5 mm. Front without anterior line. Elytra with striæ less distinctly impressed and interspaces less convex than in female; declivity convex, with striæ and strial punctures obscure; interspaces flat, shining, finely but distinctly punctured and without granules except on vertex.

Type labeled, "♂ type," name label, "Hopk. 1/22/08, *Picea engelmanni*, Capitan, N. M., W. F. Fiske, collector, ♂, Hopk. U. S. 3958."

Variations.—The length varies from 5 to 7 mm., with the average at about 6.5 mm. The color ranges from uniform light to dark red and black, to black head, thorax, and abdomen, and red elytra. The sculpture and vestiture of the epistoma vary as usual, with the greatest variation in size, color, and punctures.

Distinctive characters.—The characters which serve to distinguish this species from the one preceding are the larger average size, slightly more elongate form, more shining elytra, with the lateral striæ somewhat less impressed, the punctures usually coarser, and the interspaces less acutely rugose. It is more closely allied to *D. obesus*, from which it is distinguished by the commonly darker prothorax, and more distinctly impressed lateral striæ of the elytra, with coarser punctures.

Revisional notes.—This species, like the preceding, has been involved in the confusion in revisions and collections under *D. rufipennis*. The species under this name was represented in the Le Conte collection by two specimens labeled "Alta, Ut." and "Colo.," by two in Horn's collection labeled "H. B.," and "Alta, Ut.," and by one specimen from Doctor Dietz, labeled "Ut." These were doubtless involved in Le Conte's and Dietz's revisions.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apices of the front and middle femora are smooth; abdominal tergites 2 to 6 with small pleural spines; 1 and 2 without dorsal but with lateral spines, and 3 to 6 with dorsal and lateral spines; 7 and 8 smooth; 9 with pleural spines, as usual. Pupal type labeled "Webb No. 2."

The usual variation in minor details prevails, but the pupa of this species is distinguished from that of the preceding one by the more distinctly impressed vertex of the head, the generally coarser spines, and the presence of dorsal spines on the third abdominal tergite.

Larva.—In addition to the generic, divisional, and subdivisional characters, the front has a transverse rugose elevation situated near the middle; the anterior surface, including the elevation, is opaque; the area behind the elevation is impressed and shining, clypeus

broad, with median dorsal groove and the apex subacutely emarginate; labrum prominent, its anterior margin truncate; mandibles opaque toward base, more shining toward apex, with a distinct dorsal impression and oblique ridge near the middle; sternellar lobes of the thoracic segments moderately prominent and with distinct foot calli. Larval type labeled "Webb No. 2."

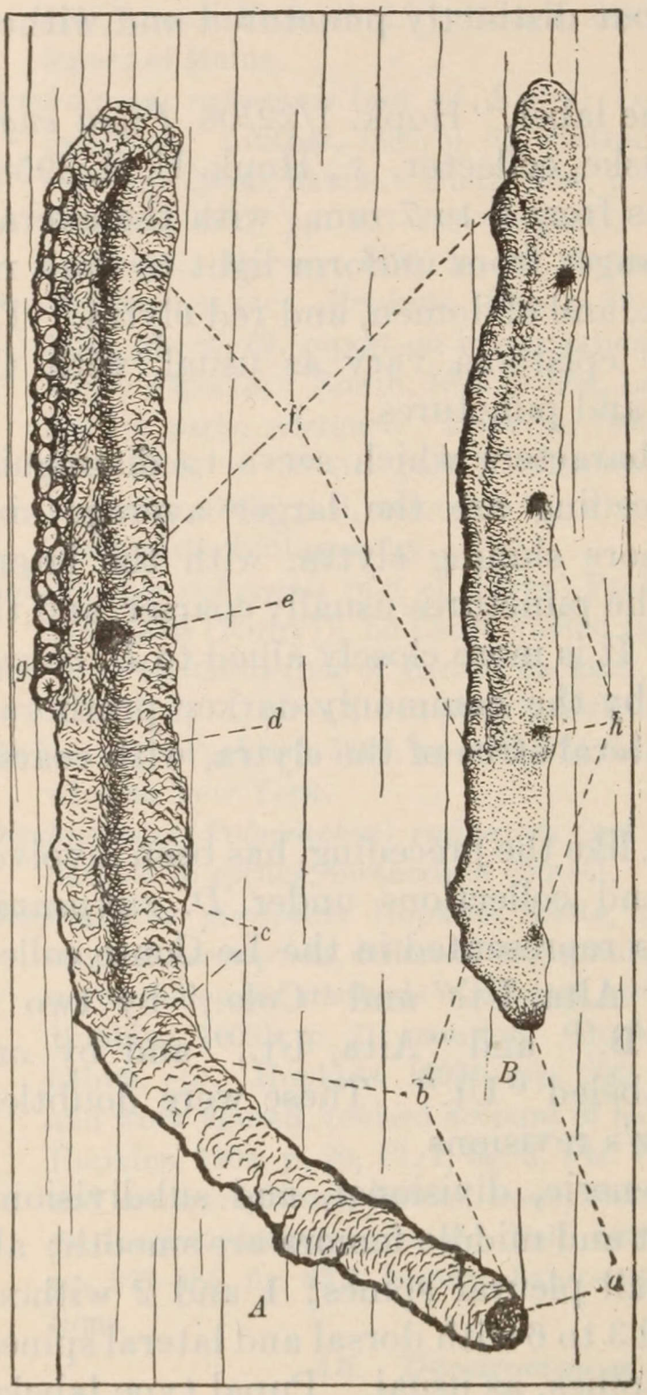

FIG. 81.—*Dendroctonus engelmanni:* Egg gallery in living bark. *A*, Normal; *B*, boring dust removed; *a*, entrance; *b*, basal section; *c*, boring dust packed in gallery; *d*, subsequent or inner gallery; *e*, ventilating burrow; *f*, egg nest, with and without eggs; *g*, freshly hatched larvæ; *h*, pits in roof of gallery. (Original.)

The most distinctive characters separating the larva of this species from that of the preceding one are the more shining mandibles, with much deeper dorsal impression and more prominent oblique ridge and the much less distinctly elevated anterior margin of the epicranium.

Galleries (fig. 81).—The galleries of this species are very much the same as those of the preceding one, except that the larval mines are more distinctly contiguous for a greater distance from the egg galleries.

Distribution (fig. 82).—(Hopk. U. S.) *Arizona:* Chiricahua Mountains. *Colorado:* Clyde, Boulder, Craig, Fort Collins, Glenwood Springs, Gunnison, Hahn's Peak, Holy Cross National Forest, Meeker, Ouray National Forest, San Isabel National Forest, Steamboat Springs, White River National Forest. *New Mexico:* Capitan Mountains, Sierra Blanca Mountains, Sacramento National Forest. *South Dakota:* Spearfish Canyon, Black Hills. *Utah:* Ephraim. *Wyoming:* Encampment. *Additional localities from specimens in other collections:* (Horn) "H. B." (Northwest Territory, probably in Mackenzie River region) and Alta, Utah. (Wickham) Argentine, Leadville, and Silver Plume, Colo. (Cockerell) Las Vegas, N. Mex. (H. & S.) Calgary, Alberta; Glacier, British Columbia. (Webb) Collins, Idaho.

Host trees.—*Picea engelmanni* and *P. canadensis.*

Identified specimens.—Le Conte collection, 2 specimens; Horn, 2; Dietz, 1 (Utah); U.S.N.M. (H. & S.), 4; Wickham, 4; Cockerell, 7; Webb, 25; Hopk. U. S., more than 200 specimens, including all stages and work.

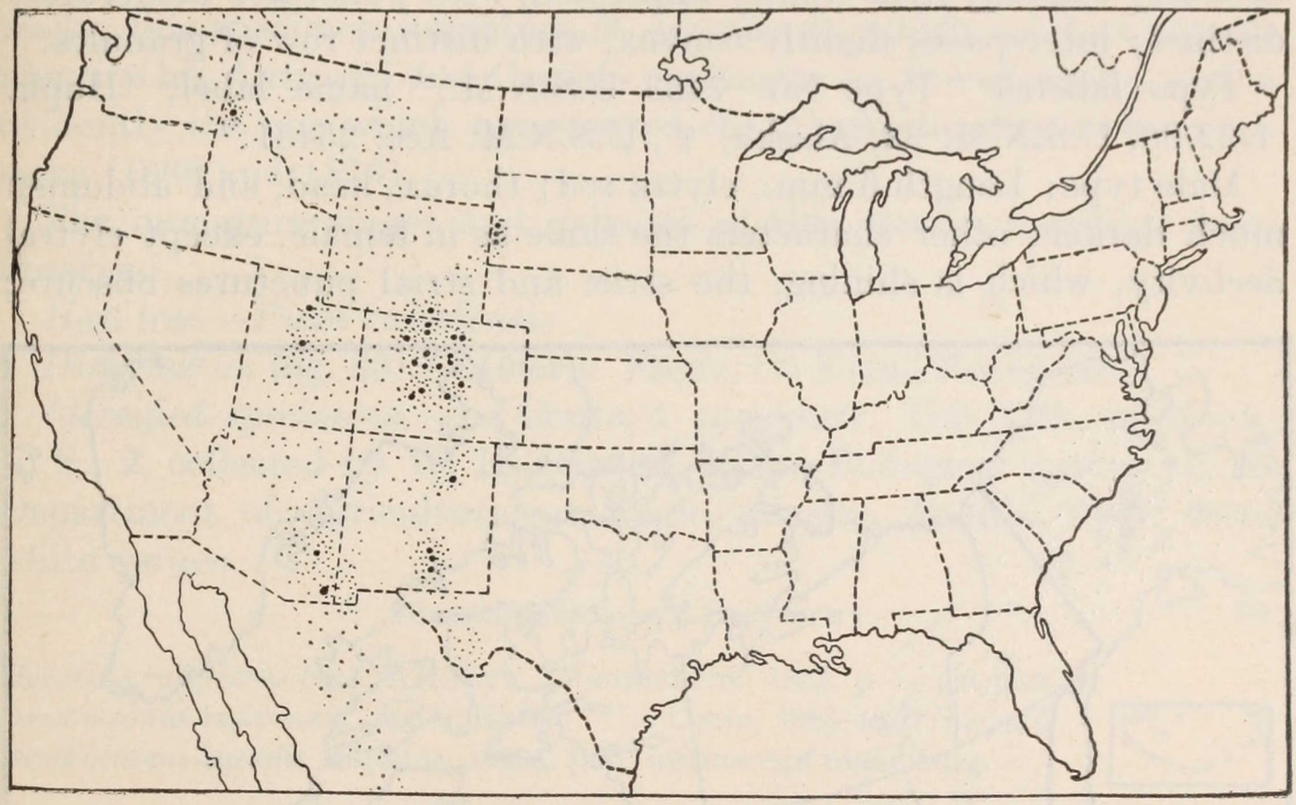

FIG. 82.—*Dendroctonus engelmanni:* Distribution map. (Original.)

BIBLIOGRAPHY AND SYNONYMY.

Dendroctonus rufipennis (not of Kirby) Le Conte, 1876, p. 385, revision (?). Le Conte, 1878, p. 469 (in part) (in collection 1900–1907, under *D. rufipennis*). Packard, 1887, pp. 177–243 (in part). Packard, 1890, p. 721 (in part), p. 722 (in part), quotes Le Conte. Dietz, 1890, p. 30, Colorado, Utah. Wickham, 1902, p. 309, list, localities.

Dendroctonus dietzi Hopkins, 1902a, manuscript name only for variation (Utah).

Dendroctonus californicus Hopkins, 1902a, p. 3, manuscript name only, locality.

Dendroctonus wickhami Hopkins, 1902a, p. 3, manuscript name only.

Dendroctonus piceaperda (not of Hopkins) Wickham, 1902, p. 310, in list, locality, host, reference to synonymy. Hopkins, 1906a, pp. 4, 5, old work on Pike's Peak.

Dendroctonus piceaperda var. *engelmanni* (Hopk.) Fall, 1907, p. 218, manuscript name, list, localities.

Dendroctonus piceaperda (not of Hopkins) var. Fall, 1907, p. 218, list, Cloudcroft, N. Mex.

The Engelmann spruce beetle. Hopkins, 1908, pp. 161–162, depredations.

16. **Dendroctonus borealis** n. sp.

(Pl. V, fig. 16.)

Adult.—Type of species, female: Length 6 mm., nearly black. Head with front convex, with faint anterior and posterior impressions and faint anterior line; elytral declivity with striæ not deeply im-

pressed; punctures of pronotum distinctly irregular; posterior half of proepisternal area not punctured; punctures of pronotum and elytra moderately coarse; elytral striæ scarcely impressed except in dorsal area; interspaces scarcely coarser and but faintly rugose, except toward base and vertex. Secondary sexual characters: Elytral declivity convex; striæ faintly impressed, with punctures moderately distinct; interspaces slightly convex, with distinct row of granules.

Type labeled "Type No. 7453 U.S.N.M.," name label, "Hopk. 1/22/08, U.S.N.M. 22, Alaska, ♀, U.S.N.M. Acc. 25431."

Male type: Length 6 mm., elytra red; thorax, head, and abdomen much darker; other characters the same as in female, except elytral declivity, which is shining, the striæ and strial punctures obscure;

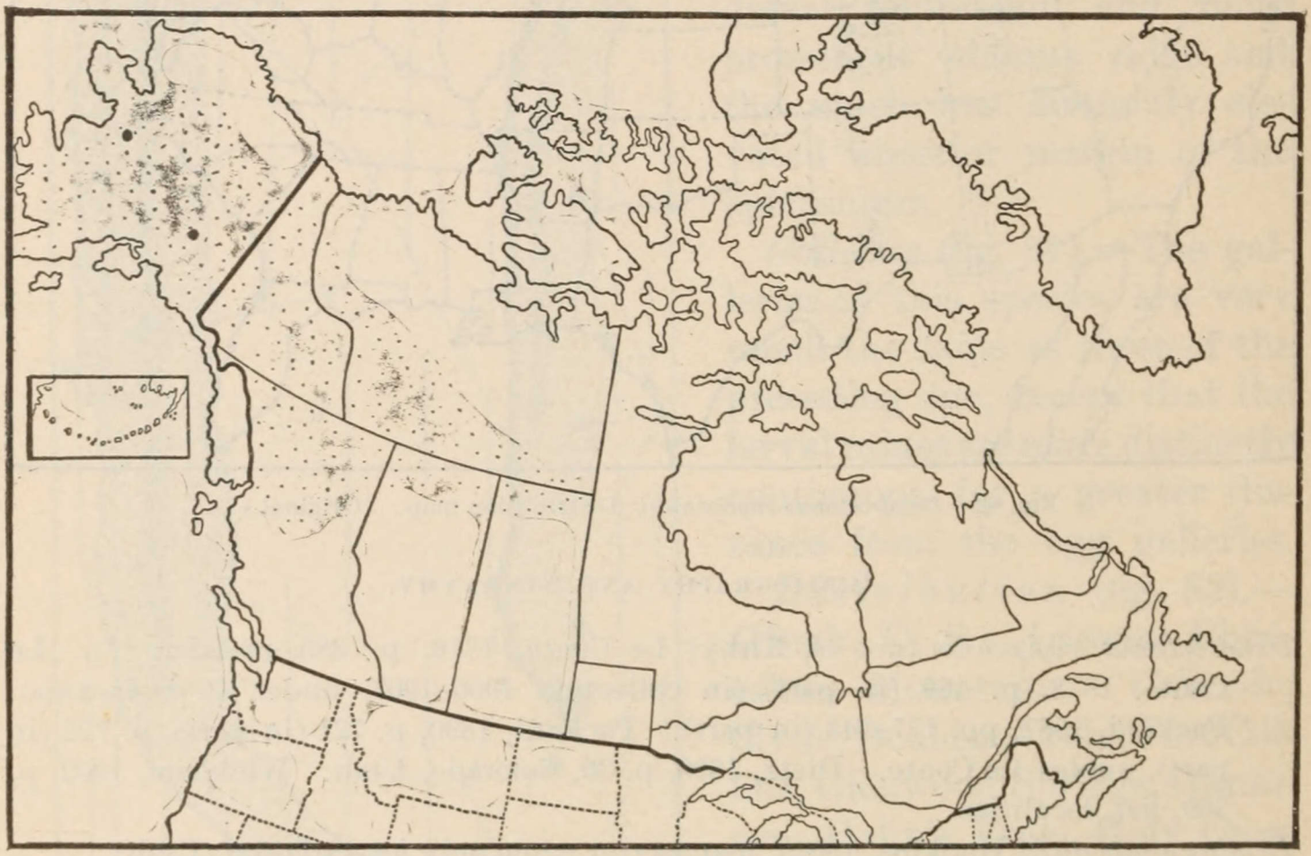

FIG. 83.—*Dendroctonus borealis:* Distribution map. (Original.)

interspaces flat, shining, and 1 and 2 without granules except toward vertex.

Male type labeled "type of drawing," "♂ type," name label, "Hopk. 1/22/08, *Picea canadensis*, Eagle, Alaska, W. H. Osgood, collector, ♂, Hopk. U. S. 1170a."

Variations.—There is scarcely any variation in the four specimens in the collections, but the color varies from nearly black in the type to the head, thorax, and abdomen dark, and the elytra red in the other specimens.

Distinguishing characters.—The short, stouter form, short and broad pronotum, with the punctures more uniform in size, the punctures of the dorsal striæ of the elytra finer and less distinct, serves to distinguish this species from all of the allied forms. It appears to be more closely allied to *D. obesus*, but is distinguished from it by its shorter pronotum and elytra, and the other characters mentioned.

