BULLETIN OF THE CALIFORNIA INSECT SURVEY

VOLUME 16

THE BARK AND AMBROSIA BEETLES OF CALIFORNIA

Coleoptera: Scolytidae and Platypodidae

BY

D. E. BRIGHT, JR. and R. W. STARK

UNIVERSITY OF CALIFORNIA PRESS

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INTRODUCTION

THIS BULLETIN attempts to bring together in one source, keys, descriptive comments, distributional notes, host data, and biology of every species of Scolytidae and Platypodidae found within the state of California. More than 170 species in 44 genera are treated.

Scolytidae, commonly known as "bark and ambrosia beetles," are small, cylindrical insects which feed and reproduce in the tissues of living, dying, or recently dead trees and shrubs. They constitute the most serious threat to the forest industry in the United States and Canada. In view of their secluded habitat, these insects are infrequently collected by general collectors and subsequently are poorly known in much of the world. It is hoped that the information presented in this bulletin will aid in the study of this fascinating and important group of insects in California and adjacent regions.

The terminology utilized here is essentially the same as that used by Swaine (1918) and Wood (1951 to date).

The first comprehensive review of the bark beetles of North America was published in 1876 by LeConte and Horn. At that time, 127 species were recognized. In 1918, Swaine discussed the species occurring in Canada. Chamberlin (1939) brought together all the scattered species descriptions, revisions, and other taxonomic literature published up to that date. His work contains about 550 species and is still the only complete treatment of North American bark beetles. It is considered to be the starting point for recent research.

There has been considerable interest in the scolytids because of their economic importance. The bark beetles of North Carolina and Minnesota have been treated by Beal and Massey (1945) and Dodge (1938) respectively and most of the important genera have been revised or reviewed (Blackman 1928*b*, 1931*a*, *b*, 1934, 1938, 1940, 1941, 1942*a*, *b*; Bright 1963, 1967, 1968, 1969; Hopping 1963*b*, *c*, 1964, 1965*a*, *b*, *c*, *d*, *e*; S. L. Wood 1954*a*, 1961, 1963). Most of these publications have included Californian species and all but Hopping have described new species from California. Miscellaneous new species from California have been described by S. L. Wood (1964) and Bright (1964, 1966, 1967, and 1971). Wood (in Hatch, 1971*c*) has discussed the species occurring in the Pacific Northwest and also mentions those species that occur in California.

ECOLOGICAL AND ECONOMIC IMPORTANCE

The scolytid fauna of California is unusually rich in genera and species for an area the size of California in a predominantly temperate climate. The diversity of genera and species is due to the great physical and climatic variation and the large number of real and potential hosts which occur in the state. Munz and Keck (1959) recognize 11 vegetation types with 29 distinct plant communities, 26 of which contain woody shrubs, trees, or host records of scolytids. A conservative estimate of potential hosts exceeds 400 species.

No other state has such extreme ranges of physical conditions. Elevations range from 90 meters below sea level in Death Valley to about 4,800 meters above sea level at Mt. Whitney only a few miles away. Two great

series of mountain ranges, the Coast Ranges and the Sierra Nevada extend almost the entire length of the state. The southern end of the Cascade Range extends into northern California.

The climate is affected by most western air mass systems, e.g., polar maritime, tropical maritime, polar continental, and continental. Frost-free days range from 365 near the coast to fewer than 100 at elevations above 2,000 meters. Rainfall ranges from less than 5 cm in Death Valley to more than 275 cm in Del Norte County. Scolytids are found in almost all such environments—wherever woody plants can survive.

Ecological Importance

The scolytid fauna is of particular importance in the evolution of forest stands. In an undisturbed forest succession they commonly feed upon and kill the excess plants in the stand. It is only when such stands reach a climax stage and become decadent from a predominance of overmature trees that natural "outbreaks" occur. This results in a release of the understory and a new phase of succession begins.

Many scolytids also aid in the recycling process necessary for maintenance of forest soils and plant succession. They do this by their physical activities of tunnelling and reducing a significant portion of the fiber to a more readily decomposable form; by changing the state of the wood so that other insects can further reduce it; by introducing pathogens which further enhance the decomposition process; and by accelerating the effect of physical factors such as temperature and moisture.

Bark and ambrosia beetles are an important link in food chains. They play host to a vast array of entomophagous insects, mites, and nematodes and are an important source of food for many vertebrates, principally birds and small mammals. They are an integral part of faunal ecosystems and contribute to the stability of plant communities as much as or more than they contribute to instability.

Economic Importance

Much has been written about the destruction of forest resources by bark and ambrosia beetles. Annual "loss" figures are published citing billions of board feet of timber destroyed with "values" usually in the millions of dollars. The majority of such estimates are inflated, for most trees of commercial size, if salvaged promptly, lose little market value.

However, bark beetle outbreaks do destroy vast supplies of timber which cannot be salvaged, or which cannot be absorbed into the economy and these are real resource losses. The southern pine beetle, in the southeastern United States, and the mountain pine, western pine, Douglas-fir, and Engelmann spruce beetles in the western states are capable of great local and regional destruction.

Such outbreaks may occur naturally in mature and overmature forests initiated by such predisposing events as fire, windthrow, and flooding, but most are, directly or indirectly, man-caused. Poor logging and management practices, urbanization, air, water, and soil pollution, and other abuses all predispose trees and forests to bark beetle outbreaks.

Logging, without appropriate attention to prevention of spread of root diseases, has resulted in an increase in intensity and distribution of root pathogens. The debilitating effect of root pathogens on shrubs and trees has apparently made them more susceptible (or less resistant) to attack by bark beetles. Given an increase in a suitable habitat or food source the beetle populations increase in numbers until they exceed the predisposed supply and attack "healthy" plants in the outbreak phase.

Management of Scolytid Populations

The concept of pest management is slowly replacing the "insect control" philosophy. Bark beetle control in the past, and to a large degree today, has relied upon removal of infested trees and destruction of the infested portion or felling infested trees and destroying them or spraying with an insecticide such as lindane or benzene hexachloride (BHC). That such treatments kill bark beetles has been well established and probably has a temporary local effect in reducing pest numbers. However, the value of such endeavors over large forested areas and for long-term population regulation is questionable.

Under the concept of pest management, two principal means of regulating a bark beetle population will emerge—prevention and the use of an integrated control system. Prevention, well known but largely ignored, basically consists of avoiding those practices which weaken trees or plants and practicing good forest management so that stands are vigorous and healthy. Consideration is given to such matters as the optimum number of plants that can be grown on a given site to minimize competition for nutrients and space, selection of the tree best suited to a particular site, harvesting at an age when the tree is still vigorous—prior to decline in vigor due to overmaturity—and other forestry practices. In noncommercial or unmanaged areas such as primitive or wilderness areas, such treatments should

not be used and should usually not pose a severe threat to surrounding well-managed stands.

Where treatment is necessary, an integrated control system offers the greatest potential for reducing populations. An integrated control system utilizes all means of population suppression that are compatible and which will cause the least disruption to the ecosystem. For example, a system might consist of heavy cutting in an area known to be a chronic center of beetles, stump and soil treatment to prevent invasion by root pathogens, trapping of flying beetle populations using chemical attractants, encouragement of woodpecker populations by leaving a suitable number of nesting trees or using artificial nesting boxes, and introduction of mass-reared parasites or predators, or both. Simultaneously the nutrient value and water capacity of the soil would be determined and depending on the findings, fertilization, soil amelioration, draining, or irrigation may be considered.

The use of these methods demands a thorough knowledge of the bionomics of the particular species of scolytid involved.

BIONOMICS

The biology and ecology of relatively few species of Scolytidae have been studied in any great detail. The genera *Dendroctonus, Scolytus, Ips, Phloeosinus,* and *Pseudohylesinus* have been the subjects of detailed studies, primarily because of their economic importance. Data on the bionomics of species in the remaining genera are usually confined to a knowledge of the gallery pattern or the host or both.

All members of the family, with a few exceptions, feed and reproduce in the cambium region (true bark beetles) or deep in the wood (ambrosia beetles) of dying, injured, or fallen trees and shrubs. The majority of Californian species attack forest trees, of which the conifers are preferred hosts. Other hosts such as nuts and cones serve as breeding places for the few exceptions.

All woody parts of a tree are attacked, but beetles of each genus generally restrict their activities to a particular portion. For example, *Pityophthorus* and *Myeloborus* are found in smaller branches and twigs; *Conophthorus* in the cones; *Ips* in the larger branches, bole, and tops; *Dendroctonus* is found only in the bole and sometimes in the roots and *Hylurgops* and *Hylastes* are most often found in the lower portions and roots. Species in all these genera may be found in a single pine tree.

After selecting a suitable location, usually under a bark scale, under moss or lichens, or in a bark crevice, the beetle bores a hole, generally at a slight upward angle, directly into the cambium region. In the case of ambrosia beetles, the adult bores directly into the wood for a distance of several centimeters. The first evidence of attack is the appearance of reddish or whitish boring dust or pitch tubes under or around each entrance hole.

Both monogamy and polygamy are characteristic conditions, depending on the genus involved. In all known cases of polygamy, the male initiates the entrance hole and is subsequently joined by three to five females. In the case of monogamous species, the female makes the initial attack and is joined by the male. Mating may take place in the gallery, on the surface of the host plant, or before the insects leave the host plant of the parents.

Females of true bark beetles tunnel away from the entrance hole in the cambium region and lay eggs singly or in groups along the gallery. The eggs may be laid in specially constructed niches along the gallery wall or scattered in the boring dust along the gallery. Females of the ambrosia beetles lay eggs scattered along the gallery or in niches.

The larvae of true bark beetles generally mine at right angles to the parent gallery and may or may not engrave the sapwood. The larval mines may continue in a straight line or curve in various directions. Later instars usually mine with the grain of the wood.

Adult galleries may be packed with frass and boring dust (e.g., *Dendroctonus*) or kept clean, the frass being pushed out the entrance hole (e.g., *Ips*). Larval mines are always packed with frass. Some species mine entirely in the inner bark and the larval mines are exposed when the bark is removed. Others may mine for a short period in the inner bark, then complete their feeding in the outer bark, while other species feed entirely in the outer bark. The larval mines may be straight and very regular or they may be very irregular and meandering. However, they rarely cross one another unless the beetles are crowded. In those species which lay their eggs en masse in grooves or cavities, the larvae frequently extend their borings as a group, forming an enlarged chamber without distinct larval mines; or the mines may be contiguous at first, becoming separated in later instars. The larvae of ambrosia beetles feed in larval "cradles" constructed by the parent beetle.

Pupation occurs in enlarged cells at the end of the larval mines in the inner bark, in the cambium region, in the outer bark or, in the case of ambrosia beetles, in the cradles or in the open mines. Most emerging beetles exit individually, boring their own exit hole which often results in characteristic patterns on the bark. New adults of ambrosia beetles generally exit through the parental entrance galleries.

The number of generations per year varies considerably depending on the species involved and the climatic

factors of its habitat. One to two generations per year seem to be most common with more in the lower elevations and the south and fewer in the higher elevations and in the north.

Galleries

A characteristic and most interesting part of scolytid biology is the adult egg gallery under the bark (figs. 1–28). In uncrowded conditions these galleries are often very symmetrical and interesting in appearance. The galleries may be so characteristic in the family that one familiar with gallery patterns can readily identify the genus, or in some cases the species, responsible for the work.