Revisional notes.—It is quite evident that the specimens described by Mannerheim (1853, p. 238) under *D. rufipennis* are *D. borealis*. The single specimen in Le Conte's collection under *D. rufipennis*, labeled "*Hylurgus rufipennis* Kirby," and locality Kenai, is evidently from Mannerheim's collection, and probably one of the specimens before him when he prepared his description under that name. Superficially, this specimen resembles *D. piceaperda*, which led Le Conte to identify his Anticosti and Canada specimens as *D. rufipennis*, and is evidently the one which represented the Alaska locality in his revisions (1868 and 1876).

The immature stages and galleries of this species have not been observed.

Host tree.—Picea canadensis.

Distribution (fig. 83).—*Alaska:* Eagle, (?) Kenai Peninsula.

Identified specimens.—Le Conte, 1 specimen; U.S.N.M., 2; Hopk. U. S., 2, collected by W. H. Osgood, of the Biological Survey, U. S. Department of Agriculture, at Eagle, Alaska, August, 1903, from white spruce.

BIBLIOGRAPHY AND SYNONYMY.

Hylurgus rufipennis (not of Kirby). Mannerheim, 1853, p. — (in part).
Dendroctonus rufipennis (not of Kirby). Le Conte, 1868–1876 (in part).
Dendroctonus borealis Hopkins, 1902a, p. 3, manuscript name only.

17. **Dendroctonus obesus** (Mannerheim).

(Pl. VI, fig. 17.)

Adult.—Typical female: Length 6.5 mm., nearly black. Head with front convex, with faint anterior and posterior impression and moderately distinct anterior line. Elytral declivity with striæ not deeply impressed; punctures of pronotum distinctly irregular; posterior half of proepisternal area not punctured; punctures of pronotum and elytra moderately coarse; elytral striæ scarcely impressed; interspaces flat, finely, sparsely rugose on dorsal area and toward base of vertex. Secondary sexual characters: Declivity convex, subopaque; striæ faintly impressed, with punctures moderately distinct; interspaces faintly convex, with distinct row of granules.

Typical female labeled, name label, "Hopk. 1/22/08, *Picea sitchensis*, Queen Charlotte Il., Keen [collector], ♀."

Typical male: Length 6.7 mm., black. Front convex, with faint anterior impression and distinct anterior line. Agrees with female, excepting that the punctures of elytral striæ and interspacial rugosities are coarser; declivity subopaque; strial impressions and punctures obscure; interspaces flat, faintly punctured, and with a few granules toward vertex; pronotum with distinctly elevated line.

Typical male labeled, name label, "1/22/08, *Picea sitchensis*, Queen Charlotte Il., J. H. Keen, Collr., ♂."

Variations.—The length varies from 6 to 7 mm., with the average about 6.5 mm. The color ranges from uniform light red to brown in young specimens, to uniform black in matured ones, it being exceedingly rare to find examples with the pronotum darker than the elytra, which is so characteristic in the three preceding species. The sculpture and vestiture of the epistoma, front, pronotum, and elytra vary as usual. The greatest variation is in the punctures of the pronotum and in the presence and absence of the dorsal line; the presence or absence of a frontal carina is also an important variation, and in some examples the body is noticeably more elongate than in others.

Distinctive characters.—The characters which serve to distinguish this species from the three preceding are the uniform black color of the matured adults and the prevailingly less impressed elytral striæ, especially those of the lateral area, and also the prevailing slightly more elongate form. Its host tree and distribution also serve as distinguishing characters, except, perhaps, in the case of *borealis*, which may be found in the Sitka spruce.

Revisional notes.—There can be little or no doubt that the material under observation represents Mannerheim's species, whose varieties *a*, *b*, and *c* were evidently immature specimens. *D. similis* Lec. is to be referred to this, which fact was recognized by Le Conte in his 1868 paper, but the beetle was subsequently confused with the species discussed in the present paper under *D. pseudotsugæ*. *D. obesus* is represented in the Le Conte collection by two specimens, one specimen from Mannerheim's collection, labelled *D. obesus* ("Specimen 5" under *D. rufipennis* in 1900), and one specimen, the type of *D. similis*. It is possible that "specimen 2" under *D. rufipennis* is also *D. obesus*, but was not recognized by the writer when examined in 1900. Dietz, 1890, did not recognize or mention *D. obesus*, and it was not found by the writer in the Horn collection or that of the Academy of Natural Sciences.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the apices of the front and middle tibiæ are smooth or rarely with a single granule, abdominal tergites 2 to 6 with very small pleural spines, 1 without dorsal but with small lateral spines, and 2 to 6 with dorsal and lateral ones, 7 and 8 smooth, 9 with prominent pleural spine as usual. Pupal type labeled "Hopk. U. S. No. 4049a."

The usual variation in minor details prevails, but the pupa of this species is distinguished from that of the three preceding by the more evident lateral spines of the first abdominal tergite and the prevailing darker tips to the abdominal spines.

Larva.—In addition to the generic, divisional, subdivisional, and sectional characters, the front has a faint transverse elevation dis-

tinctly in front of the middle and the pronotal area is flat to apex. The clypeus is short and broad, with an anterior dorsal groove and the apex broadly emarginate, labium prominent, slightly longer than the clypeus, with the apex broadly rounded. Larval types, labeled "Hopk. U. S. Nos. 4081, 4046a, and 4049a."

The most distinctive characters appear to be the anteriorly placed transverse elevation of the front; the characters of the mandibles and anterior margin of the epicranium more nearly approach those found in *D. engelmanni*.

Galleries.—The galleries of this species are of the same, or of similar character to those of *D. piceaperda*, as given in divisional,

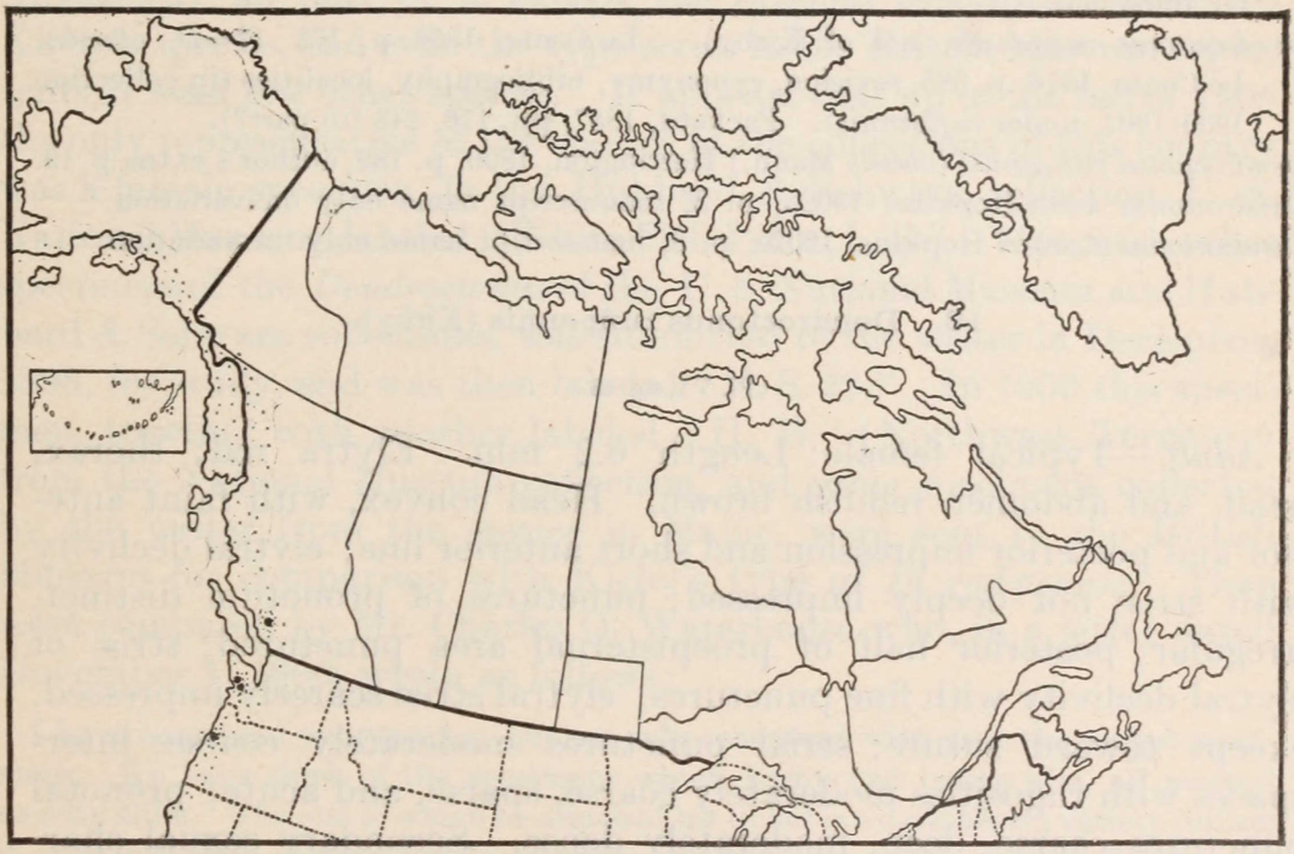

FIG. 84.—*Dendroctonus obesus:* Distribution map. (Original.)

subdivisional, or sectional characters, but differ in the more extended common larval chamber which precedes the independent larval mines which are usually so confused by crossing each other that they are difficult to follow.

Distribution (fig. 84).—(Hopk. U. S.) *Oregon*: Newport. *Washington:* Hoquiam, Aberdeen. *Additional localities from other collections:* (U.S.N.M.) (H. & S.) Vancouver, British Columbia; (Rev. Keen) Queen Charlotte Islands, British Columbia.

Host tree.—Picea sitchensis.

Identified specimens.—Le Conte collection, 2 specimens: U.S.N.M., 1 from Doctor Fletcher; H. & S., 3; Hopk. U. S., more than 120 specimens, including all stages.

Bibliography and Synonomy.

Hylurgus obesus [a] Mannerheim, 1843, p. 296, original description. Mannerheim, 1852, p. 356, spec. 474, list, variety *b* and variety *c*, brief descriptions. Mannerheim, 1853, p. 238, separate p. 146, list, var. *d* described. Le Conte, 1868, p. 173, mentioned, synonymy.

Dendroctonus similis Le Conte, 1860, p. 59, description (from one specimen which= *D. obesus*). Le Conte, 1868, p. 173, mentioned as synonymous with *D. obesus* Mann. Hopkins, 1902a, p. 3, recognized as synonymous with *D. obesus* (Mann.).

Dendroctonus obesus (Mann.) Le Conte, 1868, p. 173 (in part). Chapuis, 1869, p. 35; 1873, p. 243, revised description. Hamilton, 1894, p. 35 (in part). Hopkins, 1899b, pp. 15, 21, habits, host, etc. Schwarz, 1900a, p. 537, author's reprint p. 185 (in part), list. Hopkins, 1902a, p. 3, species recognized as distinct from *D. rufipennis* Kirby. Hopkins, 1902c, p. 22, habit and host. Hopkins, 1903a, p. 60, reference.

Dendroctonus rufipennis (not of Kirby). Le Conte, 1868, p. 173 (?=*D. obesus*). Le Conte, 1876, p. 385, revision, synonymy, bibliography, localities (in collection 1900–1907, under *rufipennis*). Packard, 1887, pp. 176, 243 (in part?).

Dendroctonus rufipennis (*obesus* Mann.) Harrington, 1890, p. 189, author's extra, p. 19.

Dendroctonus keeni Hopkins, 1902a, p. 3, manuscript name only on variation.

Dendroctonus fletcheri Hopkins, 1902a, p. 3, manuscript name only on variation.

18. **Dendroctonus rufipennis** (Kirby).

(Pl. VI, fig. 18.)

Adult.—Typical female: Length 6.2 mm. Elytra red; thorax, head, and abdomen reddish brown. Head convex, with faint anterior and posterior impression and short anterior line; elytral declivity with striæ not deeply impressed; punctures of pronotum distinct, irregular; posterior half of proepisternal area punctured; striæ of elytral declivity with fine punctures; elytral striæ scarcely impressed, except toward suture; strial punctures moderately coarse; interspaces with rugosities moderately coarse, sparse, and acute; pronotal punctures coarse, deep, moderately dense. Secondary sexual characters: Elytral declivity convex; striæ faintly impressed; punctures obscure; interspaces faintly convex, with row of fine granules.

Typical female labeled "type of drawing," name label, "Hopk., 4/25/02. Agrees with Kirby's type, compared by C. O. Waterhouse, H. S. 28, ♀, White Fish Point, L[ake] S[uperior]."

Typical male: Length 6.7 mm. Elytra dark red, thorax and head reddish brown. Agrees with female, excepting that the elytral declivity is more shining, the strial punctures are less distinct, and the interspaces have less distinct rows of granules.

Typical male labeled, name label, "Hopk. 1/22/08, *Pinus strobus*, Grand Island, Mich., W. F. Fiske, collector, ♂, Hopk. U. S. 3761."

Variations.—The length varies from 5 to 7.3 mm., with the average at about 6.5 mm., the head, thorax, and ventral segments from

[a] This was Eschscholtz's manuscript name, published in Dejean Cat., 3me. Edit., p. 331, but Mannerheim published the first description.

darker reddish brown to nearly black, while the elytra are light to dark red. The greatest variation noted in the few specimens under observation is in size, with less variation in sculpture and vestiture than in the preceding species, Nos. 14, 15, and 17.

Distinctive characters.—The characters which serve to at once distinguish this species from the preceding allied ones are the coarse punctures of the posterior section of the proepisternal area, the more distinctly red elytra, the bright-red hairs, and the much less distinctly impressed elytral striæ of the lateral area.

Revisional notes.—There is quite extensive literature under the name *Hylurgus rufipennis* Kirby and *Dendroctonus rufipennis* Kirby. Apparently no part of it except the original description refers to Kirby's species, and even the type series in the British Museum represents at least one other species. It appears that up to the fall of 1906 the only representative of the species in the collections of this country was a female specimen in the Hubbard & Schwarz collection, U. S. National Museum, labeled "White Fish Point, L. S." This, with other specimens of the *Dendroctonus* of the U. S. National Museum and Hubbard & Schwarz collections, was submitted to the writer in December, 1898, for study, and was then labeled "H. S. 28." In 1900 this specimen, together with another labeled "H. B." (Northwest Territory) from the National Museum collection, and some specimens collected by the writer from the spruce in Maine, were sent to the British Museum for comparison with Kirby's type of *D. rufipennis*. They were compared by Mr. Charles O. Waterhouse who, in a letter dated November 1, 1900, wrote as follows:

> I have examined your species, but am only concerned with your two largest specimens. We have three of the specimens which Kirby had before him, all marked exactly alike. The one to which he attached his ticket is a dark-brown variety (unless it is stained with grease), but in all other respects agrees with your H. S. 28, with fairly equally distributed punctuation on the thorax. Kirby's two other specimens have red elytra and agree with your H. B. 7401, 824, and have a closely punctured impression or flattening at the base of the thorax.

The specimen in the type series which bore the name label when the comparison was made should be recognized as the type. Thus it is quite certain that our H. S. 28 from White Fish Point, Lake Superior, is a true representative of the species, while the two other specimens with which our H. B. 7401, 824, etc., agree evidently represent *D. engelmanni* and are probably the specimens referred to by Kirby as coming from Lat. 65°. The writer is informed by Mr. Schwarz that our H. B. (No. 7401) specimen came from about the same latitude. The other specimens from Maine, which were so different from the type as to be at once recognized as distinct, were representatives of *D. piceaperda* Hopk.

The pupæ, larvæ, and galleries have not been observed.

Distribution (fig. 85).—*Michigan*: White Fish Point and Grand Island.

Host tree.—Pinus strobus.

Identified specimens.—U.S.N.M.,H. & S., 1 specimen; Hopk. U. S., 14 specimens of adults, collected by W. F. Fiske at Grand Island, Mich.

Bibliography.

Hylurgus rufipennis Kirby, 1837, p. 195, No. 261, original description. Packard, 1887, p. 176, note. Hopkins, 1899c, p. 343 (in part?). Schwarz, 1900a, p. 537, author's copy, p. 185 (in part?). Hopkins, 1901a, p. 16, reference to distribution, characters, first time recognized since description.

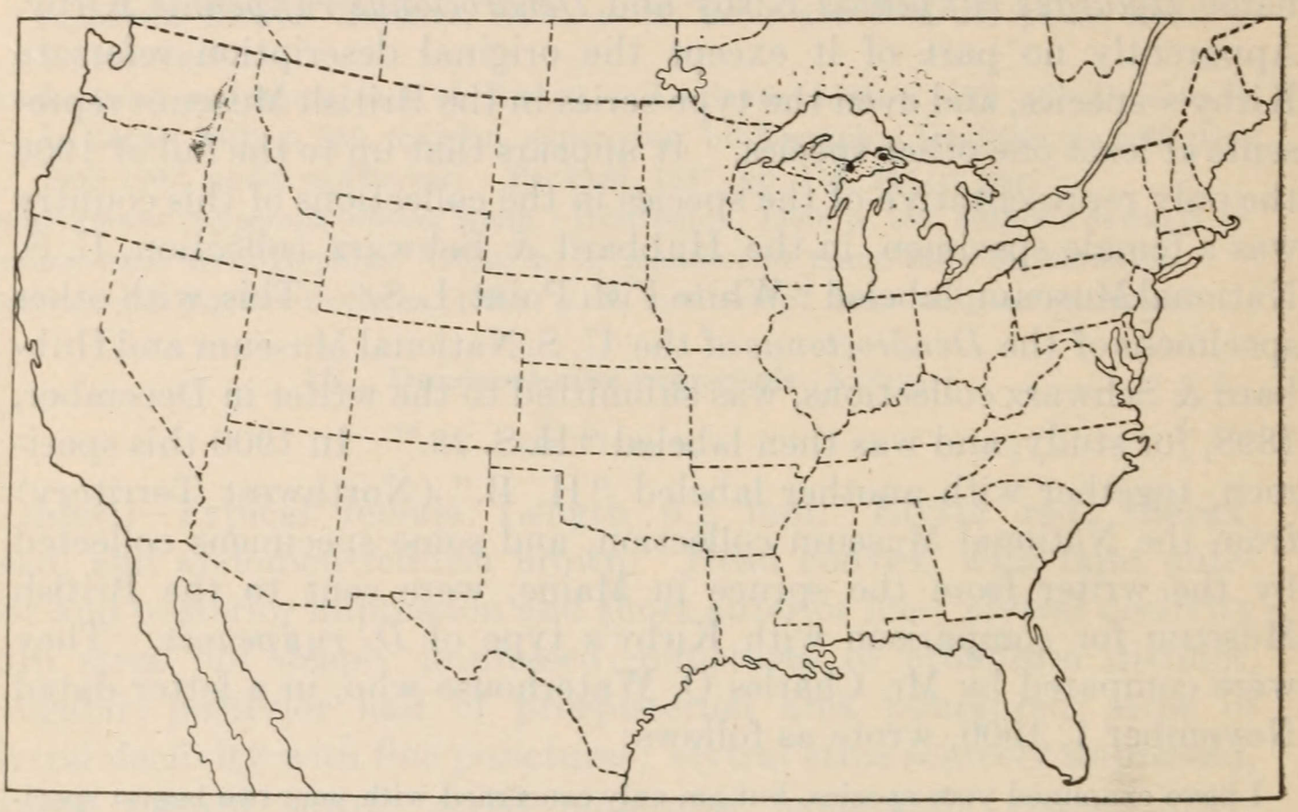

Fig. 85.—*Dendroctonus rufipennis:* Distribution map. (Original.)

19. Dendroctonus murrayanæ n. sp.

Adult.—Type of species, female: Length, 6.9 mm; elytra red; thorax, head, and abdomen nearly black. Head convex, with obscure impression; elytral declivity with striæ not deeply impressed; punctures of pronotum distinct, coarse, irregular; posterior half of proepisternal area punctured; striæ of elytral declivity with fine punctures; elytral striæ scarcely impressed; punctures moderately coarse; interspaces with rugosities moderately coarse, acute, and rather coarsely placed; pronotal punctures coarse, deep, moderately dense. Secondary sexual characters: Elytral declivity convex; striæ distinctly impressed; punctures obscure; interspaces convex, with irregular punctures and rows of granules.

Type labeled "No. 7454 U.S.N.M.," name label, "Hopk. 1/22/08, *Pinus murrayana*, Keystone, Wyo., J. L. Rebmann, collector, ♀, Hopk. U. S. 2690."

Male type: Length, 6.5 mm. Agrees with female, except that the elytral declivity is more shining and the interspaces are more distinctly punctured and less rugose.

Type labeled "♂ type," otherwise same as female.

Variations.—The length varies from 5.4 to 6.5 mm., with the average about 6 mm.; the head, thorax, and ventral segments are dark reddish brown to black, while the elytra are light to dark red. The greatest variation noted in the few specimens under observation is in the size, with less variation in sculpture and vestiture than in species Nos. 14, 15, and 17.

Distinctive characters.—The characters which serve to distinguish this species from *D. rufipennis*, to which it is more closely allied, are its slightly smaller size and more distinctly impressed elytral striæ

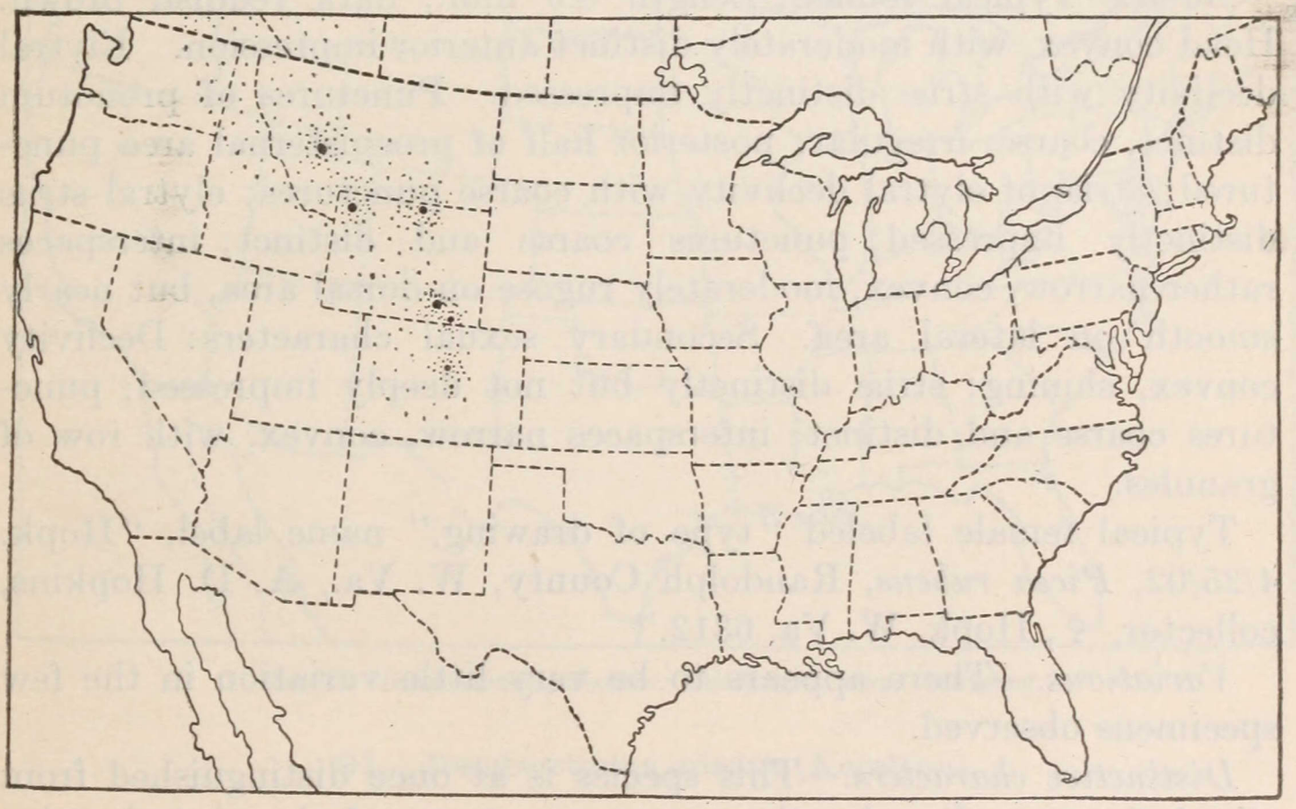

FIG. 86.—*Dendroctonus murrayanæ:* Distribution map. (Original.)

on the dorsal and lateral areas and the finely, densely punctured interspaces of the declivity in the male.

It appears that this species has not been referred to in literature.

The pupa has not been observed.

Larva (Pl. VIII, fig. 19).—In addition to the generic, divisional, and subdivisional characters, the front has an impression toward the anterior angles and a faint transverse elevation in front of the middle. The clypeus is longer than the labrum and marked with a median groove, and with the apex broadly emarginate; labrum with apex faintly emarginate, and the mandibles with distinct dorsal impression. Larval type labeled "Hopk. U. S. No. 2690c."

Galleries.—Only fragmentary specimens of the galleries have been observed, but they appear to come between *piceaperda* and *valens*, the larvæ, for the most part, excavating a common chamber.

Distribution (fig. 86).—(Hopk. U. S.) *Wyoming:* Homestake, Saratoga, Keystone, Cheyenne National Forest, and Big Horn National Forest. *Colorado:* Jefferson. *Additional localities from other collections:* (U.S.N.M.) (H. & S.), National Park, Wyoming.

Host trees.—Pinus murrayana and *Picea engelmanni.*

Identified specimens.—H. & S., 5; Hopk. U. S., over 100 specimens, including adults, larvæ, and work.

Bibliography.

Dendroctonus shoshone Hopkins, 1902a, p. 3, manuscript name only.

20. **Dendroctonus punctatus** Le Conte.

(Pl. VI, fig. 20.)

Adult.—Typical female: Length 6.5 mm., dark reddish brown. Head convex, with moderately distinct anterior impression. Elytral declivity with striæ distinctly impressed. Punctures of pronotum distinct, coarse, irregular; posterior half of proepisternal area punctured; striæ of elytral declivity with coarse punctures; elytral striæ distinctly impressed; punctures coarse and distinct; interspaces rather narrow, convex, moderately rugose on dorsal area, but nearly smooth on lateral area. Secondary sexual characters: Declivity convex, shining; striæ distinctly but not deeply impressed; punctures coarse and distinct; interspaces narrow, convex, with row of granules.

Typical female labeled "type of drawing," name label, "Hopk. 4/25/02, *Picea rubens,* Randolph County, W. Va., A. D. Hopkins, collector, ♀, Hopk. W. Va. 6312."

Variations.—There appears to be very little variation in the few specimens observed.

Distinctive characters.—This species is at once distinguished from all of the preceding by the coarse punctures of the elytral striæ, especially on the declivity. Its nearest ally is *D. micans,* of Europe, from which it differs in its smaller size, more elongate form, and more distinctly impressed elytral striæ.

Revisional notes.—While the original description does not include the more distinctive characters, it was based on a type which was readily recognized as a distinct species. Dietz referred the specimen in the Horn collection, labeled *D. punctatus* Lec., to *D. rufipennis* (Kirby), but it is certainly distinct from what is now recognized as *D. rufipennis.*

Host tree.—Picea rubens.

Pupæ, larvæ, and galleries of this species have not been observed.

Distribution (fig. 87).—(Hopk., W. Va.) 1 specimen collected by the writer May 21, 1892, in the high mountains of Randolph County,

West Virginia, under bark on spruce stump. (Le Conte, M. C. Z.) 3 specimens labeled "New York"; (Horn, A. E. S.) 1 specimen labeled "Pa."

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Dendroctonus punctatus Le Conte, 1868, p. 173, original description, synonymy, locality. Le Conte, 1876, p. 385, revision, synonymy, bibliography, localities. Packard, 1887, p. 177, Le Conte quoted. Packard, 1890, p. 722, Le Conte quoted. Hopkins, 1899a, p. 447, habit, etc., West Virginia. Hopkins, 1902a, p. 3, recognized as a good species and restored.

Dendroctonus rufipennis (not of Kirby) Dietz, 1890, p. 30, Pennsylvania.

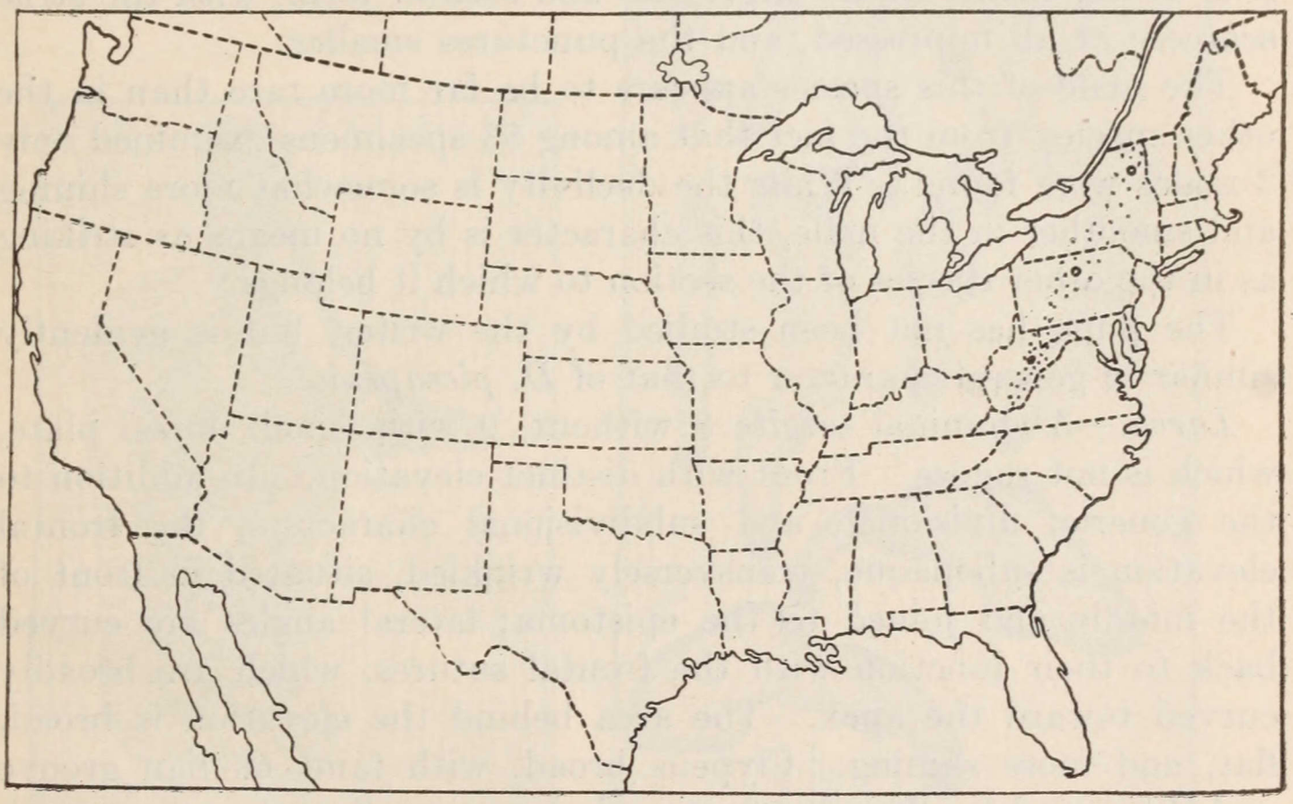

FIG. 87.—*Dendroctonus punctatus:* Distribution map. (Original.)

21. Dendroctonus micans (Kugelann).

(Pl. VI, fig. 21.)

Adult.—Typical female: Length 7.25 mm., dark reddish brown. Head convex, with faint anterior impression, without anterior line; elytral declivity with striæ not deeply impressed; punctures of pronotum distinct, coarse, irregular; posterior half of proepisternal area punctured; striæ of elytral declivity with coarse punctures; elytral striæ not impressed, punctures moderately coarse, interspaces broad and flat, sparsely and finely rugose. Secondary sexual characters: Elytral declivity convex, subopaque; striæ faintly impressed; punctures coarse and distinct; interspaces moderately convex, with sparse, irregular granules.

Typical female labeled "type of drawing," name label, "Hopk. 4/25/02, ♀. Determination No. 20, Eichhoff, Sachsen, Horrung."

Typical male: Length 6 mm., black. Agrees with female in every respect, except that it may have stouter mandible, the club of antenna smaller, more elongate; the declivity of elytra with strial punctures finer, and the interspaces without granules.

Typical male labeled "♂, from Dr. Severin."

Variations.—Length 7 to 8 mm., average about 7.5 mm.; uniform reddish brown to nearly black, with usual variation in sculpture and vestiture.

Distinctive characters.—This species is more closely allied to *D. punctatus* than to any of the other species of the genus, from which it is distinguished by its larger size and stouter form, with the striæ scarcely at all impressed, and the punctures smaller.

The male of this species appears to be far more rare than in the other species, from the fact that among 83 specimens examined only 2 males were found. While the declivity is somewhat more shining and smoother in the male, this character is by no means as striking as in the other species of the section to which it belongs.

The pupa has not been studied by the writer, but is evidently similar in general character to that of *D. piceaperda.*

Larva.—Abdominal tergite 8 without, 9 with, small dorsal plate, which is not rugose. Front with distinct elevation. In addition to the generic, divisional, and subdivisional characters, the frontal elevation is subopaque, transversely wrinkled, situated in front of the middle and joined to the epistoma; lateral angles are curved back to their junction with the frontal sutures, which are broadly curved toward the apex. The area behind the elevation is broad, flat, and more shining. Clypeus broad, with faint median groove and the apex broadly emarginate. Labrum small, rather stout, with broad dorsal impression, the apex subtruncate; mandibles shining, with a distinct dorsal impression and oblique ridge near the middle; sternellar lobes of the thoracic segments moderately prominent and with distinct foot calli.

Type.—One of a large series of larvæ received from Dr. G. Severin, conservateur, Royal Museum of Natural History, Belgium.

The larva of this species is at once distinguished from that of all of the other species of the genus, so far as observed, by the faint dorsal plate of the ninth abdominal segment, by the absence of a plate on the eighth, by the frontal elevation connected with the epistoma, and by the greater number and more distinct hairs on the scutellar lobes of the thorax and abdomen.

Galleries (fig. 88).—The galleries are evidently quite similar to those of *D. terebrans* and *D. valens*, especially in the fact that the larvæ live together in a common chamber exposed in the inner bark. According to Dr. G. Severin, the egg gallery is vertical, frequently

curved and somewhat irregular, sometimes doubly inflected and from 12 to 20 cm. long. The female here deposits from 20 to 25 eggs in several places. The larvæ eat very close together, growing equally in size and age and making a common cavity underneath the bark. In order to go through the pupal stage, they return to the large space which they left behind them and which is now filled with excrement and resin. Departing from their common cavity, they eat out isolated galleries, and at the end of these they pupate.