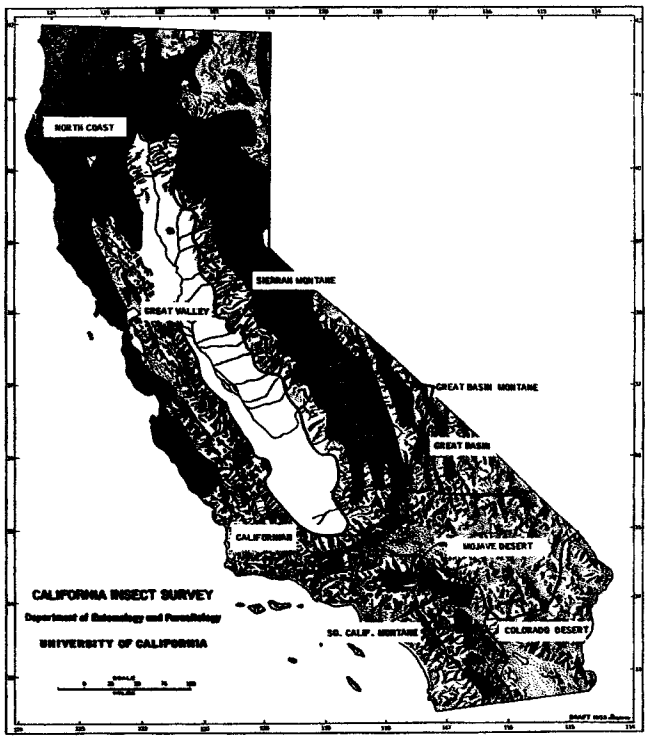
Several analyses of the gallery patterns are available (Beal and Massey, 1945; Chamberlin, 1939, 1958; Swaine, 1918; Traghardh, 1930). All these authors use essentially the same terminology in discussing the various types of galleries.

Three types of ambrosia beetle galleries are found in the California forests. These are: cave type (*Xyleborus*), simple tunnel (*Platypus*, fig. 1), and the compound tunnel (*Trypodendron*, fig. 20, *Gnathotrichus*, figs. 1, 28, and *Monarthrum*, fig. 27). All these tunnels are excavated in the wood. The cave type is merely an enlarged chamber; the simple tunnel goes directly into the wood and has no side tunnels and the compound type is a branched tunnel which contains individual cells or cradles in which the larvae develop.

Eight types of galleries can be recognized as the work of the true bark beetles. These are: cave type (*Dendroctonus valens*); radiate or star-shaped type (*Ips*, figs. 22, 23, *Pityophthorus*, fig. 26, *Carphoborus*, *Dryocoetes*, *Orthotomicus* and others); forked type (*Scolytus ventralis*, fig. 3, *Alniphagus aspericollis*, fig. 10, various species of *Pseudohylesinus*, figs. 7, 8, and others); simple longitudinal or transverse (*Phloeosinus*, figs. 11–15, *Scolytus unispinosus*, fig. 4, *Dendroctonus ponderosae*, fig. 6, and others); irregular elongate tunnels (*Dendroctonus brevicomis*, fig. 5); pith tunnels (*Myeloborus* and some *Pityophthorus*, fig. 26); wood tunnels (*Micracis* and *Hylocurus*); and cone tunnels (*Conophthorus*). No attempt will be made to describe each type in detail since they have been adequately treated by the authors mentioned above.

DISTRIBUTION

Among the 44 genera discussed in this paper, more than 170 species occur within the state. This is an unusually high number of species for an area the size of California in the temperate region. As an indication of the relative wealth of species, it may be noted that Japan and India, both areas rich in Scolytidae, each have barely 200 species (Browne, 1961). About 30 percent of the total number of species for North America are represented in California. This high percentage reflects the diverse ecology and topography of the state.



Map 1. Boreal (dark stippled) and austral (light stippled) regions showing the biotic subdivisions occupied by bark beetles shown in table 1.

The desert area of the southern part of the state with its disjunct mountain ranges and high degree of floral endemism is of special interest. This area produces most of the endemic genera and species of Scolytidae found in the state. The northern portion of the state and the forested regions of the Sierra Nevada contain genera with a boreal distribution, and most of these are also Holarctic. This is the same fauna, with few exceptions, that occurs in the Pacific Northwest.

In order to discuss adequately the distribution of species within California, the biotic areas presented by Miller (1951) and utilized by Hurd and Michener (1955) have been adopted. The terminology utilized here is essentially the same as that used by Hurd and Michener. They recognize two broad faunal areas in the state—boreal and austral. The boreal region includes all the forested portions of the coast, the Sierra Nevada, and the isolated mountain ranges of southern California. The boreal region is further divided into the North Coast, Sierran Montane, Southern California Montane,

and Great Basin Montane. The austral region includes the desert and foothill areas of southern California and the Great Valley and is divided into the Great Basin, Mojave Desert, Colorado Desert, Californian, and Great Valley.

Boreal Region

The boreal fauna is well represented in the northern mountainous part of the state and continues southward along the Coast Range, the Sierra Nevada, the San Bernardino Mountains, the San Jacinto Mountains, and into the Sierra San Pedro Martir of Baja California. The principal host trees are the various species of pines and firs. Characteristic genera of the boreal fauna are: *Carphoborus* (pines), *Scolytus* (firs), *Dendroctonus* (pines), *Crypturgus* (pines), *Hylurgops* (pines), *Hylastes* (pines), *Trypodendron* (all hosts), *Gnathotrichus* (all hosts), *Pityogenes* (pines), *Ips* (pines), *Pityokteines* (firs) and *Orthotomicus* (pines). All of these genera except *Gnathotrichus* are Holarctic. There are no endemic genera in the boreal region of California.

The North Coast subdivision, as a whole, contains only a few endemic species, with the exception of the Monterey Bay area. Such species as *Scolytus dentatus* Bright, *Carphoborus radiatae* Swaine, and *Pityophthorus setosus* Blackman are endemic species of the Monterey region. The only other known endemic of the north coast is *Pityophthorus tumidus* Blackman.

The Sierran Montane subdivision contains four known endemic species plus three other species that are suspected endemics. The endemic species are *Dendroctonus jeffreyi* Hopkins (which extends into the Southern California Montane), *Carphoborus declivis* Wood, *Pityophthorus sierraensis* Bright and *P. inyoensis* Bright. The three suspected endemics are *Pityophthorus serratus* Swaine, *P. dolus* Wood, and *P. absonus* Blackman.

The Southern California Montane subdivision is simply an extension of the Sierran Montane and occurs on the isolated mountain ranges of southern California. Because of this, it contains few endemics. At the present time, the only species that can be considered endemic is *Cactopinus pini* Blackman. Three rather rare and little-known species of *Pityophthorus* are known only from this area, but are suspected to have a broader range.

The final subdivision of the boreal region is the Great Basin Montane. This is the smallest subdivision and occurs only in the White and Inyo Mountains of Mono and Inyo counties. It contains one known endemic, *Carphoborus tuberculatus* Bright, associated with *Pinus aristata.*

Austral Region

The austral region is the most interesting and diverse region within the state. It includes areas of wide ecological differences with a high degree of endemism, both at the generic and specific level. This region includes all of the area below the lowest level of the coniferous forest and is divided into the five subdivisions mentioned above.

The austral flora is composed of desert chaparral or desert trees such as *Quercus*, *Cupressus*, *Bursera*, and *Salix*. Characteristic scolytid genera present in this broad area are: *Chaetophloeus*, *Cactopinus*, *Stenoclyptes*, *Pseudothysanoes*, *Hypothenemus*, *Ancyloderes*, *Dendrocranulus*, *Hylocurus*, *Micracis*, *Phloeosinus*, and *Monarthrum*. All these genera, with the possible exception of *Phloeosinus*, could be considered Neotropical derivatives. *Stenoclyptes*, with two species, is the only endemic genus.

The Colorado Desert subdivision contains only a few known species. *Cactopinus desertus* Bright and *Dendroterus striatus* (Leconte), associated with the desert tree, *Bursera*, and *Myeloborus keeni* Blackman, associated with the pinyon pine, are the most interesting. Undoubtedly other species of Scolytidae occur in the Colorado Desert subdivision but the area is very poorly collected and the fauna is not well known.

The largest and most ecologically diverse part of the austral zone is the Californian subdivision. It encompasses the oak-grassland regions of the foothills of the Sierra Nevada and central coast mountains and extends into the chaparral areas of southern California. Because of the great diversity of habitats, this area is highest in the number of endemic species of Scolytidae. Six endemic species of *Phloeosinus* are associated with various endemic species of *Cupressus*. Other endemics are: *Carphoborus blaisdelli* Swaine (in Big-cone Spruce, *Pseudotsuga macrocarpa*), *Chaetophloeus hystrix* (Leconte) and *C. maclayi* (Bruck) (in shrubs), *Cactopinus rhois* Blackman and *Stenocleptes rhois* Blackman (in *Rhus*), *S. sulcatus* (Bruck) (in *Ceanothus*), *Pseudothysanoes hopkinsi* Blackman (in *Fremontodendron*), *P. bartoni* Bruck (in *Malacothamnus*), *Hylocurus hirtellus* (Leconte) (in various trees and shrubs), *Dendrocranulus californicus* (Hopkins) (in wild gourd), *Pseudopityophtorus agrifolia* Blackman and *Monarthrum dentiger* (Leconte) (in oak).

The Great Basin, Mojave Desert, and the Great Valley subdivisions of the austral region can be disregarded in this discussion since they contain no presently recognized endemic species.

Of the more than 170 species treated in this work, 50 are known or thought to be endemic. There are pres-

ently sufficient data available to regard 40 to 45 species as true endemics. The remainder may be unrecognized synonyms of more widespread species or may actually occur in areas outside the state. This represents nearly 30 percent of the total scolytid fauna, a high percentage for any area. Several explanations for this can be given, the most obvious of which is poor collecting.

Table I shows the distribution in California of species of the two families treated here. An "x" indicates that at least one species in the particular genus occurs in the subdivision. The number of species occurring in each area has not been given due to the difficulty of placing species because of generally scanty evidence.

MORPHOLOGY

The following section reviews most of the terms used in this Bulletin and briefly discusses the types of variation found in the California members of the family. Only those terms used in the keys or likely to cause confusion are included.

HEAD (fig. 29)

Frons.—The frons is not readily defined by visible lines or sutures but is used to distinguish the area between the frontal sutures. It may be concave or convex and is variously ornamented with punctures, carinae, setae, or other modifications. It is of special value in the classification of the scolytids since it presents characters useful in distinguishing major and minor divisions, species, and sexes.

Epistoma.—The epistoma is represented in scolytids by a thickened, more heavily sclerotized region below the frons. It serves as a rigid support for the articulation of the mouthparts. It, like the frons, may be ornamented with various structures. The *epistomal process*, seen in *Dendroctonus* and several other genera, is on the upper margin of the epistoma. The *median lobe*, most prominent in *Dendroctonus*, is variably developed. The *epistomal margin* usually bears a fringe of stiff light-colored setae.

Eyes.—The eyes are usually elongate-oval and are placed on the side of the head just posterior to the antennal insertions. In most genera and species a slight to deep emargination is present on the front margin. In *Trypodendron*, this emargination is so deep as to appear to completely divide the eye.