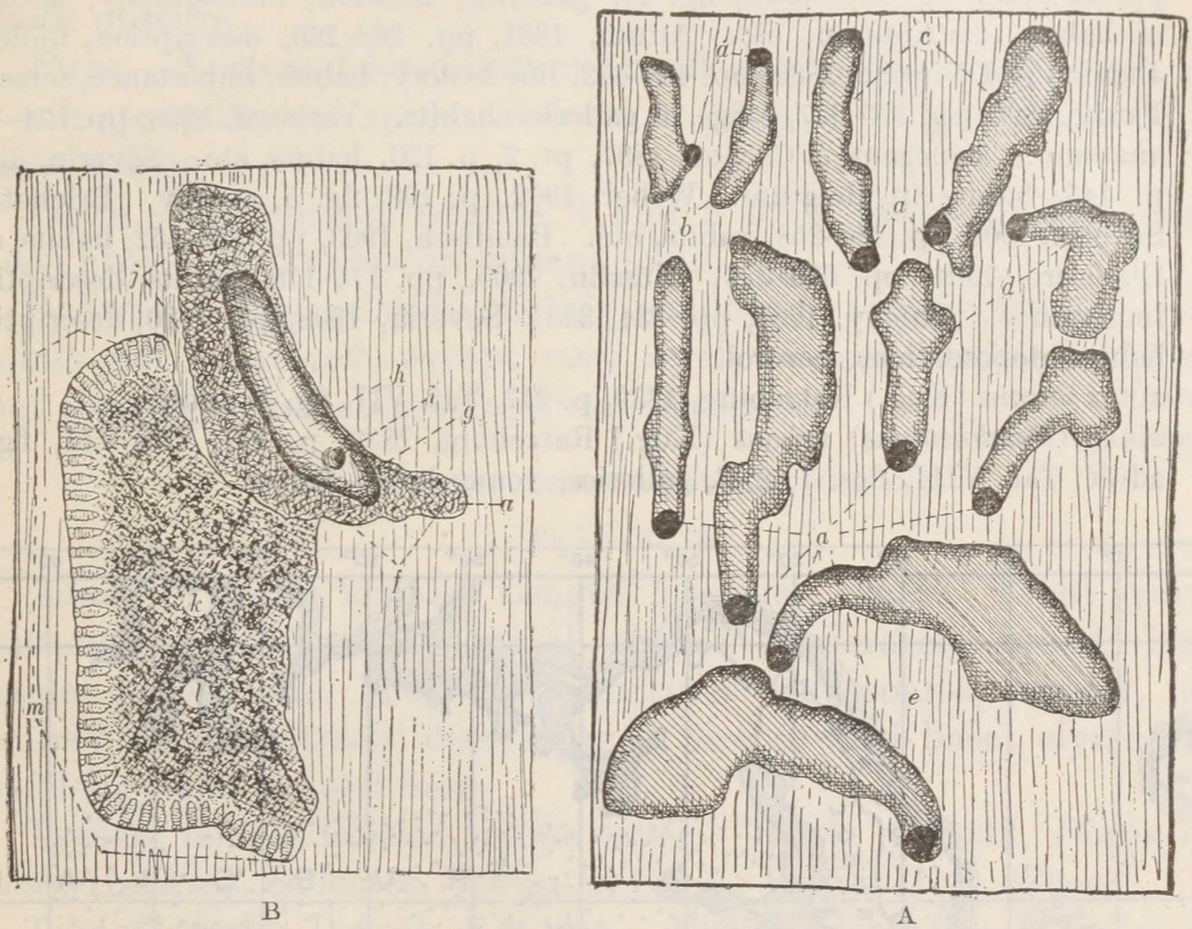

FIG. 88.—*Dendroctonus micans:* Egg galleries and larval chamber. *A*, Basal sections of egg galleries; *B*, advanced stage of work; *a*, entrance burrow; *b*, excavated July 8–16; *c*, excavated July 8–29; *d*, eight days old; *e*, three weeks old; *f*, basal section; *g*, boring-dust; *h*, subsequent or inner gallery ("mother gallery"); *j*, egg nest with eggs scattered about in boring-dust; *k*, social chamber excavated by larvæ; *l*, boring-dust and resin; *m*, larvæ at work. (Adapted from Pauly Forstlich-natur wissenschaftliche Zeitschrift, I Jahrgang, figs. 3 and 4.)

Distribution (fig. 89).—According to the literature, this species ranges from central to northern Europe and from Denmark and Russia eastward into Siberia.

Host trees.—It is said to infest *Pinus*, *Picea*, *Abies*, and *Larix*.

Identified specimens.—The writer has examined 1 specimen received from W. Eichhoff, 8 from B. W. Schlick, Denmark; 2 with specimens of work from Reitter's collection, collected in Bohemia, and about 70 specimens of adults, as well as larvæ and specimens of work from Dr. G. Severin, of the Musée Royale d'Histoire Naturelle, Brussels, Belgium.

Bibliography and Synonymy.

?*Bostrichus ligniperda* Herbst, 1793, p. 107 (in part).

Bostrichus micans Kugelann, 1794, p. 523, original description.

?*Hylesinus ligniperda* Gyllenhal, 1813, pp. 335, 336 (in part).

Dendroctonus micans (Kug.) Erichson, 1836, p. 53, type of genus. Bach, 1849, p. 144. Stein, 1854, pp. 277–279, habits, destructiveness. Kollar, 1858, pp. 23–28, habits, control. Eichhoff, 1864, p. 27, pl. 1, fig. 5, tarsi, fig. 6, maxilla, fig. 7, labium, in revision of genus. Lacordaire, 1866, p. 360, in revision of genus. Chapuis, 1869, p. 35; 1873, p. 243, revised description. Lindemann, 1875, pp. 213, 221, pl. 1, figs. 1–10, male reproductive organs described and illustrated. Eichhoff, 1881, pp. 125–128, fig. 23, adult, fig. 24, galleries, revision, bibliography, account of habits, distribution, etc. Altum, 1881, pp. 262–266, description, biology. Judeich and Nitsche, 1889, pp. 458–462, life history, habits, importance, remedy. Pauly, 1892, pp. 315–327, 4 figs. of galleries, habits. Verhoeff, 1896, pp. 124–133, anatomy. Ménégaux & Cochon, 1897, pt. 2, p. 120, habits, etc. Severin, 1902, p. 145, habits in Belgium. Weber, 1902, p. 108, fig. 5, enemy. Brichet et Severin, 1903, pp. 244–258, habits, etc. Baudisch, 1903, pp. 151–152, habits, etc. Quairière, 1904, pp. 626–628. Nüsslin, 1905, pp. 175–178, habits, description, importance. Quiévy, 1905, pp. 334, 335. Severin, 1908, pp. 1–20, description, habits, depredations, control.

Hylesinus micans (Kug.) Ratzeburg, 1839, p. 217, Taf. VII, fig. 3, adult.

Hylesinus (*Dendroctonus*) *micans* (Kug.) Ratzeburg, 1839, p. 217, Taf. VII, fig. 3, adult; Taf. VIII, figs. 1, 2, 3, galleries, young larvæ, pupæ.

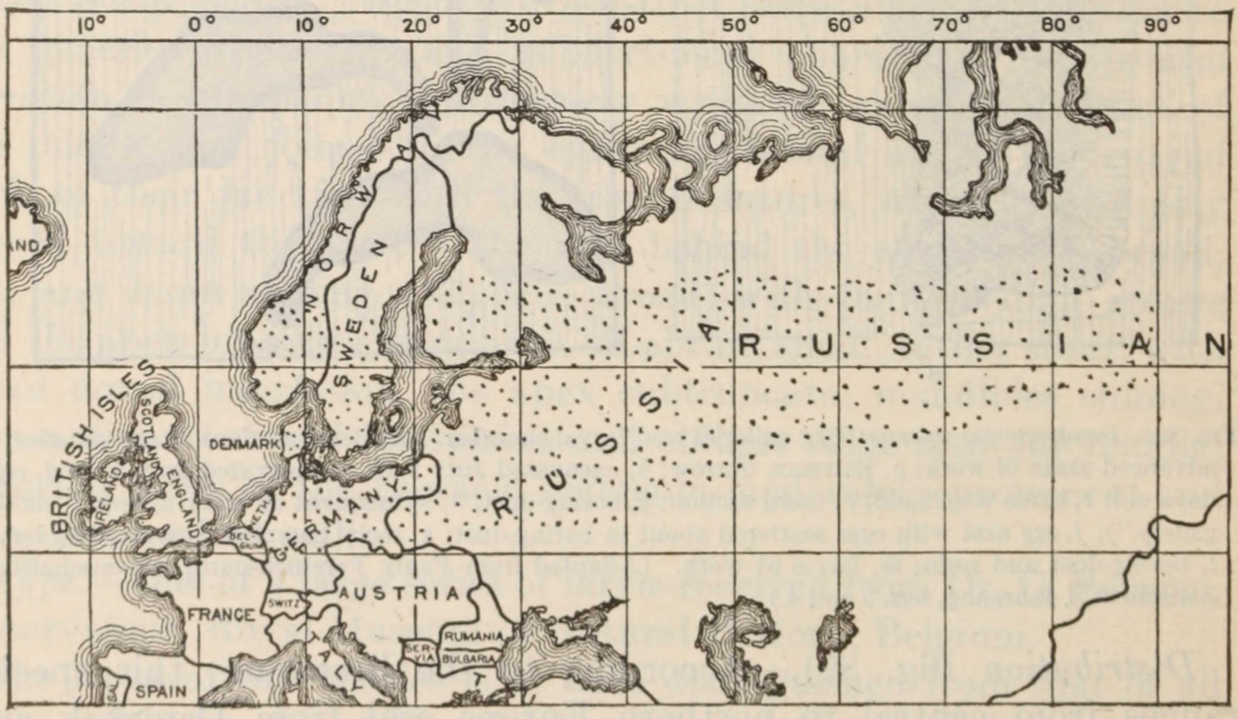

FIG. 89.—*Dendroctonus micans:* Distribution map. (Original.)

Subdivision D.

The distinguishing characters common to the species of the fourth subdivision are:

Adult.—Front without median or posterior impression. Pronotum somewhat elongate, slightly narrower than elytra, moderately constricted toward head, with regular punctures or without coarse and fine punctures intermixed, long hairs absent on median and posterior dorsal areas, present on anterior and lateral areas; head

broad, convex; epistomal process and elytral rugosities variable within the same species.

Sexes.—Females with front of head moderately broad; mandibles shining, moderately stout; antennal club broad and stout; elytral declivity slightly more rugose; striæ impressed with distinct punctures.

Males with front of head distinctly broader; mandibles opaque, stout; antennal club narrow, more elongate, and the elytral declivity slightly less rugose; striæ less distinctly impressed, and the punctures more obscure.

Pupa.—Vertex of head convex; front and middle femur each with a minute subapical spine; abdominal tergites with moderately distinct spines.

Larva.—Abdominal tergites 8 and 9 with distinct dorsal plates, each armed with three prominent teeth.

Galleries.—Egg galleries slightly winding to nearly straight; larval mines not separated, except very rarely near the outer extremity, but forming broad common larval chambers.

22. **Dendroctonus terebrans** (Olivier).

(Pl. VII, fig. 22.)

Adult.—Typical female: Length 5.6 mm., black. Front convex, without impressions; epistomal process moderately broad, lateral angles tuberculate. Pronotal punctures very coarse, regular, moderately dense, scarcely decreasing in size toward base; elytra without long hairs toward base.

Typical female labeled, name label, "Hopk. 1/22/08, *Pinus echinata*, Hopkins, collector, Tryon, N.C., ♀, Hopk. U. S. 530aa."

Typical male: Length 5.6 mm. Differs from female in stouter mandibles and slightly coarser rugosities of elytral declivity.

Typical male labeled same as female.

Variations.—The length varies from 5 to 8 mm., with the average about 7 mm. The color ranges from piceous to deep black, the latter prevailing. Immature specimens are reddish, but fully matured ones are always darker than the darkest *D. valens.* The greatest variation is in size, and while the usual variation prevails in some of the other characters, it is much less so than in *D. valens.* In New Jersey, Pennsylvania, Virginia, and West Virginia, where there is an overlapping of the range of *D. valens* and *D. terebrans,* specimens are sometimes found which appear to be hybrids, but it appears that the more dominant characters of *D. terebrans* prevail in such hybrids, so that the darker color and coarse punctures of the pronotum serve to distinguish them as being more closely allied to the latter species.

Distinctive characters.—The characters which serve to distinguish this species from *D. valens,* to which it is more closely allied, are its

prevailing black or dark color, the more uniform and coarser punctures of the pronotum, the narrower epistomal process, with the angles more tuberculate, and the less evident long hairs on the anterior dorsal area of the elytra.

Revisional notes.—While the type of this species has not been seen by the writer, it is clearly evident from Olivier's description and figures (Olivier, 1795) that the large black form common to the southern United States represents the species described. The only distinctive specific character mentioned, however, is the reference to the Black Scolytus and to the body being black, brown, or brownish-black. The confounding of *Dendroctonus valens* and *D. terebrans* under the latter name has resulted in much confusion in the literature. With our present knowledge, however, it is not difficult to clear up some of the confusion and to revise and correct the literature so that it may be known in many cases whether or not one or both species was included in a given reference. Erichson, 1836, Lacordaire, 1866, and Chapuis, 1869, evidently did not compare *D. valens* and *D. terebrans*. While a specimen of this species has been in the Harris collection since 1839, Harris apparently made no reference to its characters. Zimmermann, 1868, page 149, did not mention *D. valens*, but evidently had the two species confused in his revised description. Le Conte, 1868, page 173, referred *D. valens* to *D. terebrans*, and in 1876, pages 384–385, confuses the characters and distribution of the two species. Dietz, 1890, page 29, included this species under his variety *a*, and (p. 30) evidently includes two specimens from Florida under his revision of *D. rufipennis*. In subsequent literature up to 1906 there is more or less confusion of this species with *D. valens*. The writer, 1906c, page 81, restored *D. valens* Lec. and called attention to the characters distinguishing *D. terebrans* (Oliv.). In 1900 the writer found one specimen in the Harris collection, under *Hylurgus terebrans*, under his No. 99, referred to in his note as "Dark specimen abundant under bark of pitch pine, October 27, 1839," but it appears that no reference was made to this dark specimen in any of his publications. The locality is not given, but it is presumably Cambridge. It appears that this species was not represented in the Horn collection under *D. terebrans* when Doctor Dietz prepared his revision, and that the only example involved in the revision under *D. terebrans* was the one in the Ulke collection from Pennsylvania, designated as "variety *a*." Two examples were found in the Horn collection under *D. rufipennis*, labeled "Fla.," and it was evidently on these that Doctor Dietz based his Florida locality in his revision of *D. rufipennis*. In 1907 this species was represented in the Le Conte collection by 9 specimens and 8 additional specimens in the general collection of the Museum of Comparative Zoology.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the front and middle femora are armed each with a minute apical spine; abdominal tergites 1 to 6 have moderately small pleural spines, 1 is without dorsal spine, but with distinct lateral ones; 2 to 6 have small dorsal and lateral spines, the former increasing in size to 6. All have pale tips; 7 and 8 unarmed; 9 with usual stout pleural spine. Pupal type labeled "Hopk. W. Va. 7701."

The usual variation prevails in the number and arrangement of minor spines and between the young and older examples.

The character which in general serves to distinguish the pupa of this species from the preceding is found in the paler tips of the body spines.

Larva.—In addition to the generic, divisional, and subdivisional characters, front of head with posterior angle and median area not elevated but transversely rugose except near apex, where it is smooth; epistoma flat, opaque, smooth, with straight anterior margin; clypeus broad, prominent, convex, with faint median longitudinal line, sides rounded, apex broadly emarginate; labrum short, with sides nearly parallel and apex tuberculate. Prothoracic tergum with two broad, shining dorsal plates separated by a rather broad median space, and a smaller lateral plate each side; sternellar lobes each with a faint foot callus; mesoterga and metaterga with shining plates on the lateral lobes. Abdominal scutellar lobes with a rather prominent tubercle on each epipleurum. Larval type labeled "Hopk. U. S. 1201."

The larva of this species is scarcely to be distinguished from that of *D. valens.*

Galleries.—The egg galleries are generally longitudinal, more or less winding, and vary greatly in length, sometimes being very long. They are irregular in width, sometimes with branches, and are slightly grooved in the surface of the wood. The eggs are placed in masses at intervals along the sides and in the inner bark; the larvæ excavate broad chambers which vary in size from a square inch to many square feet. The galleries of this species do not differ materially from the following, and have a wide range of variation in size and general character.

Distribution (fig. 90).—(Hopk. U. S.) *Alabama:* Calhoun. *Delaware. District of Columbia:* Takoma. *Georgia:* Cornelia, Thomasville. *New Jersey:* Lakewood, New Brunswick. *New York:* Islip (Long Island). *South Carolina:* Chicora, Lumber, New Landing, Pregnall. *Texas:* Austin, Call, Deweyville, Kirbyville, Tarkington. *Virginia:* Glen. *West Virginia:* Kanawha Station. (Hopk. W. Va.) *West Virginia:* Crow, Marion County, Morgantown, Romney. *Additional localities from other collections:* (Le Conte) Georgia, North Carolina, New Hampshire, Pennsylvania. (M. C. Z.) Texas, South

Carolina, Maryland. (A. E. S.) New Jersey, Delaware. (A. N. S.) Marion County, Fla. (U.S.N.M.) Lakewood, N. J. (D. A.) Islip, Long Island, N. Y. (Laurent) Pennsylvania.

Host trees.—Pinus palustris, P. rigida, P. tæda, P. serotina, P. strobus, P. echinata, Picea rubens.

Identified specimens.—Le Conte, 9 specimens; M. C. Z., 8; Horn, 7; U.S.N.M., 2; H. & S., 4; D. A., 7; Hopk. U. S., about 400 specimens, including adults, larvæ, and work.