Antennae.—The antennal regions are illustrated (fig. 31). The *scape* is generally club-shaped except in *Micracis* (fig. 49) and related genera in which case it is roughly triangular. The funicle varies from 1- to 7-

TABLE 1

DISTRIBUTION IN CALIFORNIA OF SPECIES IN THE GENERA OF SCOLYTIDAE AND PLATYPODIDAE

(x's indicate occurrence of species in each area)

			Boreal				*Austral*	
Genera	*North America, north of Mexico species*	*Californian species*	*North Coast*	*Sierran Montane*	*Southern Californian Montane*	*Great Basin Montane*	*Colorado Desert*	*Californian*
Scolytidae:								
Alniphagus	2	2	x	x	x			x
Ancylocleres	1	1			x			
Cactopinus	5	4			x		x	x
Carphoborus	19	10	x	x	x	x		x
Chaetophloeus	9	7		x	x			x
Chramesus	9	2						x
Coccotrypes	2	1						x
Conophthorus	16	7	x	x	x	x		
Cryphalus	4	2		x	x			
Crypturgus	3	1	x					
Dendrocranulus	6	1						x
Dendroctonus	15	6	x	x	x	?		
Dendroterus	2	1					x	
Dolurgus	1	1	x					
Dryocoetes	7	1	x	x				
Gnathotrichus	6	2	x	x	x			
Hylastes	21	6	x	x	x	?		
Hylastinus	1	1						x
Hylocurus	13	2					x	x
Hylurgops	7	5	x	x	x	?		
Hypothenemus	81	2					x	x
Ips	27	13	x	x	x	x		
Leperisinus	8	1						x
Micracis	8	1						x
Monarthrum	5	2	x					x
Myeloborus	8	2		x	x?	x?	x	
Orthotomicus	2	1	x	x	x			
Phloeosinus	23	14	x	x	x			x
Pityogenes	6	3	x	x	x	x?		
Pityokteines	4	3	x	x	x			
Pityophthorus	121(?)	33	x	x	x	x	?	x
Procryphalus	3	1		x	x			
Pseudohylesinus	9	7	x	x	x			
Pseudopityophthorus	8	3	x	x	x			x
Pseudothysanoes	13	2						x
Scierus	2	1	x					
Scolytus	22	11	x	x	x			x
Stenoclyptes	2	2						x
Taenioglyptes	4	2	x	x	?			
Thysanoes	9	1						x
Trypodendron	5	3	x	x	x			
Xyleborus	18	3	x	x	x			x?
Xylechinus	2	1	x					
Platypodidae:								
Platypus	7	1	x	x	x			
Totals	546	176						

segmented and is frequently used in classification. The *club* is extremely variable and is one of the most useful structures used in classification. It may be regularly segmented with transverse or arcuate sutures on both sides (*Pityophthorus*, figs. 62–64) or the inner margins of the segments may be thrust toward or to the apex of the club so that the segments lie obliquely and the sutures are visible only at the apex or not at all on the inner face (*Ips*, figs. 56–57) or the club may be thickened at the base with the apical segments more or less telescoped producing the obliquely truncate club (*Xyleborus*, *Dryocoetes*, etc., figs. 54, 55). In the genera *Pseudopityophthorus* (fig. 61), *Pityophthorus* (figs. 62–64), *Ancyloderes* and *Gnathotrichus* (figs. 65–66), the sutures of the club are strongly chitinized, resulting in more or less distinctly visible septa. In *Chramesus* (figs. 41–43) the club is unsegmented.

Thorax (figs. 29, 30)

Pronotum.—The pronotum is the dorsal area of the prothorax. There is considerable specific variation in its structure, sculpture, and relative proportions. The anterior margin may or may not bear serrations. A lateral and/or basal line may or may not be present. The *disk* is the central area of the pronotum and is the region most frequently used in classification.

Legs.—The tibiae and tarsi offer several modifications of value in classification (figs. 32–34). A major character separating the Scolytini from other scolytid tribes is the presence of a large curved spine on the upper apical angle (fig. 32). The presence of elongate tarsal and tibial hairs is a secondary sexual character in some genera. The shape of the fore tibia is important in separating the Xyleborini and Micracini from other tribes, and the presence of tubercles scattered over the outer face of the anterior tibia will separate the Corthylini from the Pityophthorini.

Elytra.—The elytra are extremely variable in structure and sculpture. The *elytral striae* are usually punctured in rows; the spaces between the rows are the *elytral interspaces*. For use in classification they are numbered, beginning with those next to the dorsal suture when the elytra are closed. The first interspace is sometimes called the *sutural interspace*. There are 11 interspaces and 10 striae. The interspaces are quite variable in width and sculpture, bearing *interstrial punctures, setae, tubercles,* and the like. The *strial punctures* are almost always visible but they may be obsolete and may or may not be in regular rows. The *elytral suture*, the junction of the elytra along the dorsum, is frequently elevated by the convexities of the first or sutural interspace. The posterior portion of the elytra that descends to the apex is the *elytral declivity*. This area, and the antennal club, are the most important areas used in the classification of the Scolytidae. The declivity is usually steep, sometimes truncate or concave, and may be smooth and unarmed as in *Dryocoetes* or may bear spines, teeth, tubercles, or special pubescence in all forms of variation imaginable. The declivity is absent in *Scolytus*.

Metepisternum (fig. 39).—This is a plate having the shape of a narrow triangle with the base facing forward. It is completely visible (fig. 29) in all genera except those in the tribes Pityophthorini and Corthylini (fig. 30). In these two tribes, the elytra, when closed, extend ventrad to a greater degree than in other scolytids and completely cover at least the posterior two-thirds of the metepisternum.

Abdomen (fig. 29)

The abdomen is not generally used in the classification of the Scolytidae except to separate the tribe Scolytini from the remainder of the scolytids. In this tribe, the elytra are nearly flat and the ventral sternites of the abdomen ascend to meet them. The five visible sternites vary in the degree of fusion, relative length, and convexity. The last sternite may be modified in some genera. It is generally considered that the first two sternites are fused and hidden in the metacoxal cavities; in this Bulletin the five visible segments are numbered 1 to 5.

METHODS

Only those species of Scolytidae which have been collected within the borders of California are included in this Bulletin.

The genera are arranged in the order they appear in the key to genera. For each genus the following information is given: reference to original description; type species; diagnostic characters; an indication of how the California fauna relates to that of North America; references to significant taxonomic treatments where additional information can be obtained; and a key to the California species.

Species are arranged following the sequence given in the key. The following information is given for each species: original citation; information on type specimen, including kind (holotype, lectotype, etc.) and sex, locality, and present location, if known; synonyms, if any, and the reference where the synonymy is first indicated, abbreviated to "Syn. by ——"; geographic range; California records, including either all available data or only a listing of counties where the species has been collected; host plants in California; a brief synopsis of, and significant references to, biology; and, for most species, a discussion of the economic significance and

the most obvious taxonomic characters distinguishing it from close relatives. In those cases where only county records are given, the complete locality data are in the files of the senior author.

Common source references for the known biologies of all scolytids include: Chamberlin (1958, 1960), Keen (1952, 1958), Doane, Van Dyke, Chamberlin, and Burke (1936), Essig (1958), and Swaine (1918). These are *not* cited in the text to avoid repetition since each contains some information on the majority of species treated. Only additional source references are listed under each species and where the literature is extensive, an arbitrary selection was made to include those which presented new factual data or an extensive review.

The nomenclature of host plants follows Munz and Keck (1959) and McMinn (1958) except in the citations of "California Records" where the original label is quoted.

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SYSTEMATICS AND BIOLOGIES

Taxonomic Position

The Scolytidae and Platypodidae both belong to the large superfamily Curculionoidea. They have, in the past, been placed in a superfamily of their own, Scolytoidea, but this concept is erroneous. The Scolytidae, and probably the Platypodidae, are highly specialized weevils (Browne, 1961) and the Scolytidae are closely related to certain groups of weevils, particularly *Cossonus* and *Rhyncolus*. Crowson (1967) considers the Scolytidae and Platypodidae as subfamilies in the family Curculionidae. This concept has not yet found favor among the authorities in these families but the arrangement has merit and may well be the classification of the future. The Scolytidae and Platypodidae are kept as separate families in this work, mainly for convenience but also to conform to the more generally accepted arrangement.

KEY TO THE FAMILIES SCOLYTIDAE AND PLATYPODIDAE

1. Anterior tarsus with segment 1 longer than segments 2, 3, and 4 combined (fig. 34); head as wide as thorax and visible from above; body more than 4 times as long as wide.....Platypodidae Shuck, (p. 9)
   Anterior tarsus with segment 1 shorter than 2, 3, and 4 combined (figs. 32, 33); head never as wide as thorax and often invisible from above; body less than 4 times as long as wide.....Scolytidae Westwood, (p. 10)

Family PLATYPODIDAE Shuck

This family contains hundreds of species throughout the world, mostly in the tropical and subtropical regions. It is easily recognized by the elongate, cylindrical body shape. The head is large, broad, not covered by the pronotum, and lacks a beak. The antenna has a large scape and a compressed solid club. The pronotum is elongate, truncate anteriorly, slightly bisinuate at the posterior margin, and the lateral portions are excavated for reception of the front legs. The male elytra are elongate, striate, and prolonged into spinelike processes. The legs are short with tarsi long and slender, and the first segment as long or longer than those following.

Only one genus is represented in California.

Genus *Platypus* Herbst

Platypus Herbst, 1793, Natursyst. Ins., 5:128. Type-species: *Bostrichus cylindrus* Fabricius, monotypic.

Only one species of this very large, cosmopolitan genus has been recorded from California. However, one other species, *P. abietis* Wood, may possibly occur in the mountains of southern California in white fir, since it occurs in Arizona.

Map 2. California distribution of *Platypus wilsoni* Swaine.

Platypus wilsoni Swaine
(Figs. 1, 34; map 2)

Platypus wilsoni Swaine, 1916, Can. Entomol., 48:98. Holotype ♀, Campbell River, British Columbia (CNC).

Geographic distribution and host range.—Pacific Northwest and coastal states and British Columbia in all conifers except the Cupressine group and rarely in pines. Recorded in California from *Abies concolor, A. magnifica,* and *Pseudotsuga menziesii.*

California records (map 2).—Numerous localities in the following counties: Calaveras, El Dorado, Fresno, Humboldt, Kern, Lassen, Los Angeles, Madera, Modoc, Plumas, San Bernardino, Sierra, Tulare, and Tuolumne.

Biology. (Farris and Funk, 1965; Funk, 1965; Prebble and Graham, 1957.)

Attack is initiated by the males which may bore into the tree or log to a depth of 2 to 3 cm before being joined by a female. The female then continues the minute cylindrical gallery, which is simple at first, winding through the sapwood into the heartwood up to a depth of 30 cm. New tunnels may be added to the gallery system during the generation; as many as nine tunnels all lying in one plane at right angles to the long axis of the stem have been found. The galleries of *P. wilsoni* differ from other ambrosia beetle galleries in their complexity of nonconformity to the arc of the annual rings (except in small trees) and the square-cut gallery end (concave in other species) (fig. 1).

The borings of excavating beetles are characteristically tiny splinters, but when fresh excavation is not in progress, the frass is pellet-like. Attacks are commonly in unhealthy, dying, or recently felled trees but occasionally apparently healthy trees have been infested.

The females commence oviposition within one month of initial gallery formation, laying more than 100 eggs in groups of 10–40 along the gallery. Larvae and adults feed on ambrosial fungi implanted by the female which has special organs, mycangia, for transport of the fungus (*Tuberculanella ambrosiae* Funk). Ambrosia growth begins when tunnels are about 10 cm long, but staining of gallery walls does not appear until the second season and is less conspicuous in the heartwood than in the sapwood. Larvae and adults overwinter.

Pupal cells are cut parallel with the grain of the wood in groups of 8 to 12 along the deeper galleries. Emergence and subsequent attack occur from April through September in less temperate areas but may occur throughout the year in warmer areas. Similarly the length of the life cycle may vary from a few months to a year or more.

Discussion.—This species is very common throughout the Pacific Northwest and California. The distinguishing characters are so unique among California Coleoptera that no discussion is necessary. The adults of *Platypus abietis* are decidedly smaller, have a more slender and a more elongate process at the elytral apex, and the frons and declivity are more finely sculptured. The female of *P. abietis* has a smaller porous area on the pronotum.

Family SCOLYTIDAE Westwood

The Scolytidae make up a family of rather small beetles, the adults of which are usually recognizable by the absence of a rostrum, by the elbowed antennae, and by their cylindrical body shape (figs. 29–31). The head is not as wide as the thorax. The first segment of the anterior tarsus is shorter than the remaining ones combined. The posterior end of the elytra of most species is armed with various shaped granules, spines, or tubercles. The Scolytidae are very closely related to the Curculionidae and are considered by several authors to be nothing more than highly specialized weevils. They may be distinguished from weevils by the very short or nonexistent beak, by the elongate oval eye, and by their habitat. The length is generally small but may range from 0.7 to 10.0 mm. The body is cylindrical,

reddish-brown to black, smooth and shining or roughened, and clothed with hairs, bristles, or scales in various patterns. The head is usually hidden in dorsal view by the pronotum except in the subfamily Hylesininae. The mouthparts have well-developed mandibles, the maxillary and labial palpi are 3-segmented, and the labrum is absent. The antenna is geniculate, clubbed at the tip with a short to medium-long scape and a 1– to 7–segmented funicle (figs. 35–66). The eye is finely granulate, elongate-oval, and with an emarginate or entire margin. The pronotum is roughly rectangular or round and is usually punctured or asperate, or both. The elytral striae are usually evident. The elytral surface is roughened or smooth and usually bears striae and/or interstrial setae or scales. The declivity is rounded or concave, frequently with spines or tubercles. The tarsus is 5–segmented; the tibia is compressed, dilated near the distal portion with a serrate outer margin or short and broad with parallel sides, and devoid of teeth. Often there is a curved spine on the distal end of the tibia (figs. 32–34).

The Scolytidae is presently divided into 3 subfamilies and 17 tribes, as indicated in the key below.

KEY TO SUBFAMILIES, TRIBES, AND GENERA OF CALIFORNIA SCOLYTIDAE
(Modified from Wood (1961))

1. Lateral margin of anterior and posterior tibiae unmodified except for a single curved process at outer apical angle (fig. 32); antennal club flattened, the sutures strongly procurved (fig. 35); funicle 7–segmented; elytra slightly if at all declivous behind, the abdomen ascending abruptly behind to meet them (subfamily Scolytinae, tribe Scolytini) (fig. 67) ..... *Scolytus* Mueller

Lateral margin of anterior tibiae with several tooth-like processes, none of which curve toward the inner process (fig. 33); antennal club and funicle variable; elytra declivous behind, descending to meet the horizontal abdomen 2

2(1). Anterior margins of elytra raised and bearing a row of crenulations; scutellum, if visible, rounded, somewhat depressed and displaced posteriorly causing a slight emargination between bases of elytra; pronotum usually smooth; head usually visible from above (subfamily Hylesininae)..... 3

Anterior margins of elytra unmodified, usually smooth and either rounded or with a fine raised line; scutellum flush with elytral surface, its anterior margin and elytral bases forming an almost straight transverse line across body; pronotum roughened by asperities on anterior portion; head usually concealed from above (subfamily Ipinae).....15

3(2). Lateral prosternal area sharply elevated from coxa to anterior margin; crenulations on elytral bases usually poorly developed; head somewhat prolonged, subrostrate; antennal funicle 7–segmented, club conical (fig. 37); eyes entire (tribe Hylastini) 4

Prosternal area without elevated ridge; crenulations on elytral bases usually well-developed; head not prolonged, the frontal area usually sexually dimorphic; antennal funicle 4– to 7–segmented, club more or less flattened; eyes variable..... 7

4(3). Crenulations on elytral bases rather well developed, forming a single row of teeth; first and second segments of antennal club subequal in length (fig. 37); body less than 2.5 mm in length, rather stout; in roots of herbaceous legumes.... *Hylastinus* Bedal

Crenulations on elytral bases rather poorly developed, irregularly placed, not forming a definite single row; first segment of antennal club distinctly longer than second; body usually greater than 3 mm in length, very slender if smaller..... 5

5(4). Anterior coxae widely separated; general surface of elytral and between punctures on pronotum dull; vestiture sparse, recumbent, yellow; body color reddish brown ..... *Scierus* LeConte

Anterior coxae narrowly separated, almost contiguous; general surface of elytra and between punctures on pronotum smooth and shining; the longer vestiture erect; mature color usually dark brown or black 6

6(5). Third tarsal segment broad, bilobed; pronotum usually constricted anteriorly, about equal numbers of large and small punctures intermixed on disk ..... *Hylurgops* LeConte

Third tarsal segment narrower, emarginate; pronotum not noticeably constricted anteriorly, punctures uniformly large, intermixed with very few small punctures (fig. 68)..... *Hylastes* Erichson

7(3). Scutellum visible, elytral bases notched for its reception (fig. 69); third tarsal segment stout, usually somewhat bilobed, if slender then anterior coxae separated 8

Scutellum absent, elytral bases slightly or not at all emarginate at suture (fig. 74); third tarsal segment slender; anterior coxae contiguous.....14

8(7). Anterior coxae contiguous or very narrowly separated; antennal club strongly compressed (fig. 36); eye oval, entire (tribe Hylurgini) (figs. 29, 69) ..... *Dendroctonus* Erichson

Anterior coxae distinctly separated by an intercoxal piece; antennal club conical, or oval, sometimes flattened, usually asymmetrical in outline (figs. 38–43); eye more elongate, frequently sinuate or emarginate (tribe Hylesinini) 9

9(8). Antennal club conical, weakly compressed, sutures transverse (figs. 31, 38, 39).....10

Antennal club oval, more strongly compressed, sutures oblique or obsolete (figs. 40–43).....13

10(9). Antennal funicle 5–segmented.... *Xylechinus* Chapuis

Antennal funicle 7-segmented (figs. 31, 38, 39)....11

11(10). Lateral areas of pronotum asperate; vestiture either entirely scalelike or entirely hairlike; in broadleaf trees 12

Lateral areas of pronotum smooth, punctate; vestiture of scales and hairs intermixed; in coniferous trees (fig. 70) ..... *Pseudohylesinus* Swaine

12(11). Eye entire; costal margins of elytra ascending slightly at apex, abdomen ascending to meet them; vestiture scalelike; hosts *Fraxinus* or *Olea* species

(fig. 71) ..... *Leperisinus* Reitter

Eye shallowly emarginate; costal margin of elytra descending to apex, abdomen horizontal; vestiture hairlike; hosts *Alnus* species (fig. 72)..... *Alniphagus* Swaine

13(9). Antennal club with 3 oblique sutures (fig. 40); pronotum smooth (fig. 73).... *Phloeosinus* Chapuis

Antennal club solid, unmarked by sutures, the funicle apparently attached to its side (figs. 41–43); pronotum asperate, especially on lateral areas..... *Chramesus* LeConte

14(7). Scutellar area strongly raised and crenulate, crenulations restricted to area between fifth elytral interspaces (fig. 74); eyes entire; antennal club narrower, distinctly longer than wide (figs. 44, 45) (tribe Hypoborini) (fig. 74).. *Chaetophloeus* LeConte

Scutellar area not raised, crenulations more generally distributed, extending laterally beyond fifth elytral interspace; eyes emarginate; antennal club wider than long or nearly as long as wide (figs. 46, 47) (tribe Polygraphini) (fig. 75).. *Carphoborus* Eichhoff

15(2). Metepisternum visible to posterior extremity (fig. 29); antennal club usually thickened basally, obliquely truncate or if flattened, then sutures, if visible, strongly displaced apically on posterior surface; antennal funicle 2– to 6–segmented (figs. 48–51) 16

Metepisternum largely covered by elytra, visible only in front (fig. 30); antennal club strongly flattened with sutures on both sides, those on posterior surface not strongly displaced apically; antennal funicle 2– to 5–segmented (figs. 58–66).....36

16(15). Antennal funicle 6–segmented (figs. 48, 49) (5–segmented in *Cactopinus*); anterior coxae moderately separated by an intercoxal piece; fore tibiae with sides parallel, usually with small teeth on apical margin (tribe Micracini) 17

Antennal funicle 2– to 5–segmented; anterior coxae contiguous; fore tibiae broadened distally with teeth more widely distributed 22

17(16). Antennal club small, greatest width through basal half, apex narrowly rounded, the sutures straight, transverse 18

Antennal club usually larger, the greatest width through apical half, apex broadly rounded, the sutures procurved (fig. 48) 19

18(17). Disk of pronotum with an elevated, V-shaped, asperate area, the posterior point of the "V" extending beyond posterior pronotal margin and over scutellum; male frons bearing a large, long, partly double process which may curve upward and backward over pronotum (fig. 76)..... *Cactopinus* Schwarz

Disk of pronotum evenly convex, basal third devoid of asperities; male frons not bearing a large median process ..... *Stenoclyptes* Blackman

19(17). Posterior end of elytra broadly rounded behind....20

Posterior end of elytra drawn out to form an acuminate sutural apex 21

20(19). Pronotum wider than long, widest near base; fore tibia narrow, distal end obliquely truncate, terminal mucro usually bifurcate..... *Pseudothysanoes* Blackman

Pronotum longer than wide, widest near middle; fore tibia wider, distal end square, terminal mucro entire ..... *Thysanoes* LeConte

21(19). Sutures of antennal club broadly procurved, the first appearing bisinuate and extending less than one-third length of club; scape club-shaped, with few setae; eyes rather small, oval; fore tibia slender, slightly wider apically, with supplemental tubercles on posterior surface (fig. 77). *Hylocurus* Eichhoff

Sutures of club very strongly, narrowly procurved, the first usually reaching middle of club; scape compressed, subtriangular, with numerous long setae (fig. 49); eye large, elongate; fore tibia broad, sides subparallel, posterior surface devoid of tubercles except for teeth on apical margin..... *Micracis* LeConte

22(16). Antennal club flattened, with sutures on both faces, those on posterior face strongly procurved and limited to apical half (fig. 50); costal margins of elytra at least slightly ascending posteriorly (tribe Cryphalini) 23

Antennal club obliquely truncate or at least with sutures of posterior face restricted to less than apical one-fourth (figs. 51, 52); costal margins of elytra descending posteriorly 26

23(21). Pronotum without a fine, raised lateral line; eyes sometimes sinuate, never emarginate; costal margins of elytra ascending only slightly posteriorly 24

Pronotum acutely margined at sides and with a fine raised line at least on basal one-third; eyes emarginate; costal margins of elytra distinctly ascending posteriorly 25

24(23). Antennal funicle 5–segmented; antennal club narrow, pointed at tip, sutures straight, not septate; basal half of pronotum without scalelike setae..... *Cryphalus* Erichson

Antennal funicle 4–segmented; antennal club broadly rounded at tip, sutures straight, the first septate; basal half of pronotum with scalelike setae..... *Procryphalus* Hopkins

25(23). Antennal club not septate, with sutures indicated by rather strongly recurved rows of setae (fig. 50); third tarsal segment broad and emarginate; body more than 1.4 mm in length (fig. 78)..... *Taenioglyptes* Bedel

Antennal club with first suture partly septate; third tarsal segment cylindrical; body less than 1.3 mm in length ..... *Hypothenemus* Westwood

26(22). Antennal funicle 2– or 3–segmented (figs. 51, 52); pronotum smooth, punctured over entire surface, lateral line not raised; body 2 mm or less in length (tribe Crypturgini) 27

Antennal funicle 4– or 5–segmented (figs. 53–56); pronotum usually with granules or asperities on anterior slope, if smooth, then lateral line sharply raised; body usually larger, mostly over 2 mm in length 28

27(26). Antennal funicle 2–segmented, club with 1 obscure suture indicated at tip (fig. 51).. *Crypturgus* Erichson

Antennal funicle 3–segmented, club with 3 sutures indicated (fig. 52)..... *Dolurgus* Eichhoff

28(26). Eyes completely divided by an emargination; anten-

nal funicle 4-segmented, club without distinct sutures (fig. 53); male frons deeply, broadly excavated, the prothorax subquadrate; male frons concave (tribe Xyloterini) (fig. 79)..... *Trypodendron* Stephens

Anterior margin of eyes sinuate or emarginate, eyes never divided; antennal funicle 5-segmented, club usually with evident sutures; frons of both sexes convex or nearly so.....29

29(28). Pronotum either punctate or finely granulate over almost entire surface, dorsal profile evenly convex, not strongly declivous anteriorly, anterior margin smooth; tibiae usually slender with a few coarse teeth; elytral declivity unmodified (tribe Dryocoetini) 30

Pronotum more coarsely asperate and more strongly declivous anteriorly, usually punctate at least on posterior third, anterior margin sometimes with erect asperities; tibiae variable; elytral declivity frequently with spinous processes 32

30(29). Prothorax distinctly longer than wide, widest at middle, granulate to base; antennal club compressed, sutures rather broadly procurved; host *Cucurbita* .....*Dendrocranulus* Schedl