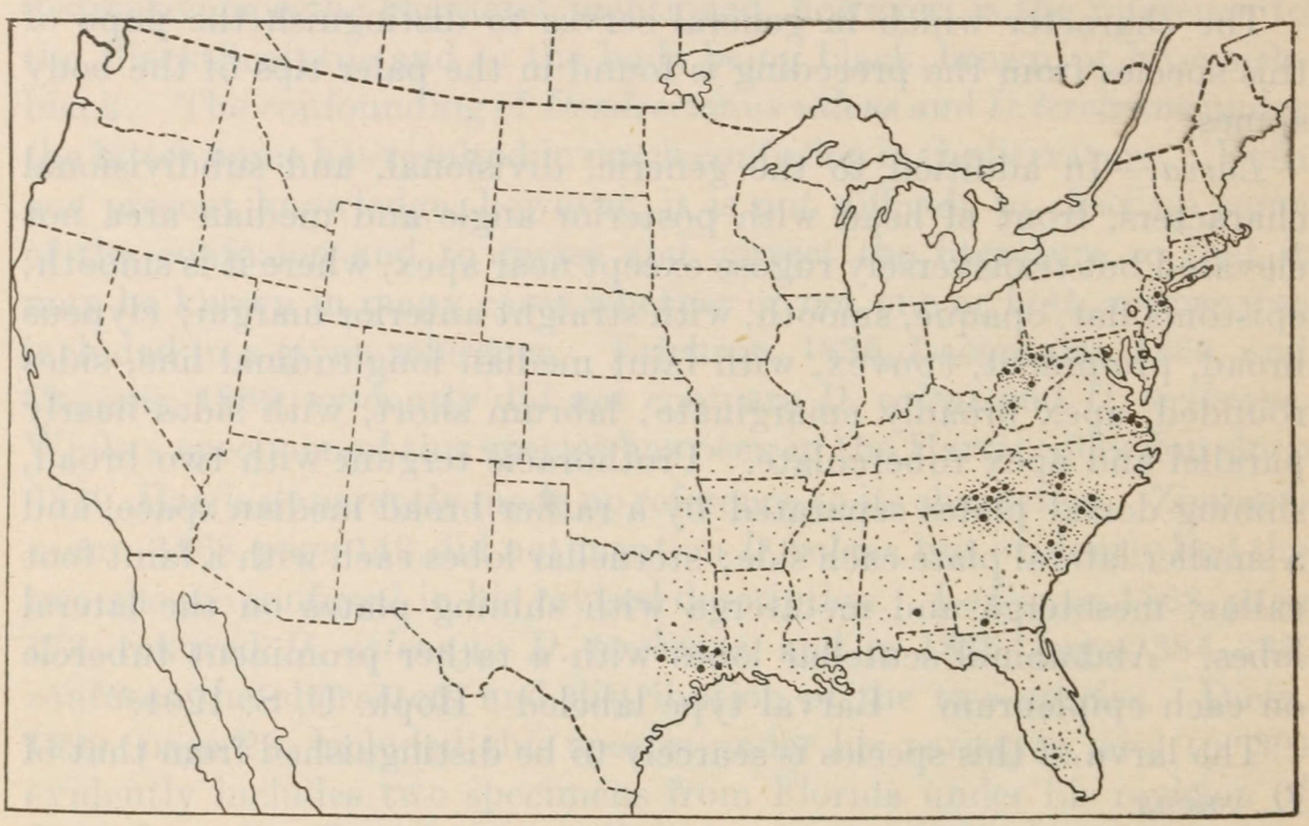

FIG. 90.—*Dendroctonus terebrans:* Distribution map. (Original.)

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Scolytus terebrans Olivier, 1795, p. 6, Pl. I, fig. 6, adult; original description, locality southern U. S. (Southern Georgia, Schwarz).

Dendroctonus terebrans (Oliv.) Erichson, 1836, p. 53 (cotype of genus). Lacordaire, 1866, p. 360. Zimmermann, 1868, p. 149 (in part), South Atlantic States. Le Conte, 1868, p. 173 (in part). Chapuis, 1869, pp. 35–36. Chapuis, 1873, pp. 243–244, revision, Texas. Schwarz, 1878, p. 469, list, Florida. Packard, 1887, p. 177 (in part), Le Conte quoted. Packard, 1890, p. 721 (in part). Dietz, 1890, p. 29 (in part). Hopkins, 1893b, p. 143, No. 76 (in part), Hampshire and Monongalia counties, W. Va. Hopkins, 1893c, p. 213, No. 300 (in part), list, host, etc. Smith, 1899, p. 364 (in part), distribution, habits. Chittenden, 1899, p. 56 (in part). Smith, 1901, p. 92, destructive to pine, Lahaway [Bordentown], N. J. Ulke, 1902, pp. 36–56, list, habits, etc. Hopkins, 1902b, p. 10, footnote, mention. Hopkins, 1906c, p. 81, distinguishing characters. Felt, 1906, pp. 342–345, Long Island.

Dendroctonus terebrans (Lacordaire) Le Conte, 1876, p. 385 (= Oliv. in part), bibliography, distribution, systematic note, on specimens from Georgia.

Dendroctonus rufipennis (not of Kirby) Dietz, 1890, p. 30, Florida.

?Dendroctonus sp. Blandford, 1897, p. 147, reference to black form from Texas.

23. Dendroctonus valens Le Conte.

(Pl. VII, fig. 23.)

Adult.—Typical female: Length, 8.7 mm. Head with front broad, convex, and with broad anterior impression. Epistomal process broad, with lateral sections oblique. Pronotum with punctures moderately coarse, much smaller and denser toward base. Elytra with a few long hairs toward base; declivity convex; striæ impressed, with small distinct punctures; interspaces moderately convex, distinctly rugose.

Typical specimen labeled, name label, "Hopk. 1/22/08, *Pinus ponderosa*, Hopkins, collector, McCloud, Cal., ♀, Hopk. U. S. 18a."

Typical male: Length 7.6 mm. Differs from female in stouter mandibles, narrower antennal club, more opaque declivity, less distinctly impressed striæ, and more obscure punctures.

Typical male labeled same as female.

Variations.—The length ranges from 5.7 to 9 mm., with the average about 8 mm. The color of the elytra, pronotum, and vertex of head ranges from light to dark red, but is never black, while the ventral part of the body varies from light red to black. The greatest variation is in size, but there is a wide and remarkable range in the epistoma and front and in the sculpture of the pronotum and elytra, as in almost every other character. Thus a large number of individuals may be easily selected, each of which might be considered as representing a good species, but when a large series of specimens is examined from any given faunal region or locality no sufficiently distinctive and constant characters have been found by which they can be readily recognized as distinct from those of any other faunal region, so that those examples from Maine can not be distinguished from examples collected in the mountains of Mexico.

Distinctive characters.—The characters which serve to distinguish this species from *D. terebrans*, to which it is closely allied, are its prevailing red color, the less uniform and more densely placed pronotal punctures, the much broader epistomal process, with the lateral sections less angular and more oblique, and the more evident and numerous hairs on the anterior dorsal area of the elytra.

Revisional notes.—See same heading under *D. terebrans*.

The typical specimen on which Le Conte's original description (Le Conte, 1860) was based is from California and represents the common red form which has heretofore been confused with *D. terebrans*. The distinguishing character, "finer and denser punctures of the thorax," mentioned by Le Conte is undoubtedly a good specific character when taken with color and other characters. The species is represented in the Le Conte collection by the type and 9 speci-

mens, and in the collection of the Museum of Comparative Zoology by over 50 specimens.

Pupa.—In addition to the generic, divisional, and subdivisional characters, the front and middle femora are armed each with a minute apical spine; abdominal tergites 1 to 6 with moderately small pleural spines; 1 is without dorsal spines, but with distinct lateral ones; 2 to 6 have small dorsal and lateral spines, the former increasing in size to 6, and all have dark tips; 7 and 8 are unarmed; 9 has the usual stout pleural spine. Pupal type labeled "Hopk. U. S. 2824."

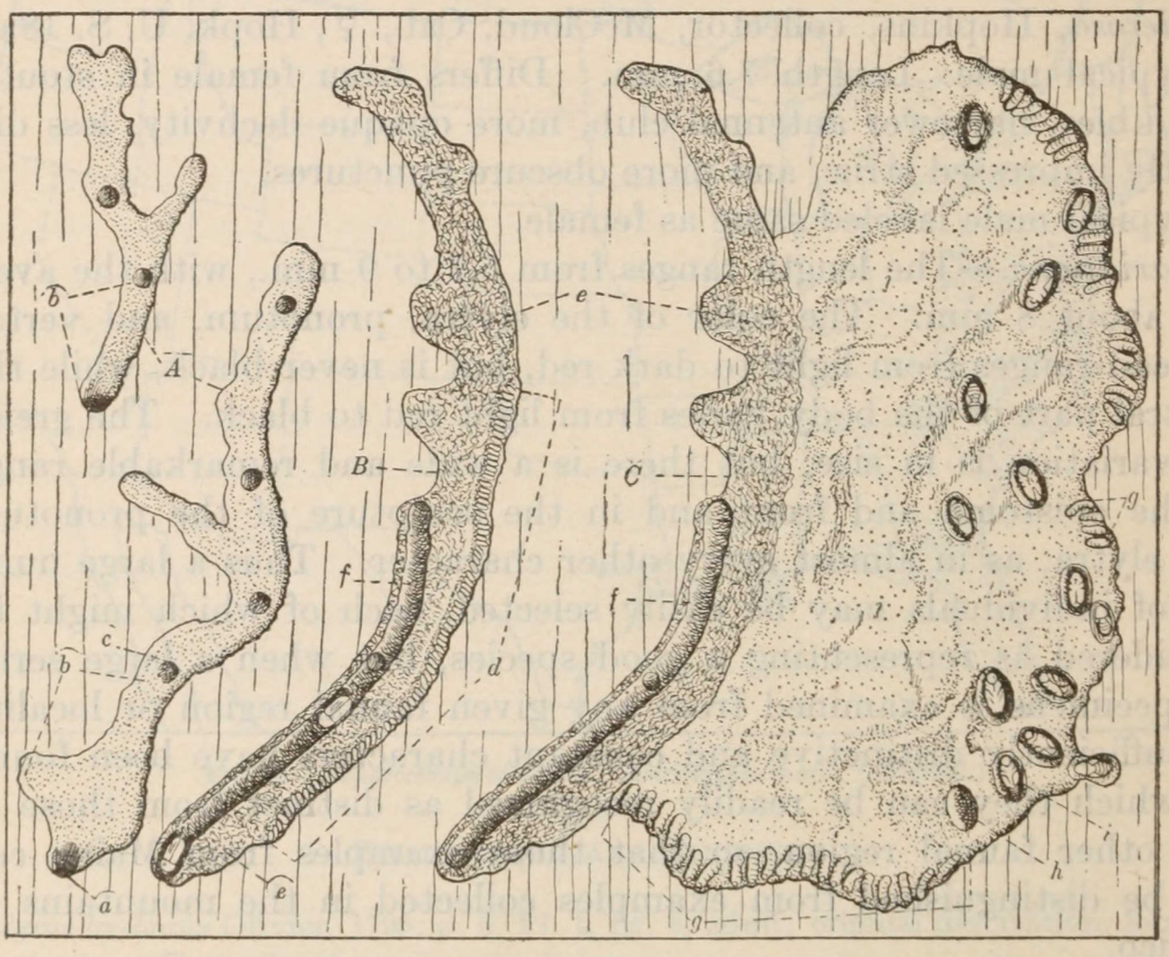

FIG. 91.—*Dendroctonus valens:* Egg galleries and larval chamber. *A*, Incomplete egg galleries with boring dust removed; *B*, normal gallery; *C*, advanced stage of work; *a*, entrance burrow; *b*, basal section; *c*, ventilating burrow; *d*, egg nest with eggs; *e*, boring dust; *f*, subsequent or inner galleries; *g*, larvæ at work; *h*, pupal cell in boring dust mixed with resin. (Original.)

The usual variation prevails in the number and arrangement of minor spines and between the young and older examples.

The character which in general serves to distinguish the pupa of this species from the preceding is found in the darker tips to the body spines.

Larva (text fig. 39 and Pl. VIII, fig. 23).—In addition to the generic, divisional, and subdivisional characters, front of head with posterior angle, median area not elevated but transversely rugose, except near apex, where it is smooth; epistoma flat, opaque, smooth, with straight anterior margin; clypeus broad, prominent, convex, with faint median longitudinal line, sides rounded, apex broadly emarginate;

labrum short, sides nearly parallel, and apex tuberculate. Prothoracic tergum with two broad, shining dorsal plates separated by a rather broad median space, and a smaller lateral plate each side; sternellar lobes each with a faint foot callus; the mesoterga and metaterga with shining plates on the lateral lobes. Abdomen with a rather prominent tubercle on each epipleurum. Larval type labeled "Hopk. U. S. 2824."

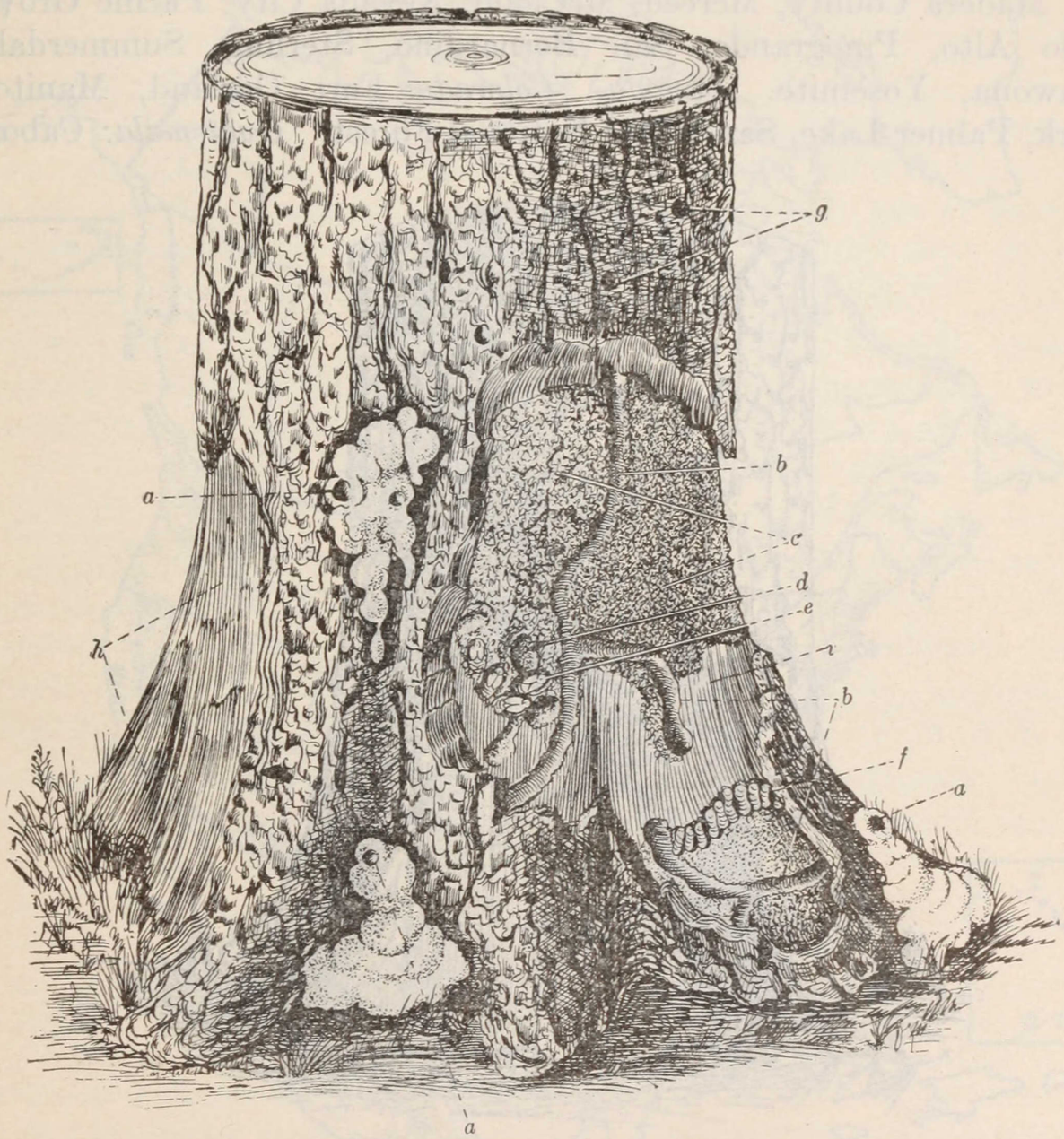

FIG. 92.—*Dendroctonus valens:* Work in bark at base of stump. *a*, Entrance and pitch tube; *b*, egg gallery; *c*, boring dust and resin; *d*, pupal cell; *e*, pupa; *f*, larvæ at work feeding on inner living bark; *g*, exit burrows; *h*, resulting old scar or basal wound, often referred to as basal fire wound; *i*, inner bark with outer corky bark removed. (Original.)

The larva of this species is scarcely to be distinguished from the preceding.

Galleries (figs. 91–93).—The egg galleries are generally longitudinal, more or less winding, and vary greatly in length, sometimes being very long; they are irregular in width and sometimes with branches, and are slightly grooved into the surface of the wood. The eggs are placed in masses at intervals along the sides in the inner bark, and the larvæ excavate broad chambers, which vary in size from a

square inch to many square feet. The galleries of this species do not differ materially from the preceding, and have a wide range of variation in size and general character.

Distribution (fig. 94).—(Hopk. U. S.) *Arizona:* Chiricahua Mountains, Flagstaff, Fredonia, Grand Canyon, Paradise, Ramsey Canyon, Rincon Mountains, Santa Catalina National Forest, Williams. *California:* Alder Creek, Berkeley, Chester, Del Monte, La Moine, Little Yosemite, Madera County, Merced, McCloud, Nevada City, Pacific Grove, Palo Alto, Pinogrande, San Bernardino, Sterling, Summerdale, Wawona, Yosemite. *Canada. Colorado:* Fort Garland, Manitou Park, Palmer Lake, San Isabel National Forest. *Guatemala:* Cabon.