Prothorax about as wide as long, widest at posterior third, rather strongly narrowed at anterior half, granulate on anterior half, punctured behind; antennal club subtruncate, sutures transverse or recurved (fig. 54) 31

31(30). Basal corneous portion of antennal club reaching beyond middle (fig. 54); elytral declivity short, steep, confined to posterior one-fourth of elytra.... *Dryocoetes* Eichhoff

Basal corneous portion of antennal club not reaching middle in central area; elytral declivity gradual, extending over at least posterior one-third of elytra .....*Coccotrypes* Eichhoff

32(29). Meso- and metathoracic tibiae rather slender, abruptly narrowed apically, with a few rather widely spaced coarse teeth; males and females similar in size and general shape (tribe Ipini)...33

Meso- and metathoracic tibiae rather broadly dilated to a point slightly beyond middle then gradually narrowed to apex, with a series of small closely set teeth of more or less uniform size and shape; males rare, usually smaller and radically different in shape (tribe Xyleborini)....*Xyleborus* Eichhoff

33(32). Elytral declivity rather narrowly bisulcate, margins elevated, rounded and with not more than 3 teeth; lower margin of declivity rounded; body usually smaller than 3 mm 34

Elytral declivity broadly, rather deeply excavated, margins acutely elevated, usually with more than 3 tubercles or teeth; lower margins of declivity provided with an acutely elevated transverse ridge separating declivital excavation from apical margin; body usually larger than 3 mm.....35

34(33). Prosternal intercoxal piece short, obtuse; female frons deeply, rather narrowly excavated; male declivity with 2 or 3 pairs of enlarged teeth; vestiture not noticeably longer on head or on anterior part of female pronotum; antennal club compressed, 2 sutures visible on distal third of posterior face (fig. 80) .....*Pityogenes* Bedel

Prosternal intercoxal piece long and acutely tapered; female frons convex, not excavated; male declivity more narrowly impressed, the lateral teeth larger; vestiture usually much longer and more abundant on anterior margin of pronotum and frons, particularly in female; antennal club obliquely truncate, without sutures on posterior face .*Pityokteines* Fuchs

35(33). Antennal club obliquely truncate, the sutures recurved; elytral declivity less strongly excavated, the third tooth displaced mesally, not on summit of lateral margin .....*Orthotomicus* Ferrari

Antennal club not obliquely truncate, flattened, the sutures procurved, bisinuate or transverse (figs. 56, 57); elytral declivity broadly excavated, all teeth on summit of lateral margin (fig. 81)..... *Ips* DeGeer

36(15). Antennal funicle 3- or 5-segmented (figs. 59–66), club smaller; outer face of fore tibiae smooth, not tuberculate; pubescence usually abundant (tribe Pityophthorini) 37

Antennal funicle 2-segmented (fig. 58), club larger; outer face of fore tibiae distinctly tuberculate; pubescent much less abundant (tribe Corthylini) (fig. 83) .....*Monarthrum* Kirsh

37(36). Basal and lateral margins of prothorax rounded, without a fine raised line; antennal funicle 3-segmented, club less than twice as long as funicle.... *Dendroterus* Blandford

Basal and posterior portion of lateral margins of prothorax with a fine raised line; antennal funicle 5-segmented, club proportionately smaller (figs. 59–66) 38

38(37). Sutures of antennal club not septate (figs. 59–60); pronotal asperities usually extending behind middle at sides, the transition from asperate to punctured area gradual; body moderately to very stout.....39

First and second sutures of antennal club septate (figs. 61–66); pronotal asperities usually not reaching middle, the transition from asperate to punctured area usually abrupt, summit usually well developed; body moderately stout to slender .40

39(38). Body usually smaller, 2.0–2.9 mm; anterior margin of pronotum rather coarsely serrate; pronotum with transverse impression behind summit; ninth interspace weakly elevated; antennal club distinctly longer than funicle (fig. 59); twig beetles, never in cones .....*Myeloborus* Blackman

Body usually larger, 2.6–4.0 mm; anterior margin of pronotum feebly if at all serrate; pronotum without transverse impression behind summit; ninth interspace not elevated; antennal club and funicle equal in length (fig. 60); in cones, rarely in twigs of *Pinus* .....*Conophthorus* Hopkins

40(38). Body slender to moderately stout; body surface smooth to rough, distinctly punctured and pubescent; antennal club and funicle of female devoid of special pubescence (figs. 61–64); twig and bark beetles 41

Body very slender; body surface smooth, punctures and pubescence nearly obsolete; antennal club and funicle of female with long, curved hairs (figs. 65, 66); ambrosia beetles 42

41(40). Pronotum and elytra minutely densely punctured; vestiture very short, usually dense; antennal club with first segment notably shorter than others (fig. 61); greater development of frontal vestiture a male character; host *Quercus*, rarely other broadleaf trees (fig. 82)....*Pseudopityophthorus* Swaine

Pronotum and elytra more coarsely, less densely punctured; vestiture usually longer and less abundant; antennal club with first segment only slightly shorter or equal to others; greater development of frontal vestiture a female character; in coniferous hosts except *P. juglandis*....*Pityophthorus* Eichhoff

42(40). Costal margins of elytra near declivital suture normal, not elevated; pronotal punctures rather coarse, abundant; elytral punctures confused, vestiture rather abundant .....*Ancylocleres* Blackman

Costal margins of elytra near declivital suture strongly elevated, forming a horizontal flange; pronotal punctures minute, rather sparse; elytral punctures in rows, vestiture sparse (fig. 84)..... *Gnathotrichus* Eichhoff

Subfamily SCOLYTINAE

Tribe Scolytini

Genus *Scolytus* Geoffroy

Scolytus Geoffroy, 1762, Hist. Abreg. Ins. Paris, 1:309. Type-species: *Bostrichus scolytus* Fabricius (Curtis, 1824).

Ekkoptogaster Herbst, 1793, *In* Jablonsky, Natursyst. Ins., Käfer, 5:124. Emended to *Eccoptogaster* by Erichson (1836). (Syn. by International Commission on Zoological Nomenclature, China, 1963.)

This is a large, economically important genus containing over 65 species throughout the world. Twenty-two species are known from North America, 11 of which occur in California. Blackman revised the genus in 1934 and Edson (1967) reviewed the species occurring in coniferous trees in North America.

Most members of the genus in California feed and reproduce in various species of *Abies*, *Pseudotsuga*, and *Tsuga*, with two exceptions. *Scolytus rugulosus* Ratzeburg is found principally in fruit trees and *S. multistriatus* Marsham is encountered in deciduous trees, usually those in the genus *Ulmus*.

Scolytus is easy to distinguish from other genera of bark beetles by the structure of the fore tibiae (fig. 32), by the characteristics of the antennal club (fig. 35), and by the ascending ventral abdominal segments.

KEY TO THE SPECIES OF SCOLYTUS IN CALIFORNIA

1. Venter of abdomen ascending gradually, second sternite not vertical; size smaller, less than 2.5 mm; usually in fruit trees .....*rugulosus* (Ratzeburg)

Venter of abdomen ascending abruptly, second sternite vertical, convex or concave; size usually larger..... 2

2(1). Abdominal sternites unarmed in both sexes; second sternite flat or slightly concave; in *Tsuga*..... *tsugae* (Swaine)

One or more abdominal sternites armed with spines or tubercles, at least in male, these occasionally reduced or lacking; second sternite convex or concave 3

3(2). Posterior margin of fourth ventral sternite of male armed with a sharp spine, this spine smaller or lacking in female; posterior margins of second and third ventral segments with faint indications of carina; size larger, 3.3–4.4 mm; in *Abies bracteata*... *dentatus* Bright

Posterior margin of fourth ventral sternite never bearing a spine in either sex..... 4

4(3). Second sternite of male concave, anterior margin strongly extended; second sternite of female similar or convex, anterior margin much less strongly extended 5

Second sternite in both sexes vertical or oblique, anterior margin not extended 8

5(4). Second sternite of both sexes lacking a carina or tubercle; anterior margin of second sternite of male distinctly thickened; surface of second sternite depressed just above anterior margin..*oregoni* Blackman

Second sternite of male bearing a carina or tubercle, this sometimes faint or lacking; margin of second sternite not thickened; surface of second sternite not depressed 6

6(5). Second sternite of male bearing a strongly elevated carina extending from posterior margin to center of sternite, carina more strongly elevated anteriorly; northeastern California .....*abietis* Blackman

Second sternite of male bearing a somewhat obscure median carina or tubercle; mostly in Sierra Nevada and vicinity 7

7(6). Size larger, up to 4.4 mm; venter of both sexes subopaque, finely and sparsely punctured; carina faint or lacking in male.....*subscaber* LeConte

Size smaller, less than 3.0 mm; venter of both sexes shining, punctures close and distinct; carina faintly to strongly developed in male, absent in female .....*praeceps* LeConte

8(4). Tubercle on second sternite of male on or extending to posterior margin 9

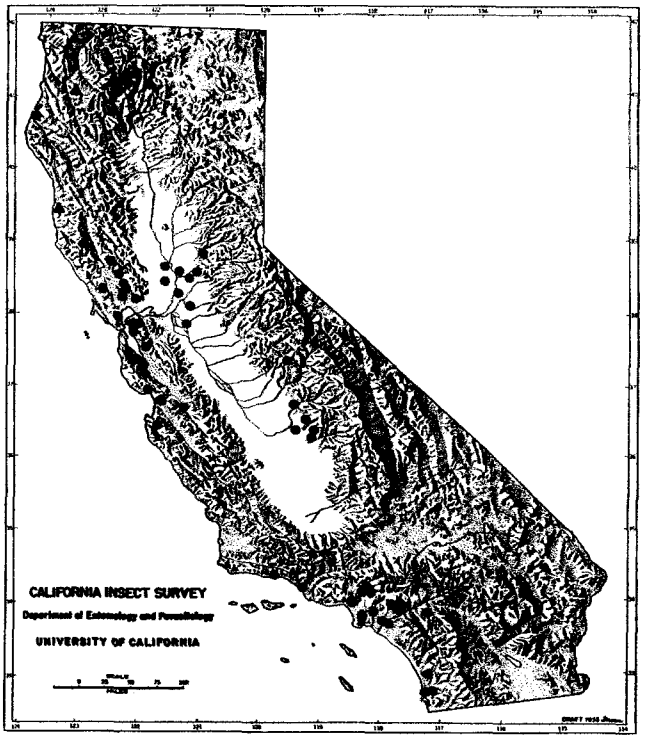
Tubercle on second sternite of male not extending to posterior margin 10

9(8). Size larger, up to 4.3 mm; second sternite with spine on posterior margin in both sexes, very faint in female: fifth sternite as wide as third or fourth (fig. 67) .....*ventralis* LeConte

Size smaller, usually less than 3.0 mm; spine of second sternite of male extending from near middle of sternite to posterior margin; spine in female smaller, occasionally absent; fifth sternite wider than third or fourth .....*unispinosus* LeConte

10(8). Spine of second sternite extending from anterior margin to near anterior third in both sexes, smaller in female; fifth sternite wider than third and fourth combined; in deciduous trees..*multistriatus* Marsham

Spine of second sternite in both sexes arising in center of sternite, not extending to either margin, smaller in female; fifth sternite narrower than third and fourth combined; in coniferous trees..*piceae* (Swaine)



Map 3. California distribution of *Scolytus rugulosus* (Ratzeburg), ● ; *Scolytus abietis* Blackman, ▲ .

Scolytus rugulosus (Ratzeburg)
(Fig. 2; map 3)

Eccoptogaster rugulosus Ratzeburg, 1837, Forstinsekt., 1:187. (Type material unknown.)

Scolytus rugulosus: Chapuis, 1869, Synopsis des Scolytides, p. 60. (Preprint of Mem. Soc. R. Sci. Liege, 2(3):268, 1873).

Geographic distribution and host range.—Throughout the Holarctic and Neotropical regions. Recorded from many stone and pome fruit trees so may be expected wherever such trees occur.