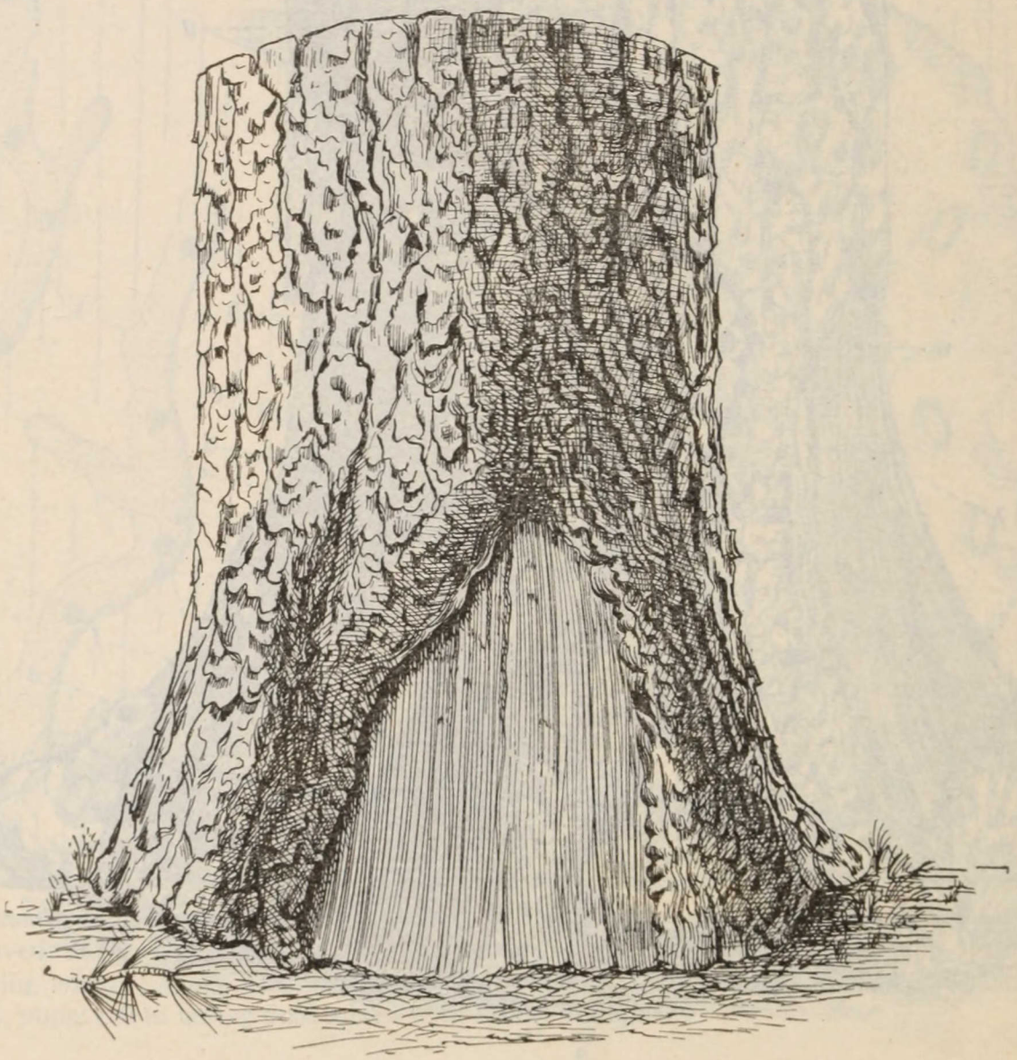

FIG. 93.—*Dendroctonus valens:* Basal wound in living tree resulting from primary injury by this species. Often mistaken for fire wound. (Original.)

Idaho: Cedar Mountain, Centerville, Grimes Pass, Harris Ridge (Kooskai), Pioneerville, Priest River, Smiths Ferry. *Kansas. Maine:* Brunswick, Casco Bay, Limerick, Peak Island, Portland. *Massachusetts:* Lynn, Wyoming. *Mexico:* Chalco, Chihuahua, Mexico City, Michoacan, Ponada, Satazin. *Michigan:* Grand Island. *Montana:* Missoula. *Nevada. New Hampshire:* Durham, Webster. *New Mexico:* Capitan, Capitan Mountains, Cloudcroft, Lincoln National Forest, Vermejo, White Mountains. *New York:* Ithaca. *North Carolina:* Biltmore, Pink Beds. *Oregon:* Albany, Hood River, Joseph, Slate Creek. *Pennsylvania:* Milford, Philadelphia. *South*

Dakota: Black Hills, Elmore, Lead, Spearfish. *Utah:* Escalante, Kamas, Kanab, Panguitch Lake. *Vermont:* Fairlee. *Virginia.* *Washington:* Buckeye, Easton, Pullman, Skykomish. *West Virginia:* Crow, Hampshire County, Hardy County, Kanawha Station,

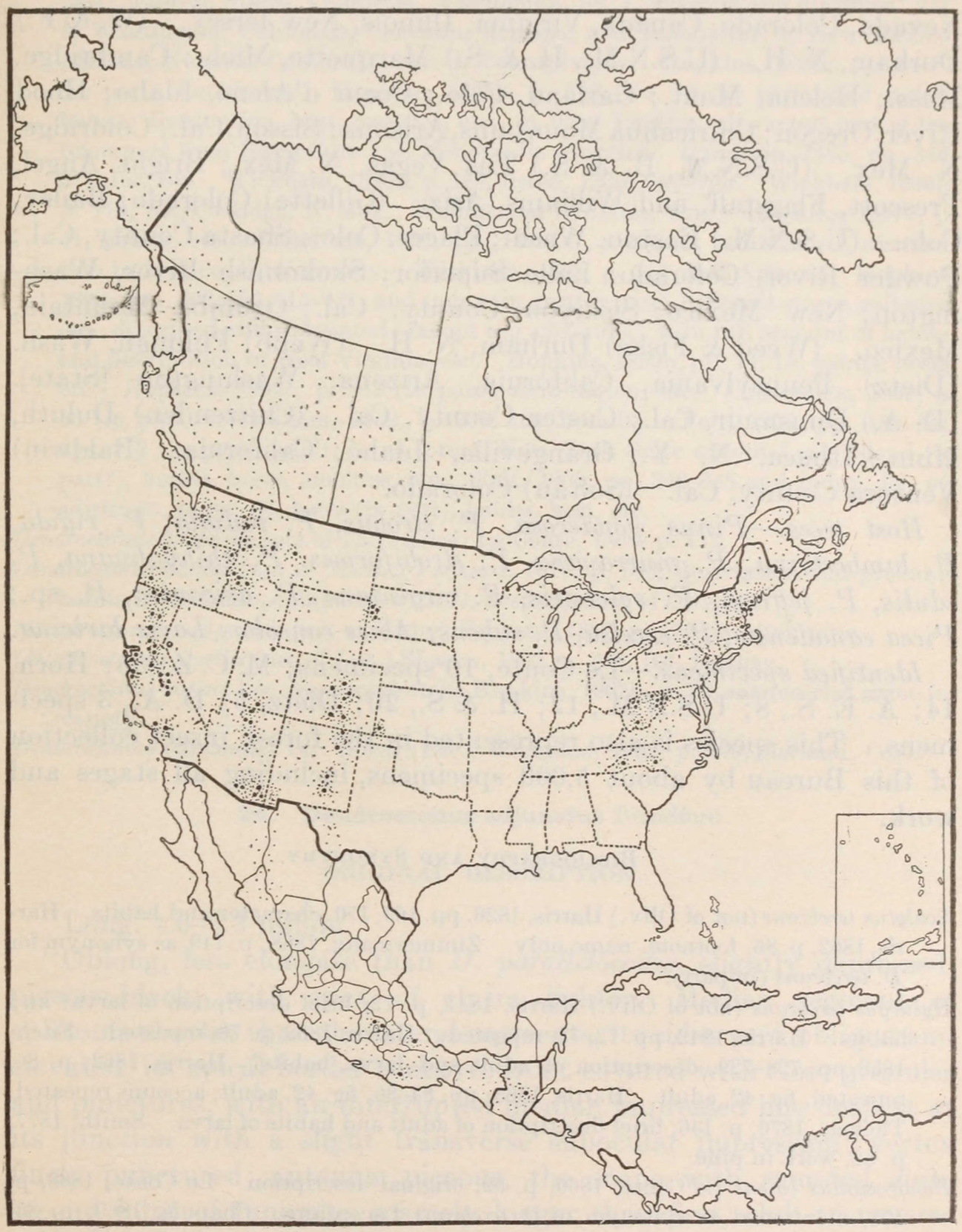

FIG. 94.—*Dendroctonus valens:* Distribution map. (Original.)

Monongalia County, Morgantown, Pendleton, Raleigh County, Romney, Roosevelt, Tucker. *Wisconsin:* Ashland, Madison. (Hopk. W. Va.) *West Virginia:* Bretz, Cranesville, Deckers Creek, Dellslow, Mayfield Hill, Moorefield, Morgantown, Pendleton, Randolph,

Romney. *Additional localities from other collections:* (M. C. Z.) New Mexico; California; Pennsylvania; Idaho; Maine; Massachusetts; Cambridge, Mass. (Le Conte) Middle States; Connecticut; Garland, Colo.; California. (Horn) North Carolina, Oregon, Wisconsin, Maine, California, New Mexico, and Pennsylvania. (A. E. S.) Kansas, Idaho, Nevada, Colorado, Canada, Virginia, Illinois, New Jersey. (W. & F.) Durham, N. H. (U.S.N.M., H. & S.) Marquette, Mich.; Cambridge, Mass.; Helena, Mont.; Garland, Colo.; Coeur d'Alene, Idaho; Hood River, Oregon; Chiricahua Mountains, Arizona; Sisson, Cal.; Coldridge, N. Mex. (U.S.N.M., B. & S.) Las Vegas, N. Mex.; Bright Angel, Prescott, Flagstaff, and Williams, Ariz. (Gillette) Colorado; Bailey, Colo. (U.S.N.M.) Easton, Wash.; Placer, Colo.; Shasta County, Cal.; Powder River, Colorado; Lake Superior; Skokomish River, Washington; New Mexico; Siskiyou County, Cal.; Ozumba Mountain, Mexico. (Weed & Fiske) Durham, N. H. (Webb) Pullman, Wash. (Dietz) Pennsylvania, California, Arizona, Washington [State]. (D. A.) Dunsmuir, Cal.; Custer County, Cal. (Chittenden) Duluth, Minn.; Ithaca, N. Y.; Grangeville, Idaho; California. (Baldwin) Ventura County, Cal. (Soltau) Colorado.

Host trees.—Pinus ponderosa, P. strobus, P. radiata, P. rigida, P. lambertiana, P. murrayana, P. strobiformis, P. chihuahuana, P. edulis, P. jeffreyi, P. sylvestris, P. virginiana, P. arizonica, P. sp.; *Picea canadensis, P. excelsa, P. rubens; Abies concolor; Larix laricina.*

Identified specimens.—Le Conte, 10 specimens; M. C. Z., 55; Horn, 14; A. E. S., 8; U.S.N.M., 12; H. & S., 20; Dietz, 5; D. A., 3 specimens. This species is also represented in the forest insect collection of this Bureau by about 5,000 specimens, including all stages and work.

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Dendroctonus valens Le Conte, 1860, p. 59, original description. Le Conte, 1868, p. 173, mentioned as synonym of *D. terebrans* Lacordaire. Chapuis, 1869, p. 35; Chapuis, 1873, p. 243. Le Conte, 1878, p. 472, list, Atlanta, Idaho. Hopkins, 1903a, p. 61, reference to habits, etc. Hopkins, 1904, p. 19, Pl. VII, figs. *a*, *b*, *g* (reprint). Powell, 1904, anatomy. Powell, 1905, ibid. Hopkins, 1905, pp. 6, 11, 17, distinctive characters. Hopkins, 1906b, p. 147, Pl. IV, figs. 6, 8, anatomy of larval head. Hopkins, 1906c, p. 81, mentioned as a good species, host, localities, etc. Fall, 1907, p. 218, list, localities.

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Dendroctonus terebrans (not of Lacordaire) Le Conte, 1868, p. 173.

Dendroctonus obesus (not of Mann.) Packard, 1877, p. 803, description and probable habits in Colorado, compared with *D. terebrans* (not of Oliv.).

?Dendroctonus rufipennis (not of Kirby) Packard, 1887, p. 176, in pitch pine.

?Dendroctonus similis (not of Lec.) Slosson, 1902, p. 319, list, locality.

Dendroctonus valens Lec. var. *occidentalis* Hopkins, 1902b, p. 12, manuscript name for variety.

Dendroctonus (*terebrans*) var. *valens* (Lec.) Wickham, 1902, p. 309, Garland, Colo.

24. **Dendroctonus adjunctus** Blandford.

ORIGINAL DESCRIPTION.

"Long. 4.6–5.3 millim.

"Oblong, less elongate than *D. parallelocollis*, slightly depressed, piceous-black, with apex of elytra lighter. Median segment of epistoma shorter than the lateral segments, its sides very oblique and elevated, its apical border concave; front covered with close granules and punctures, with an interrupted median impressed line deepest at its junction with a slight transverse subocular impression; vertex finely punctured; antennæ piceous, the scape with rounded club, second joint of funiculus scarcely longer than first, club transverse oval, its sutures curved toward apex. Prothorax more transverse than in *D. parallelocollis*, constricted in front, the apical emargination and basal bisinuation distinct; surface impressed behind apex and somewhat flattened, shining, the punctures sparse and not strong, the median line obsolete. Elytra feebly striato-punctate, shining, except

at the closely granulate base, with somewhat scattered granules, obsolete on the declivity, interstices with rows of distinct long dark hairs from middle to apex, the first with a single series of stronger granules. Legs piceous.

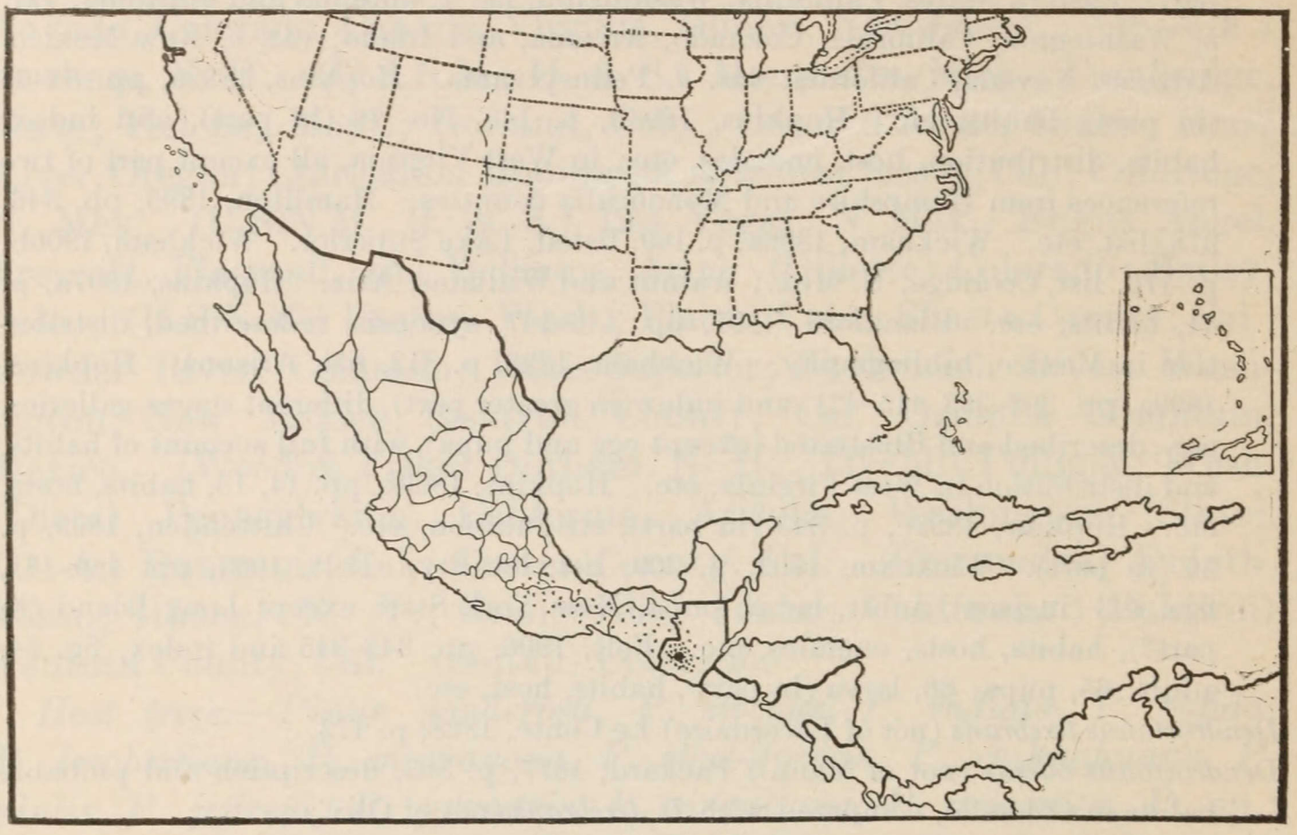

FIG. 95.—*Dendroctonus adjunctus:* Distribution map. (Original.)

"*Hab.* [See fig. 95.] Guatemala, Totonicapam (*Champion*).

"A distinct species, resembling a *Myelophilus* rather than a *Dendroctonus*. But two specimens were taken."

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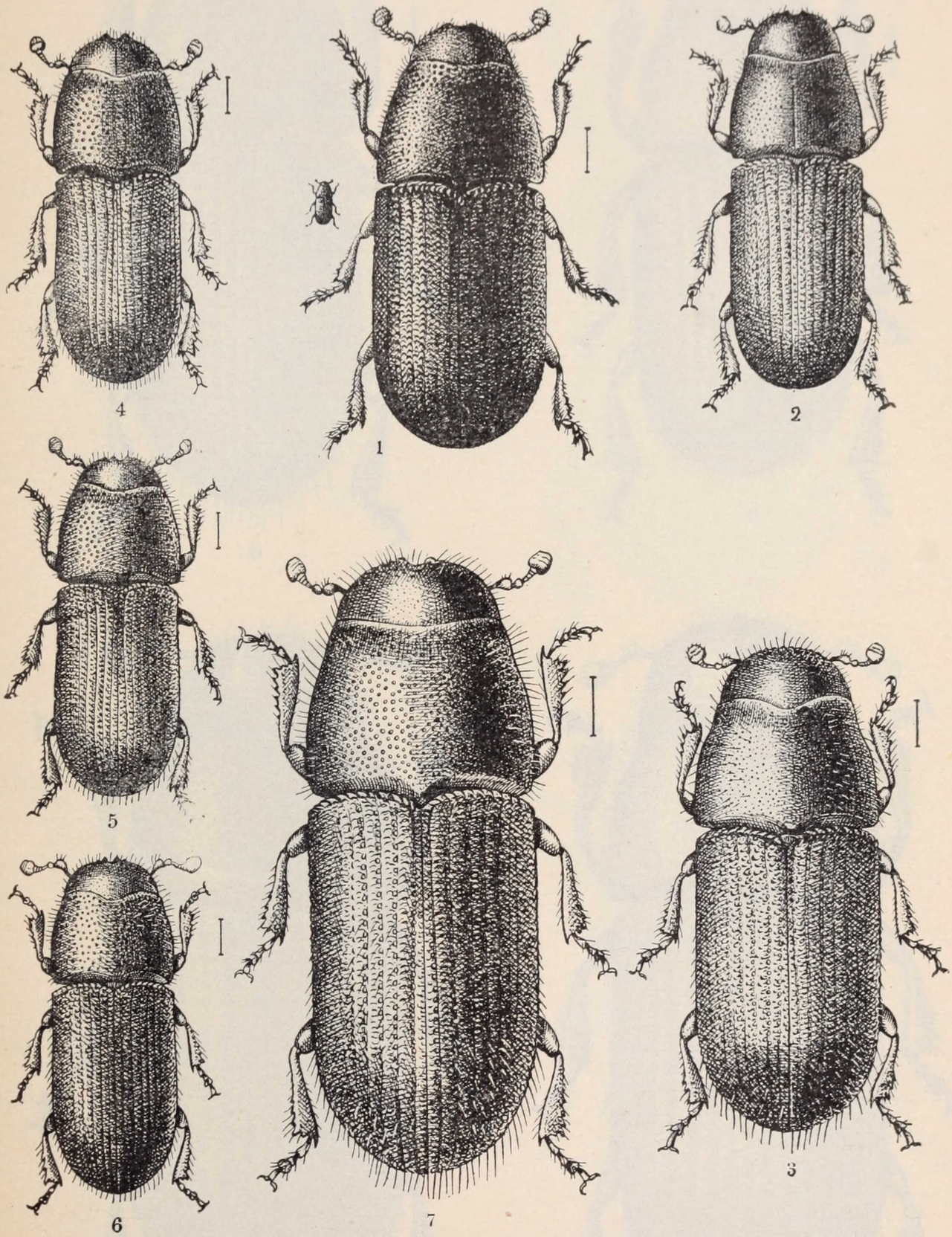
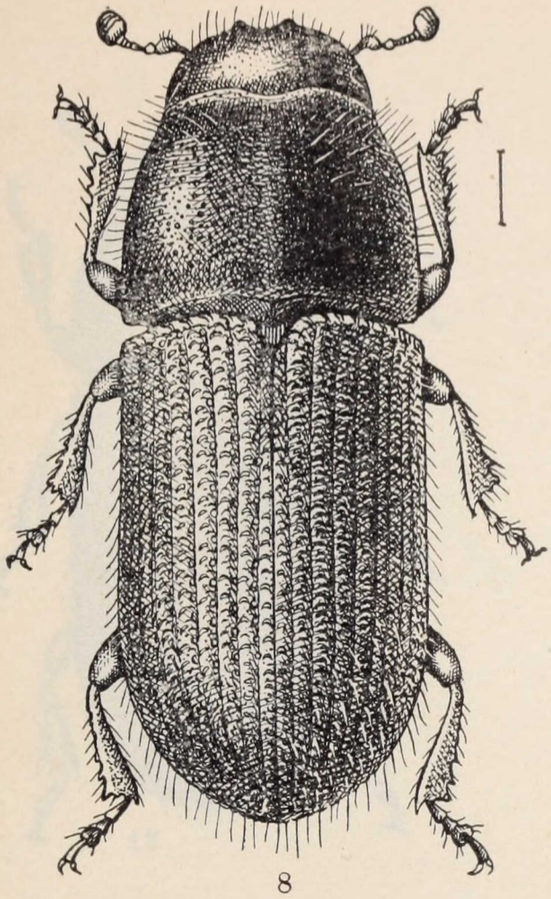


DENDROCTONUS ADULTS.

Fig. 1.—*D. brevicomis.* Fig. 2.—*D. barberi.* Fig. 3.—*D. convexifrons.* Fig. 4.—*D. frontalis.* Fig. 5.—*D. arizonicus.* Fig. 6.—*D. mexicanus.* Fig. 7.—*D. parallelocollis.* (Original.)



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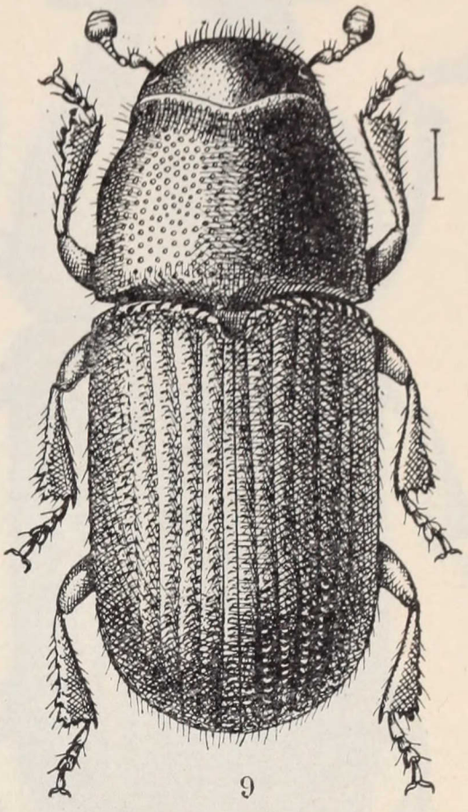

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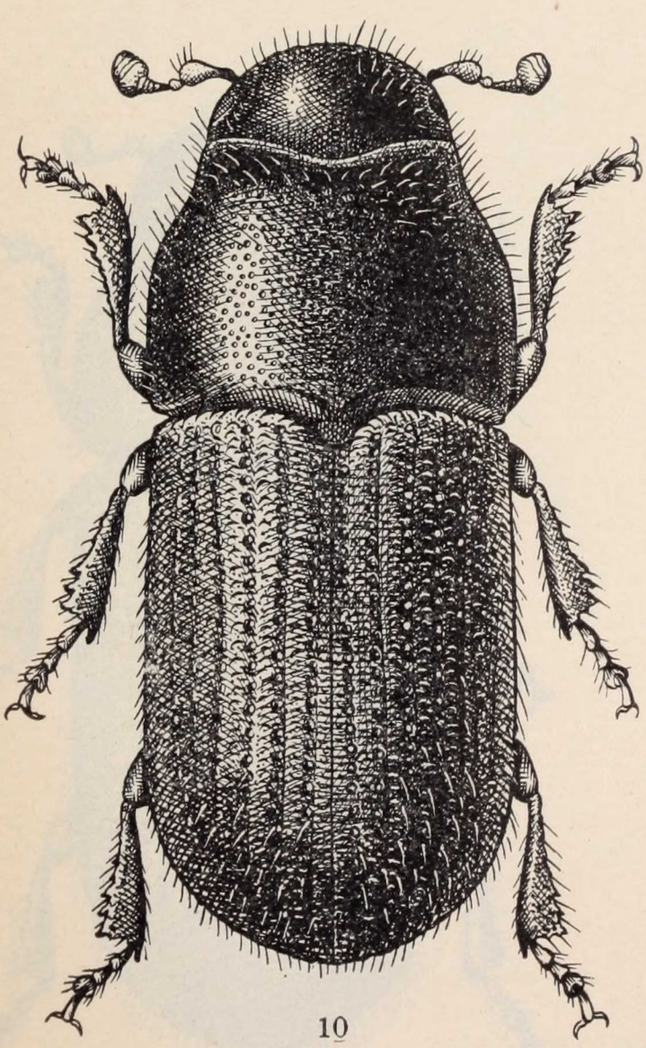

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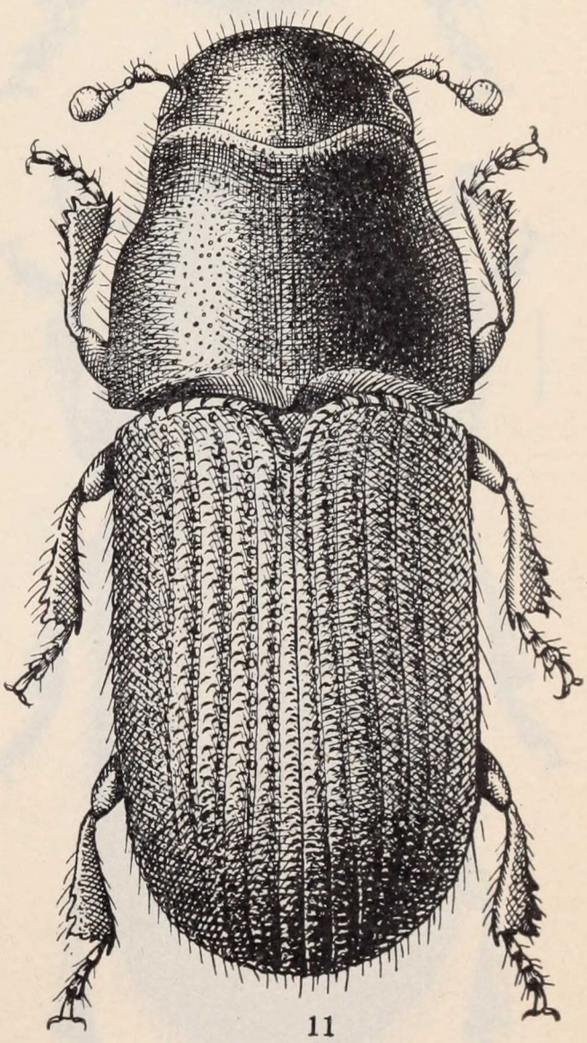

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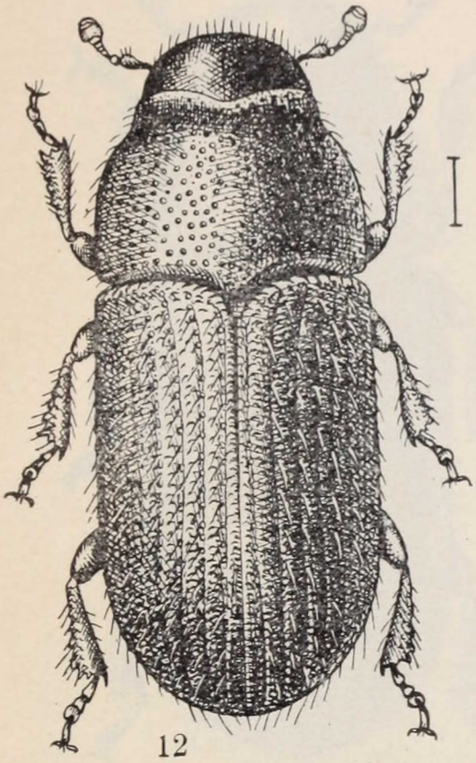
DENDROCTONUS ADULTS.

Fig. 8.—*D. approximatus.* Fig. 9.—*D. monticolæ.* Fig. 10.—*D. ponderosæ.* Fig. 11.—*D. jeffreyi.* (Original.)



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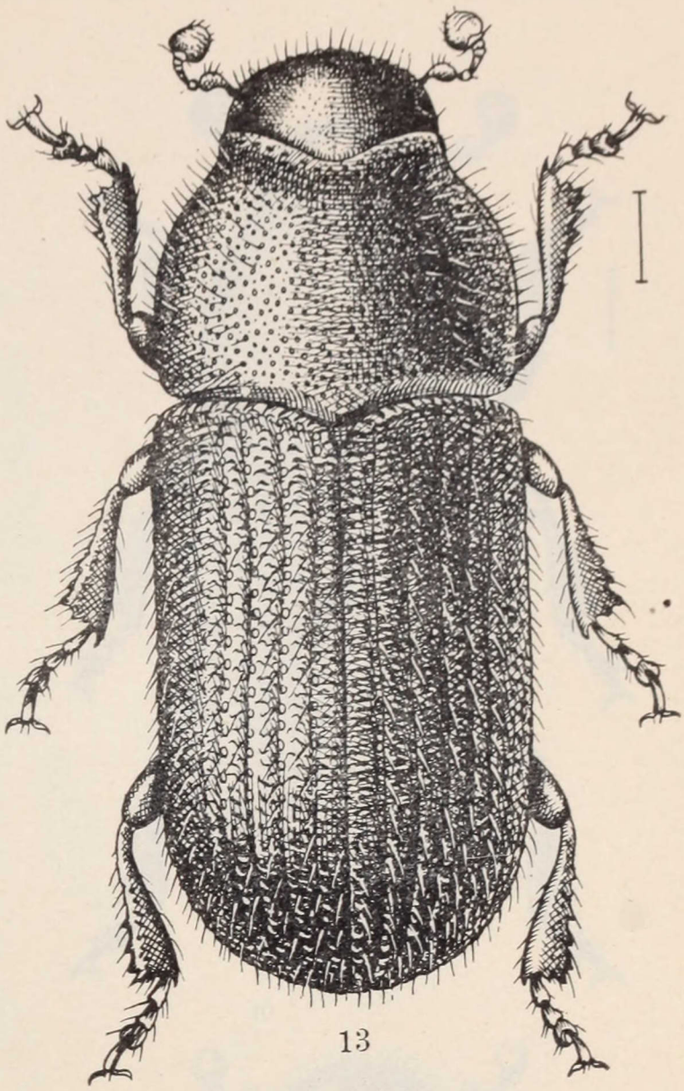

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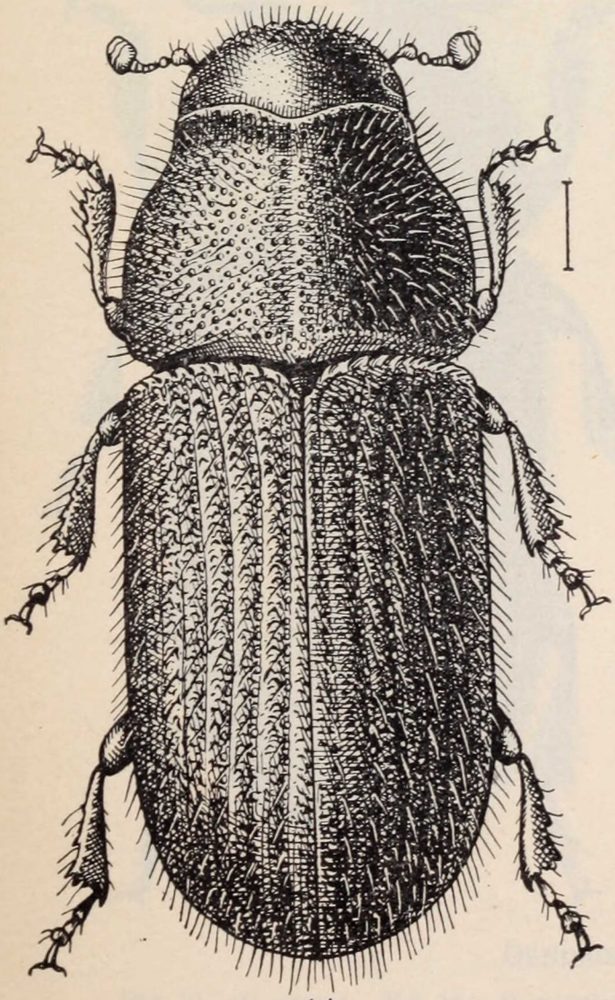

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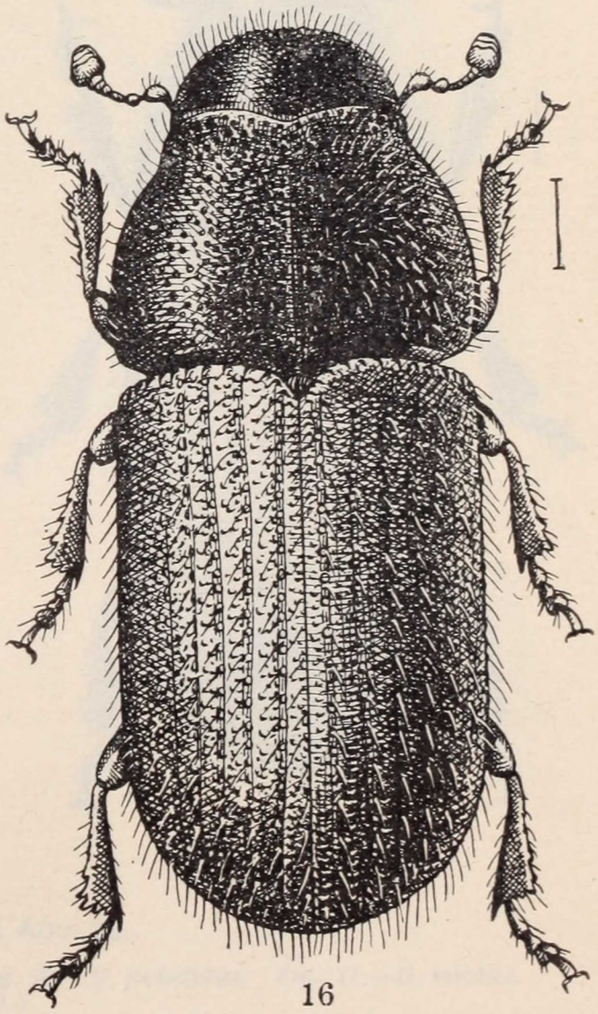

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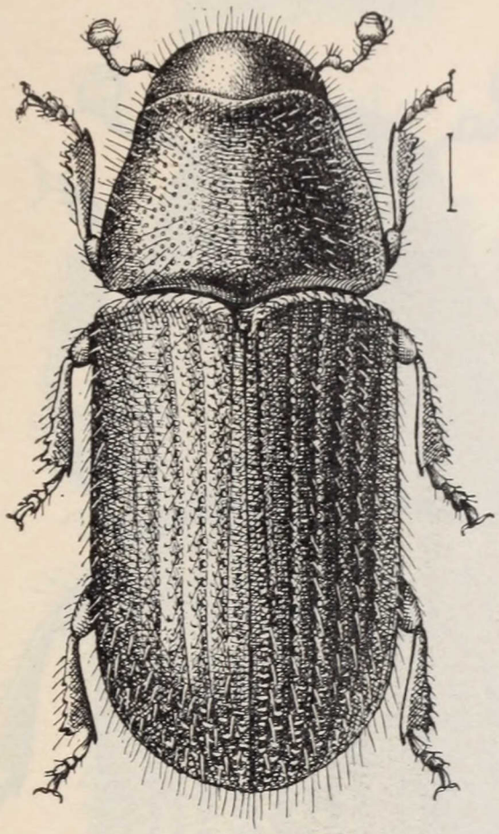
DENDROCTONUS ADULTS.