California records (map 3).—Numerous localities in the following counties: Alameda, Contra Costa, Fresno, Humboldt, Kings, Lake, Los Angeles, Marin, Mariposa, Mendocino, Monterey, Napa, Orange, Placer, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Joaquin, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Sonoma, Sutter, Tulare, Ventura, and Yolo.

Biology. (Smith, 1932; 1945)

The shot-hole borer attacks and kills small twigs, entire limbs, and even whole trees. Injury results from feeding of both adults and larvae and affects chiefly twigs and limbs. Twig injury results from adults boring shallow holes in the new wood at the base of the buds. This is apparently feeding damage since eggs are rarely laid in twigs less than 1.25 cm in diameter. Limb injury is the typical scolytid damage, a combination of adult egg galleries followed by larval feeding which may girdle the limb.

Adults can be found throughout the summer but the main attack period is from April through June. Females initiate attack, boring small, round holes (1.3 mm) through the bark—generally in the center of lenticels—of injured, dying, dead, or (rarely) healthy trees. The attack may begin in an injured area (such as sunscald) on a healthy tree and spread throughout the tree.

The typical parent gallery lies in the cambium engraving the sapwood slightly (fig. 2). The gallery usually extends straight up or down from the entrance tunnel, 1–5 cm. Eggs are deposited singly in closely spaced niches on both sides of the tunnel. The eggs hatch within a few days; larval galleries first extend at right angles to the parent gallery and then turn up or down with the grain of the wood. In heavy attacks the larval galleries may intertwine. They vary in length from 2.5 to 10 cm. At maturity the larvae generally burrow toward the center of the limb or trunk and penetrate about 16 mm into the wood. They then turn up or down and form rounded cells in which they pupate. Some larvae of the summer generation pupate in the bark but overwintering larvae are almost exclusively in the wood. The length of the summer larval period is probably a little more than a month.

The shot-hole borers overwinter primarily in the various larval stages and as pupae. The first emergence occurs in mid-March and emergence of the overwintering generation is complete by mid-May. The spring generation resulting from these adults is usually complete by the end of June. From this period until winter, discrete generations are impossible to distinguish. The long breeding season, March to October, and the short developmental time in the summer suggest that three complete generations and a partial fourth are possible.

Discussion.—*Scolytus rugulosus* was introduced into the United States about 1878 and is commonly known as the "shot-hole borer." It is an economic pest throughout the fruit-growing regions of the world. In the Santa Clara Valley of California, this borer attacks chiefly prunes and cherries. In the Sacramento and San Joaquin valleys, peaches, prunes, apricots, and almonds are often attacked.

The adults are easy to recognize since they are the only forms of *Scolytus* in California in which the venter of the abdomen ascends gradually instead of abruptly to the elytra. The size of the adults varies from about 2.0 to 3.0 mm. In color they vary from entirely black to black with touches of red on the margins of the

pronotum and elytra or entirely reddish brown. The tarsi of almost all specimens are reddish in color.

Scolytus tsugae (Swaine)

Eccoptogaster tsugae Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):32. Lectotype ♀, Glacier, British Columbia (CNC).
Scolytus tsugae: Leng, 1920, Cat. Coleopt. Am., p. 337.
Eccoptogaster monticolae Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):32. Lectotype ♀, Arrowhead, British Columbia (CNC). (Syn. by Wood, 1966.)
Scolytus monticolae: Leng, 1920, Cat. Coleopt. Am., p. 337.

Geographical distribution and host range.—British Columbia to central California, extending eastward into Idaho. Recorded only from hemlock in California but probably occurs in true firs and Douglas fir.

California record. — ALPINE CO.: Ebbetts Pass, on *Tsuga mertensiana* (CIS).

Biology. (McMullen and Atkins, 1959; Edson, 1967)
The flight period of *S. tsugae* occurs from May to late July with a peak in mid-June. Attacks are initiated by the females but males may assist in gallery construction. Although monogamous within galleries, the males may re-emerge and mate with other females in the process of their gallery construction.

Attacks are made on dead or dying host material usually when it is on the ground. Small, thin-barked branches and stems are preferred (6 to 18 cm) but trees up to 33 cm may be attacked. The entrance hole runs obliquely through the bark to the cambium where a small turning niche or nuptial chamber is made. The gallery is usually constructed transversely to the grain in both directions from the entrance tunnel and scores the sapwood to the same depth as the bark. Frequently, the egg tunnel runs longitudinally with or obliquely to the grain. The average length of a gallery is 5 cm.

Eggs are laid close together in niches cut on both sides of the gallery. About 36 eggs per female are laid. The larvae mine for a short distance at right angles to the parent gallery, then turn toward the ends of the gallery. They overwinter as fourth instar larvae and pupate in the cambium or the bark in the spring. Thus, there is a one-year life cycle with one generation per year.

Discussion.—Among the California species, adults of *S. tsugae* may be easily recognized since they are the only forms (except *S. oregoni*) with the ventral abdominal segments of both sexes vertical and devoid of any tubercles or spines. Adults measure from 2.9 to 3.5 mm in length.

Scolytus dentatus Bright

Scolytus dentatus Bright, 1964, Pan-Pac. Entomol., 40(3):167. Holotype ♂, Cone Peak, Monterey Co., California (CAS).

Geographic distribution and host range.—The only recorded host, bristlecone fir, is restricted to the Santa Lucia Mountains, Monterey County, California.

California records.—MONTEREY CO.: Cone Peak, on *Abies bracteata* (CIS & CAS); Carmel Valley, on *A. bracteata* (CIS).

Biology. (Bright, 1964; Edson, 1967)
Attacks are made on the trunk and larger limbs of standing bristlecone fir. The parent gallery consists of two tunnels extending up and down from the entrance tunnel, each terminating with a pronounced hook. The sapwood is more deeply engraved than the bark. Egg niches are closely spaced on both sides of the gallery which may be from 50 to 120 mm long. The life cycle is unknown.

Discussion.—This species seems to be related to *S. laevis* Chapuis and several other Palearctic species. It is the only species in North America in which the adults bear a prominent tooth on the posterior margin of the fourth ventral sternite of the male. Adults can be further recognized by their larger size (3.3 to 4.4 mm) and by the deeply concave second ventral segment which bears a strongly produced anterior margin.

Scolytus oregoni Blackman

Scolytus oregoni Blackman, 1934, U. S. Dep. Agric. Tech. Bull. 431, p. 18. Holotype ♂, Ashland, Oregon (USNM).

Geographic distribution and host range.—*S. oregoni* has been recorded in California only from big-cone spruce but probably occurs also in Douglas fir and *Abies concolor*. The distribution extends from California through the Pacific Northwest and probably into British Columbia.

California records.—MARIN CO.: Mt. Tamalpais (USNM). SAN BERNARDINO CO.: Fenner Canyon, on *Pseudotsuga macrocarpa* (CIS).

Biology. (Edson, 1967)
Attacks are made on larger limbs and tree tops, but are more common in fresh logging slash. The adult gallery is usually straight with the grain of the wood with two arms extending from the nuptial chamber. The nuptial chamber extends a short distance at right angles to the grain. Overall length of the gallery ranges from 6 to 18 cm.

Eggs are laid in pairs on both sides of the gallery and larval mines diverge rapidly to form a fan-shaped pattern terminating in pupal chambers which are deeply etched in the sapwood.

Discussion.—Adults of this species measure about 3.2 mm in length and are of the usual blackish color. It seems to be related to S. *robustus* but the adults are distinguished from those of S. *robustus* by the thick anterior margin of the second sternite of the male, by the shining ventral abdominal segments, and by the distribution.

Scolytus abietis Blackman
(Map 3)

Scolytus abietis Blackman, 1934, U.S. Dep. Agric. Tech. Bull. 431, p. 21. Holotype ♂, Sandpoint, Idaho (USNM).

Geographic distribution and host range.—S. *abietis* has been recorded in California only from *Abies concolor* but occurs elsewhere in other *Abies* species and probably hemlock (*Tsuga*). The distribution ranges from California to British Columbia, and inland to Idaho.

California records (map 3).—Humboldt Co.: Horse Mtn., Willow Ck., on *Abies concolor* (HSC). Mendocino Co.: Noyo R. (CAS). Siskiyou Co.: Coffee Ck., Big Flat, Trinity Center, on *A. concolor* (HSC); Scott Valley, Shackle Ford Ck., Greenview, on *A. concolor* (HSC); McCloud, on *A. concolor* (HSC); Willow Ck., Mt. Ball Meadows, Etna, on *A. concolor* (HSC). Trinity Co.: Ruth, on *A. concolor* (HSC); Weed, Dead Fall Ck., on *A. concolor* (HSC).

Biology. (Edson, 1967)

This species attacks smaller limbs and tops of living trees but prefers fresh slash. The adult gallery commonly has one arm extending across the grain from the central nuptial chamber and the other at a 45° angle to the grain. However, both galleries may be at right angles or oblique to the grain. Their length ranges from 2 to 5 cm.

Egg niches are closely spaced and larval mines parallel one another, if not crowded, and terminate in elliptical pupal chambers which score the sapwood.

Discussion.—*Scolytus abietis* is closely related to S. *opacus* Blackman and the two may be the same species. It is the only species occurring in California in which the anterior margin of the second sternite is strongly extended and the second sternite of the male bears a sharply elevated median carina. The carina is roughly triangular in shape, increasing in height anteriorly, and extends from the posterior margin to the center of the sternite.

Scolytus subscaber LeConte

Scolytus subscaber Leconte, 1876, Proc. Am. Philos. Soc., 15: 373. Type ♀, Vancouver Island, British Columbia (MCZ).

Geographic distribution and host range.—S. *subscaber* probably attacks most species of fir so may be found throughout the Pacific Northwest and the Intermountain region.

California records.—El Dorado Co.: Echo Lake, on *Abies magnifica* (CIS). Riverside Co.: Santa Rosa Mtn., on *A. concolor* (CIS).

Biology. (Struble, 1957)

Attacks occur on branches or the trunks of small (<10 cm) suppressed trees in July and August. The parent gallery resembles a rounded capital E. The nuptial chamber or entrance hole is central with two short egg galleries (total length about 2 cm) recurving around it. The parent gallery is etched deep into the sapwood. A fungus stain organism is introduced by the attacking beetle.

From 12 to 30 eggs are deposited in the cambium on the outer margin of the gallery. The larvae do not score the sapwood until they are nearly full-grown. They then mine the sapwood slightly when the pupal chamber is excavated. Larval mines are about 14 mm long.

There is one generation per year; the larvae are the overwintering stage.

Discussion.—This species appears to be most closely related, within the California fauna, to S. *praeceps* LeConte but the adults may be distinguished by their larger size (3.2 to 4.9 mm), by the lack of any carina or tooth on the venter, and by the remarkable galleries.

Scolytus praeceps LeConte
(Map 4)

Scolytus praeceps LeConte, 1876, Proc. Am. Philos. Soc. 15: 373. Type ♀, Calaveras, California (MCZ).

Geographic distribution and host range.—Since S. *praeceps* is found on the true firs, Douglas fir, and hemlock it may be found throughout the Pacific Northwest, and probably inland as well as in California.

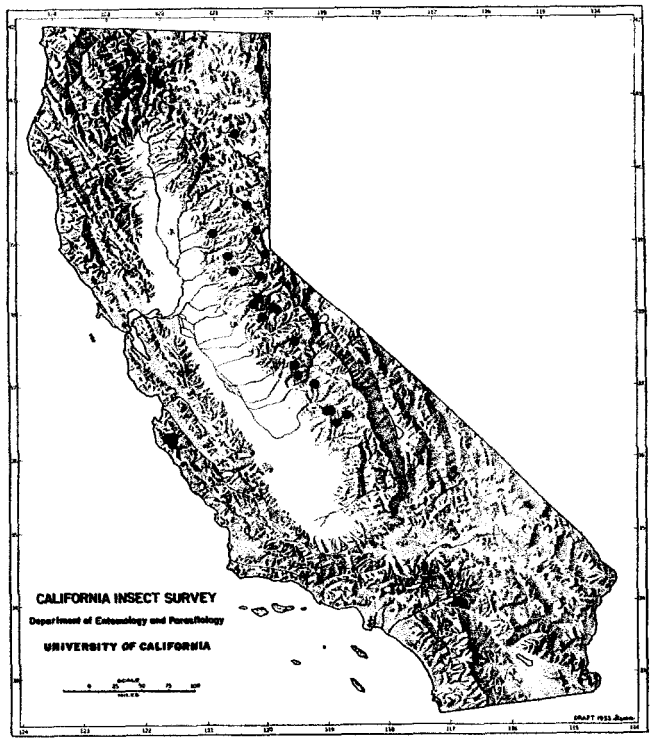
California records (map 4).—Numerous localities in the following counties: Calaveras, El Dorado, Fresno, Lassen, Madera, Mariposa, Modoc, Monterey, Plumas, San Bernardino, Siskiyou, Tulare, Tuolumne, and Trinity.

Biology.– (Struble, 1957; Edson, 1967)

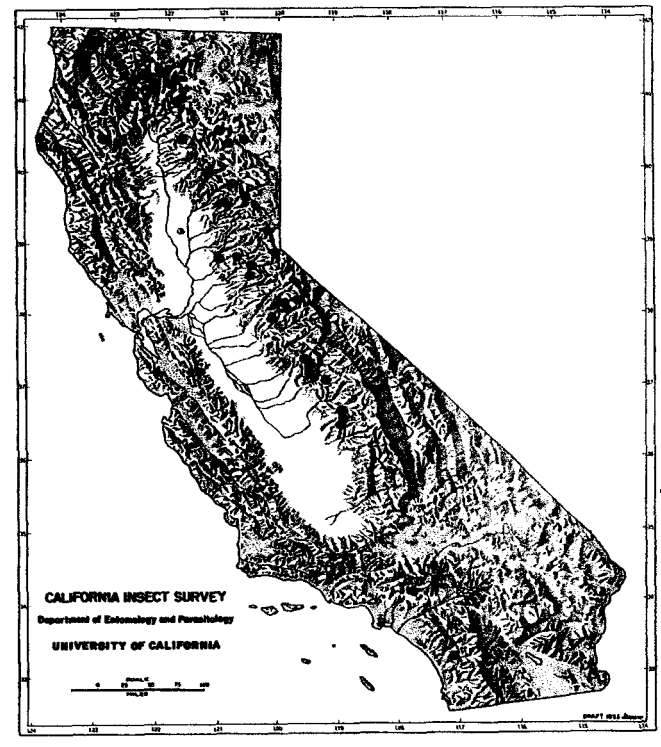
S. *praeceps* attacks the limbs and tops of its host, apparently preferring areas close to branch bases which causes variability in gallery pattern. It occasionally attacks and kills young suppressed trees but is most common on branches and thin-barked portions of the trunks on the ground. Adults are in flight from June through September. A fungus stain is also introduced by this bark beetle.

Typical parent galleries are two nearly straight, transverse galleries from a central burrow which is excavated in the direction of the grain. Frequently one of the gallery arms is at a 45° angle to the grain. Overall length varies from 2.5 to 6 cm.

Egg niches are distinctly etched in the sapwood,



Map 4. California distribution of *Scolytus praeceps* LeConte.



Map 5. California distribution of *Scolytus ventralis* LeConte.

closely spaced. Larval galleries diverge to form a fan-shaped pattern. Pupal chambers are elongate and deep in the sapwood.

One generation is produced each year.

Discussion.—The strongly extended anterior margin of the second sternite, the distinct, weakly elevated carina on the second sternite of the male, and the smaller size (2.3 to 3.0 mm) will aid in recognizing the adults of this species.

Scolytus ventralis LeConte
(Figs. 3, 32, 35, 67; map 5)

Scolytus ventralis LeConte, 1868, Trans. Am. Entomol. Soc., 2: 167. Type ♂, Washington Territory (MCZ).

Geographic distribution and host range.—*S. ventralis* attacks the true firs, Douglas fir, and hemlock and may be found throughout western North America.

California records (map 5).—Numerous localities in the following counties: El Dorado, Fresno, Humboldt, Lassen, Los Angeles, Madera, Mariposa, Modoc, Plumas, Riverside, San Diego, Shasta, Siskiyou, Tulare, Tuolumne, and Trinity.

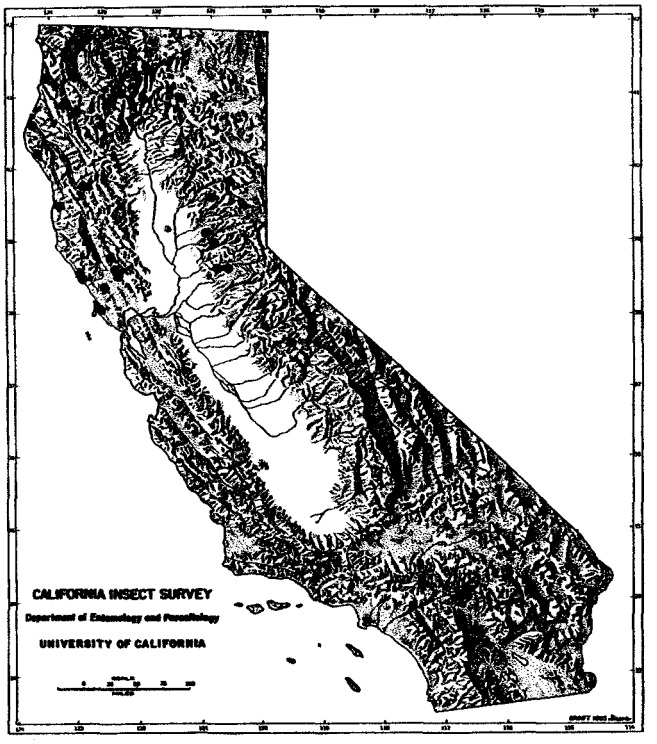
Biology. (Ashraf and Berryman, 1969; Berryman, 1968*a*, *b*; Edson, 1967; Stark and Borden, 1965; Struble, 1957)

Attacks are made from June through September but peak activity is during July and August. Individual branches are commonly infested causing "flagging," but trees from pole size to the largest sawtimber size are attacked throughout their length. Location of attack on the stem is extremely variable. The female enters first, followed soon after by the male which helps to remove boring dust from the gallery. A fungus stain, *Trichasporium symbioticum* Wright, is introduced by the beetle and spreads rapidly in all directions from the egg gallery.

Egg galleries are horizontal, extending 5 to 8 cm in both directions from the nuptial chamber (fig. 3). Egg niches, spaced 1 to 1.5 mm apart are excavated on both sides of the gallery. The number of eggs laid varies considerably but the average in small trees (<18 cm DBH) was 57 per gallery. A maximum of 260 was found.

Larvae mine at right angles to the parent gallery and parallel to one another. The length of larval mines may exceed that of the parent gallery. Developmental time of larvae varies from 41 days at the lower elevations in the south to 380 days at high elevations and in northern latitudes. The pupal cells are elongate and may be entirely in the bark. They overwinter as larvae and adults.

The number of generations per year varies. At lower



Map 6. California distribution of *Scolytus unispinosus* LeConte.

elevations (1,050–1,250 m) and on south exposures there may be one complete and a partial second generation per year. From 1,250 to 1,800 m there is commonly one per year, while at altitudes above 1,800 m the life cycle may require 2 years to complete.

Discussion.—S. *ventralis* is probably the most destructive species of this genus in the west. It is responsible for almost all of the insect-killed fir trees in its range.

The adults can be recognized by their large size (3.3 to 4.3 mm), by the strongly elevated tubercle on the posterior margin of the second sternite of the male and by the strongly extended anterior margin of the second sternite. The gallery pattern will also aid in recognizing it.

Scolytus unispinosus LeConte
(Fig. 4; map 6)

Scolytus unispinosus LeConte, 1876, Proc. Am. Philos. Soc., 15: 372. Type ♂, Oregon (MCZ).

Scolytus sobrinus Blackman, 1934, U.S. Dep. Agric. Tech. Bull. 431, p. 23 Holotype ♂, Kent, Washington (USNM). (Syn. by Wood, 1966.)

Geographic distribution and host range.—S. *unispinosus* is apparently restricted to Douglas fir, *Pseudotsuga menziesii*, and so should be found throughout the range of this tree in the western United States and Canada.

California records (map 6).—Various localities in the following counties: El Dorado, Humboldt, Lake, Marin, Mendocino, Napa, Nevada, Placer, Plumas, Shasta, Sonoma and Trinity.

Biology. (McMullen and Atkins, 1962; Daterman et al., 1965; Edson, 1967)

The flight period of S. *unispinosus* commonly occurs in late June to late August but flight has been observed as early as mid-May. Attacks are frequently intermixed with *S. tsugae* in the tops and limbs of trees killed by the Douglas fir beetle, *Dendroctonus pseudotsugae*. S. *unispinosus* is most successful in smaller branches and limbs. It has been observed attacking and killing twigs in Douglas fir reproduction.

The parent galleries are constructed by the females (fig. 4). Apparently the majority of galleries are forked, extending in both directions from the nuptial chamber, but a significant percentage extend in only one direction from the nuptial chamber. Both types are parallel to the grain. The average length of the majority of galleries is 3.5 mm, with a maximum of 7 mm.

Eggs are laid singly on either side of the gallery about 1 cm apart. The maximum number per gallery is 60. Larvae appear from June to mid-July and their mines fan out approximately at right angles to the egg gallery. Average length is 3 cm with a maximum of 5 cm. Pupation occurs at the cambium-wood interface or just beneath the outer bark scales.

There is only one generation per year in the northern part of its range and at higher altitudes, but at low altitudes in temperate climes there may be two.

Discussion.—This is the most common species found in the Douglas-fir region throughout California. The adults are small, measuring 2.3 to 2.7 mm. They may be distinguished by the nearly perpendicular second abdominal sternite which, in the male, bears a stout spine extending from the posterior margin of the segment to the middle. The anterior margin of the second sternite is not extended.

Scolytus multistriatus (Marsham)
(Map 7)

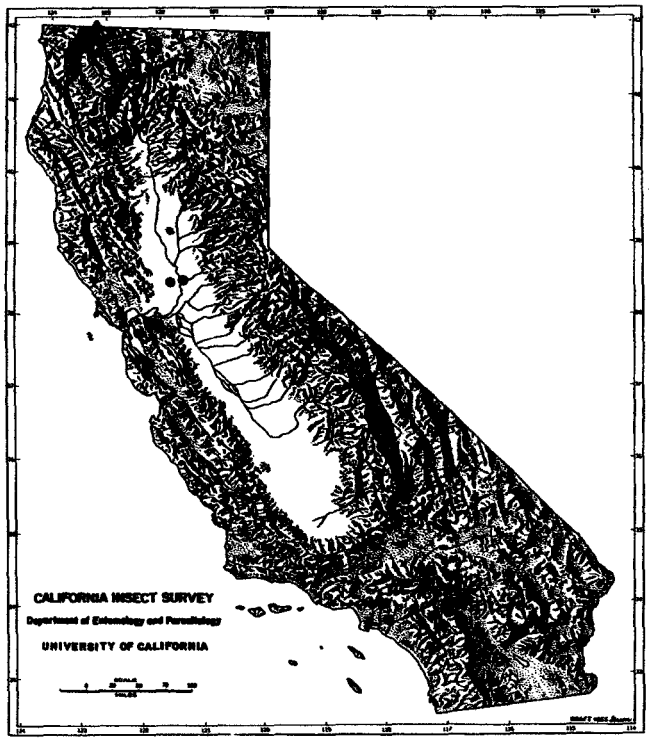
Ips multistriatus Marsham, 1802, Entomol. Brit., 1:54. Type material not known.

Eccoptogaster multistriatus: Ratzeburg, 1837, Forstinsekt., 1:220.

Scolytus multistriatus: Chapuis, 1869, Synopsis des Scolytides, p. 55. (Preprint of Mem. Soc. R. Sci. Liege, 2(3):263, 1873.)