Fig. 12.—*D. simplex.* Fig. 13.—*D. pseudotsugæ.* Fig. 14.—*D. piceaperda.* Fig. 16.—*D. borealis.* (Original.)



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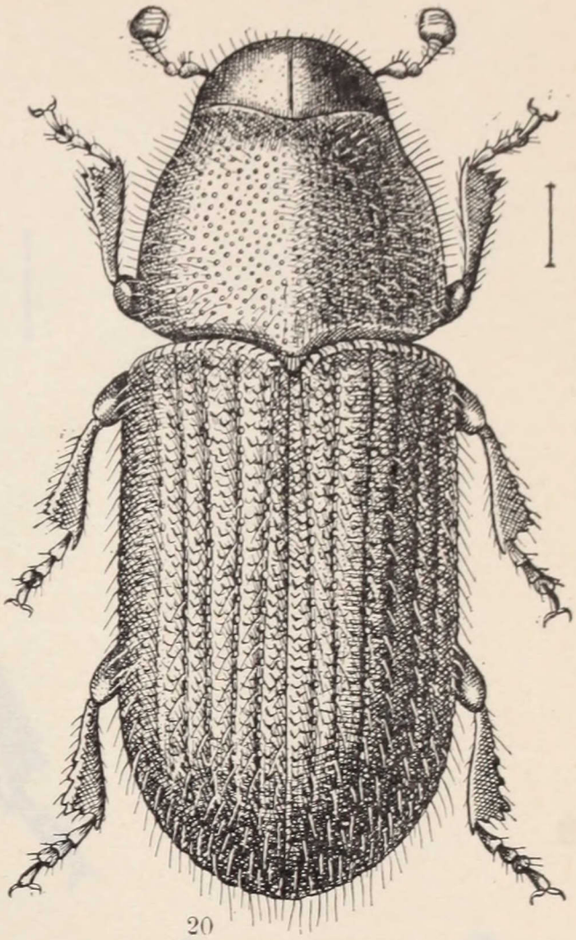

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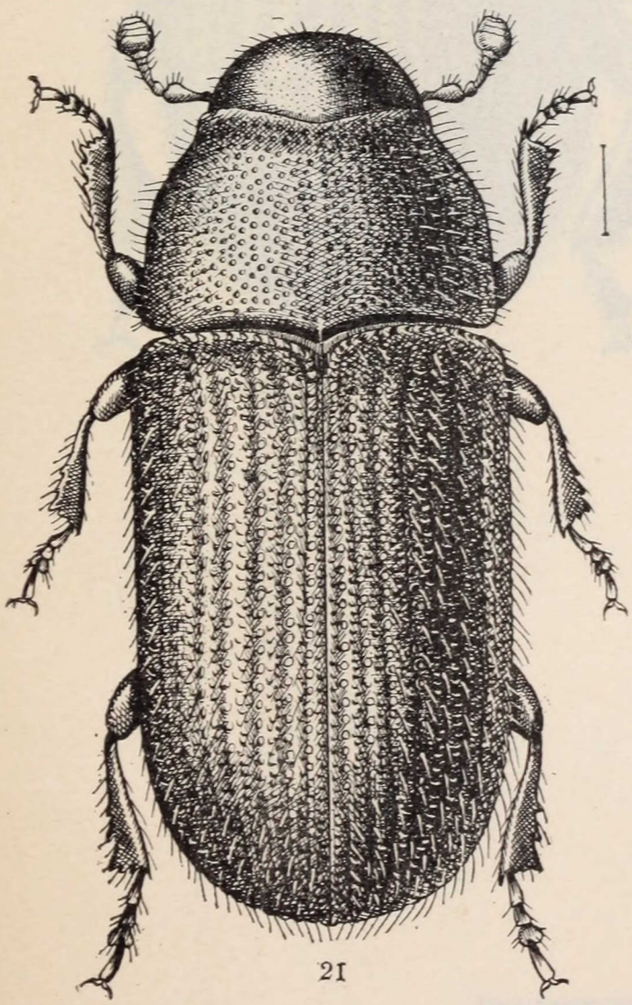

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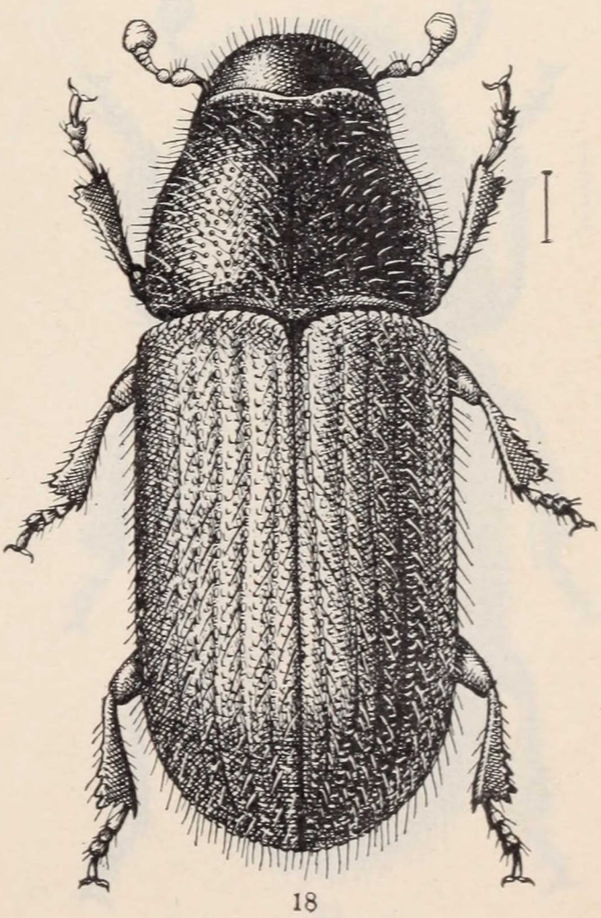

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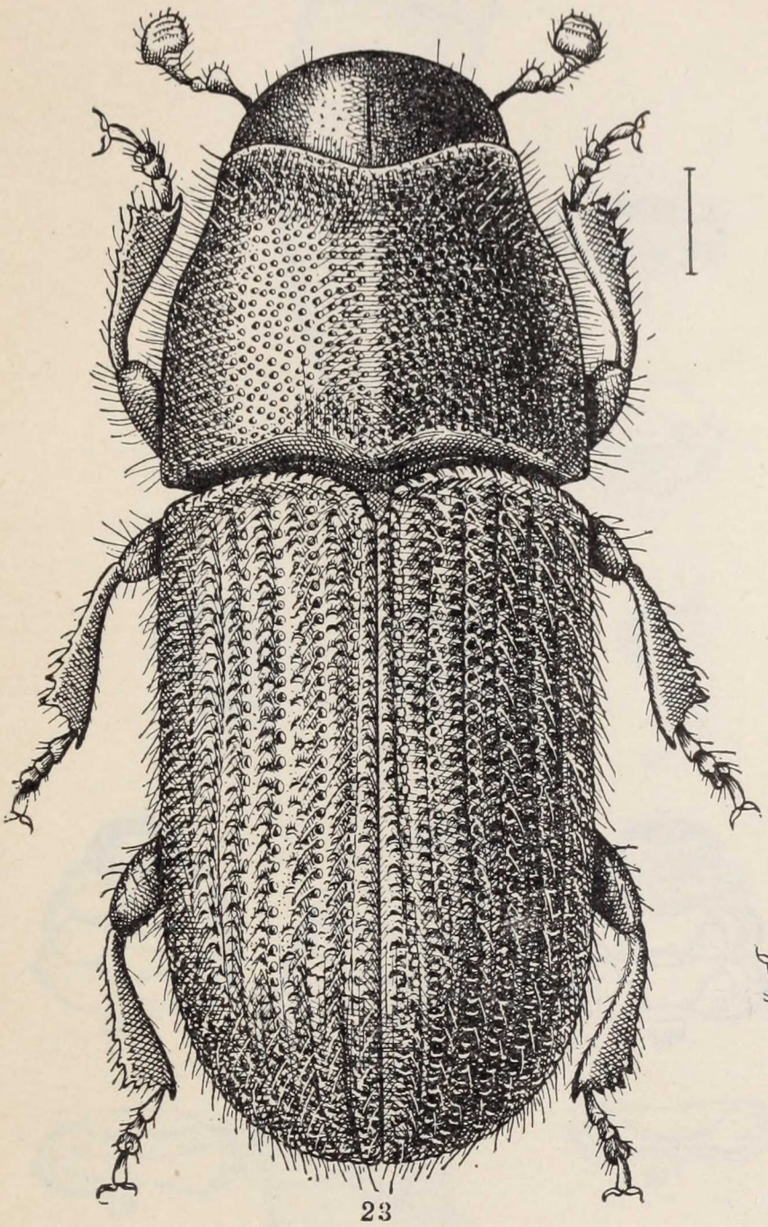
DENDROCTONUS ADULTS.

Fig. 17.—*D. obesus.* Fig. 18.—*D. rufipennis.* Fig. 20.—*D. punctatus.* Fig. 21.—*D. micans.* (Original.)



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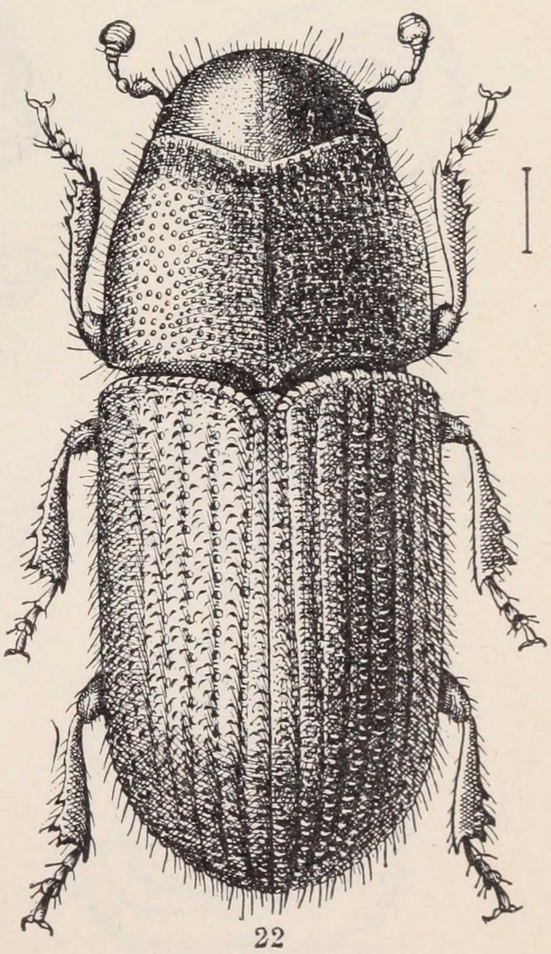

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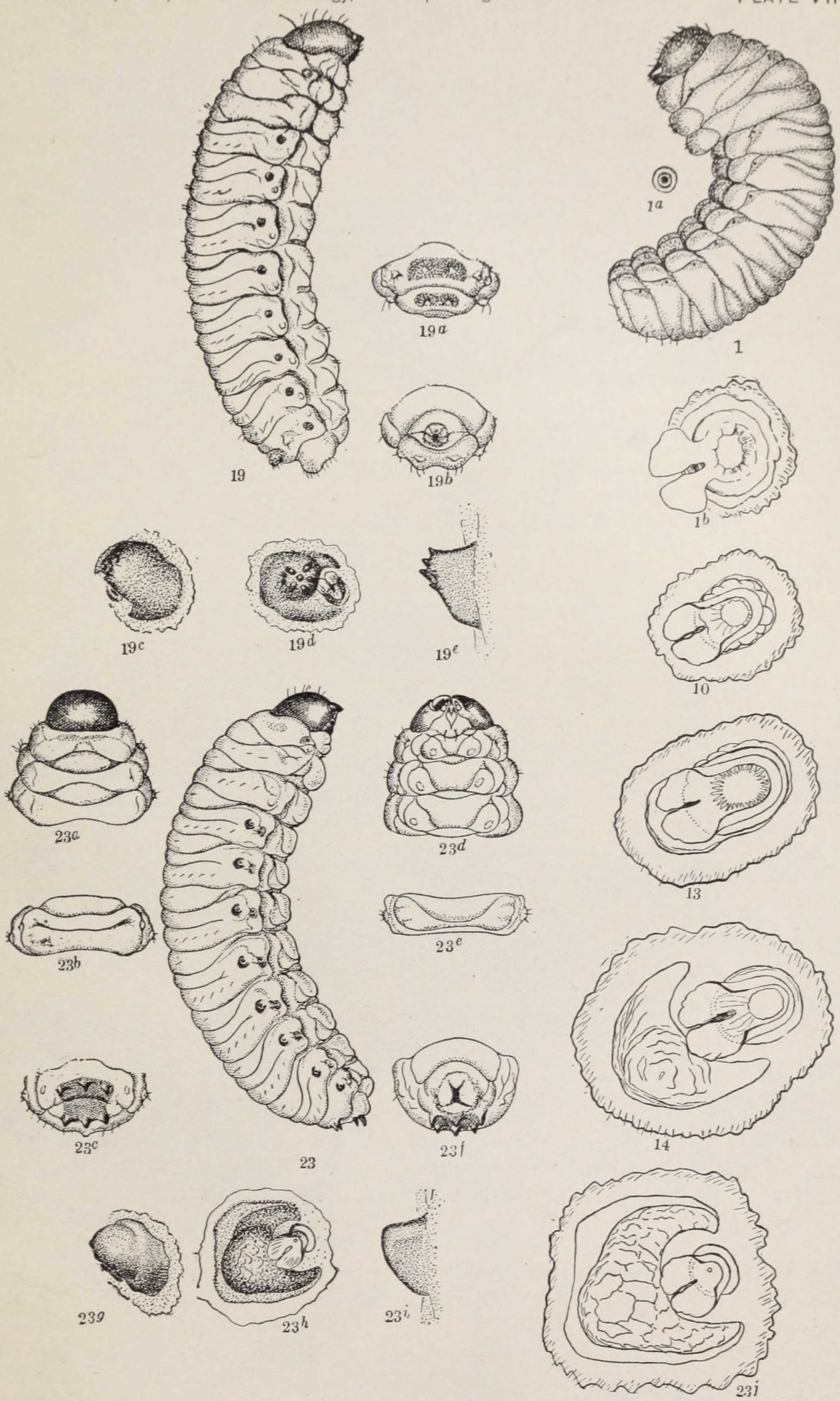
DENDROCTONUS ADULTS.

Fig. 22.—*D. terebrans.* Fig. 23.—*D. valens.* (Original.)



DENDROCTONUS LARVÆ.

Fig. 1.—*D. brevicomis;* 1*a*, spiracle, enlarged; 1*b*, spiracle, greatly enlarged, showing simple bifid processes. Fig. 10.—*D. ponderosæ*, spiracle, greatly enlarged. Fig. 13.—*D. pseudotsugæ*, spiracle, greatly enlarged. Fig. 14.—*D. piceaperda*, spiracle, greatly enlarged. Fig. 19.—*D. murrayanæ;* 19*a*, dorsal aspect of abdominal segments 8 and 9, showing plates; 19*b*, anal aspect; 19*c*, 19*d*, and 19*e*, different aspects of spiracular tubercle, much enlarged Fig. 23.—*D. valens;* 23*a*, dorsal aspect of thoracic segments; 23*b*, dorsal aspect of abdominal segments; 23*c*, dorsal aspect of abdominal segments 8 and 9, showing armed plates; 23*d*, ventral aspect of thoracic segments; 23*e*, ventral aspect of abdominal segment; 23*f*, anal aspect of abdominal segments 8, 9, and 10; 23*g*, 23*h*, 23*i*, different aspects of spiracular tubercles, moderately enlarged; 23*j*, spiracle and spiracular tubercle, greatly enlarged. (Original.)

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