Geographic distribution and host range.— S. *multistriatus* attacks most species of elm (Ulmus) and may be found throughout the world where elms are grown.

California records (map 7).—Various localities in the following counties: Alameda, Contra Costa, Los Angeles, Marin, Orange, Riverside, Sacramento, San Bernardino, Santa Clara, and Yolo.



Map 7. California distribution of *Scolytus multistriatus* Marsham, ● ; *Scolytus piceae* Swaine, ▲ .

Biology. (Becker and Mankowsky, 1965; Brown, 1965; Brown and Eads, 1966; Whitten, 1966)

The smaller elm bark beetle feeds on living elm throughout the entire growing season of the tree. Prior to boring into the tree for breeding purposes, the beetles feed in the smaller twig crotches. Mating occurs on the trunk of the tree. The female then bores into the cambium layer and excavates the egg gallery.

The egg gallery runs with the grain of the wood engraving both bark and wood for a distance of 2.5 to 5 cm. From 24 to 96 eggs are deposited in niches on both sides of the gallery. The larvae mine at right angles to the parent gallery but gradually turn to run obliquely or parallel to the grain so that the total gallery pattern is subcircular in outline. Larval galleries are usually longer than the egg galleries, often reaching lengths of 20 cm. Prior to pupation, the larvae bores into the bark and excavates a pupal chamber.

In California there are two generations and a partial third generation per year. The flight of the first brood begins in late March and reaches a peak in mid-April. The second brood begins in June and peaks in early July. The partial third generation overlaps with emerging adults of the second generation. Larvae, pupae, and adults of the third brood overwinter.

Discussion.—This European species was accidentally introduced into the United States and was first recorded from Cambridge, Massachusetts, in 1909. Attacks by *S. multistriatus* beetles cause little damage in themselves but the beetles are one of the principal vectors in the eastern part of the continent (as far west as Colorado) of a fungus *Ceratocystis ulmi* (Buisman) C. Moreau, which causes the Dutch Elm Disease. This vascular wilt disease produces a wilting and yellowing or dying of foliage followed immediately by defoliation and death of affected branches. Infected trees may die gradually over a period of several years but commonly death occurs within a few weeks. There is no known cure for the disease. Although the bark beetle spread to California in 1951, the disease has not yet appeared here.

The beetle is most easily recognized by the long spine which arises from the anterior third of the second abdominal segment of the male, and by the host plant.

Scolytus piceae (Swaine)
(Map 7)

Eccoptogaster piceae Swaine, 1910, Can. Entomol., 42:34. Lectotype ♂, St. Annes, Quebec (Cornell University).
Scolytus piceae: Leng, 1920, Cat. Coleopt. Am., p. 337.

Geographic distribution and host range: *S. piceae* has been recorded in California from two spruce species, *Picea breweriana* and *P. engelmanni* but occurs elsewhere on most *Picea* species. Its range extends from New England and eastern Canada to western Canada and the United States.

California records (map 7).—Siskiyou Co.: 7 mi N. W. Callahan, on *Picea engelmanni* (CIS); Happy Camp, on *P. breweriana* (CIS); 18 mi N. Happy Camp, on *P. breweriana* (CIS).

Biology. (Edson, 1967)

Attacks by *S. piceae* are usually in dead and dying limbs. The parent galleries may have two or three branches radiating from the central nuptial chamber. If the former, one branch usually extends directly with the grain, the other extends at right angles for a short distance before turning with the grain, and if three female tunnels are present the gallery outline will resemble a tuning fork. Length varies from 5 to 8 cm and the sapwood is deeply scored.

Ten to 30 eggs are laid in deep niches on both sides of the tunnels. Larval mines start off at right angles but soon turn and follow the grain, scoring the wood deeply. The gallery is ultimately fan-shaped. Pupal chambers are circular and these and the larval mines also etch the sapwood deeply.

There is probably one generation per year.

Discussion.—The species is unique in that both sexes have a slender spine arising from the center of the second ventral segment. The adults of *Scolytus piceae* measure from 2.4 to 3.3 mm in length.

Subfamily HYLESININAE

Tribe Hylastini

Genus *Hylastinus* Bedel

Hylastinus Bedel, 1888, Faune Coleopteres du Bassin de la Seine, 6: 388. Type-species: *Dermestes obscurus* Marsham, monotypic.

Hylastinus obscurus (Marsham)
(Fig. 37)

Dermestes obscurus Marsham, 1802, Entomol. Brit., p. 72. Type material not known.
Hylastinus obscurus: Bedel, 1888, Faune Coleopteres du Bassin de la Seine, 6: 388.

Geographic distribution and host range.—*H. obscurus* occurs in most species of wild and cultivated legumes, Scotch broom (*Cytisus scoparius*), beans, vetch, and Russel lupin. It is distributed throughout the Old World, the United States, and southern Canada.

California records.—Del Norte Co.: 10 mi N. Crescent City (CDA); Smith River, on *Trifolium* sp (CDA). Humboldt Co.: Eureka (CAS).

Biology. (Rockwood, 1926; Waloff, 1968)

Fresh attacks occur in the spring on the roots or root crowns slightly below the soil surface. Parent galleries run with the root fiber, occasionally horizontally, usually 2 to 4 cm long. Typically a single female and male are found in each burrow but occasionally two females may be present. Many females excavate up to four separate egg galleries.

Eggs are deposited in niches on the sides of the galleries. Only 4 to 9 eggs are laid per gallery on legumes, but in larger plants such as Scotch broom, the number may reach 30 to 40. The number of eggs laid per female apparently is about 40. The larvae feed in roots throughout the summer and may overwinter, pupating and emerging in the spring. Most, however, overwinter as adults.

There is one generation per year.

Discussion.—The species is commonly known as the clover root borer and is a serious pest of clover and alfalfa in the eastern states. It is considered to be one of the main factors limiting the life of red clover. It is not common in California and is not, as yet, considered a pest species.

The adult can be readily distinguished by the characters given in the key to genera.

Genus *Scierus* LeConte

Scierus LeConte, 1876, Proc. Am. Philos. Soc., 15:390. Type-species: *Scierus annectens* LeConte, monotypic.

Two species of this genus occur in North America; both occur in the west, but only one has been found in California.

Scierus annectans LeConte

Scierus annectans LeConte, 1876, Proc. Am. Philos. Soc., 15: 390. Type (sex?), Anticosti Island, Quebec (MCZ).

Geographic distribution and host range.—Although rare in California and recorded only from Engelmann spruce, *S. annectans* attacks most *Picea* species. It is widely distributed across Canada, extending southward into the northeastern and western United States.

California records.—Siskiyou Co.: 7 mi N.W. Callahan, on *Picea engelmannii* (CIS).

Biology. (Stewart, 1965)

Spring flight and host attack of *S. annectans* take place from mid-June to mid-August; the main attack period occurs in mid-July. Entrance to the cambium of the host is usually made through entrance holes bored by *Dendroctonus rufipennis* (Kirby), the spruce beetle. Preference is shown for those occurring on the underside of felled or leaning trees. Up to five *Scierus* attacks are made in a single *Dendroctonus* hole. After reaching the cambium, a characteristic "turning niche," slightly longer than the beetle, is constructed. This side niche facilitates exit by the beetle in a forward position. The egg gallery is longitudinal, slightly curved and parallel with or at an angle (ca 45°) to the grain. The sapwood is only slightly etched, if at all.

Oviposition is begun during gallery construction. The female extends the gallery just beyond the proposed niche, excavates the short, lateral egg niche in the outer cambium, deposits the egg, packs it in with frass, and then continues. After oviposition, the gallery is extended further, presumably by the adult feeding. Average length of gallery is 33 mm, maximum 42 mm.

Oviposition occurs throughout July and early August. Larvae are found about 3 weeks later. The mean number of eggs laid ranges from 10 to 16 but up to 32 have been found. Larvae burrow at right angles to the parent gallery, but their galleries may meander and often cross one another.

Discussion.—*S. annectans* is reddish, about 2.75 to 3.5 mm in length. The elytral interspaces are elevated, distinctly rugose with short yellowish setae and the

third and ninth interspaces are united at the declivity and jointed to the first. The pronotal disk is distinctly and deeply punctured, each puncture bearing a short yellowish seta.

Genus *Hylurgops* LeConte

Hylurgops LeConte, 1876, Proc. Am. Philos. Soc., 15:389. Type-species: ***Hylastes pinifex*** Fitch (Hopkins, 1914).

Chamberlin (1939) lists seven species of this genus for North America; of these, four are known from California; a fifth species was recently described by Wood (1971*a*). Another species, *H. incomptus*, has been reported from California (Chamberlin, 1939, and Swaine, 1917), but no representatives from California were seen during the preparation of this Bulletin and it is not included herein.

Species of *Hylurgops* are very closely related to those of *Hylastes* and in some respects they seem to intergrade. In the adults of *Hylurgops*, the third tarsal segment is bilobed and broader compared to emarginate in the adults of *Hylastes*, the mesosternum is protuberant, the pronotum is usually constricted anteriorly with about an equal number of large and small punctures intermixed on the disk, and usually (at least for California species) the body is stouter as opposed to the narrow, elongate form of most species of *Hylastes*.

The biologies of the species in this genus are not well known. All are considered to be of little or no economic importance. Some species infest and remain for several generations in old, disintegrating logs. Others attack severely injured, dying, or dead trees. There is some evidence suggesting a colonial habit, but such aggregations may be only hibernating adults. The larvae of all species apparently feed en masse, forming no particular larval gallery pattern and often obliterating that of the parent gallery.

KEY TO THE SPECIES OF HYLURGOPS IN CALIFORNIA

1. Alternate declivital interspaces distinctly elevated and granulate; interstrial setae of declivity much shorter than width of interspace. . ***subcostulatus*** (Mannerheim)
   Alternate declivital interspaces not distinctly raised, declivity evenly convex; interstrial setae of declivity nearly as wide or wider than width of interspace . . . 2
2(1). Sides of pronotum evenly arcuate or weakly constricted on anterior third; body more elongate, 2.6–2.7 times longer than wide; dorsal and ventral surface usually same color, sometimes elytra slightly lighter 3
   Sides of pronotum strongly arcuate, strongly constricted on anterior third; body stout, less than 2.5 times longer than wide; dorsal surface usually reddish, ventral surface darker, usually black 4
3(2). Elytra brightly shining, smooth between punctures and granules; surface between pronotal punctures smooth, shining . . . . . ***porosus*** LeConte
   Elytra dull, minutely reticulate between punctures and granules; surface between pronotal punctures dull, reticulate . . . . . ***reticulatus*** Wood
4(2). Pronotum with large and small punctures intermixed; longitudinal carina on frons strongly elevated; central Sierras . . . . . ***pinifex*** (Fitch)
   Pronotal punctures uniform in size; longitudinal carina of frons distinct but less strongly elevated; coastal regions . . . . . ***rugipennis*** (Mannerheim)

Map 8. California distribution of *Hylurgops subcostulatus* (Mannerheim).

Hylurgops subcostulatus (Mannerheim)
(Map 8)

Hylastes subcostulatus Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:297. Type (sex?) Sitka, Alaska (University of Helsingfors, Finland).

Hylurgops subcostulatus: LeConte, 1876, Proc. Am. Philos. Soc., 15:390.

Geographic distribution and host range.—*H. subcostulatus* attacks various species of pines and possibly *Abies* spp. Its distribution extends throughout the western North American coniferous forests.

California records (map 8).—Numerous localities in the following counties: Calaveras, El Dorado, Fresno, Kern, Lassen, Los Angeles, Madera, Mariposa, Mono, Nevada, Placer, Plumas, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Trinity, Tulare, Tuolumne, and Yuba.

Biology.—Attack is made on the basal portion of the trunk of recently killed pines; there is an apparent preference for those with wet fermenting sap. The parent gallery is short, slightly irregular, and usually in a longitudinal direction. The larvae work in all directions with no clearly differentiated mines. The entire cambial layer may be eaten in heavy attacks. Pupation takes place in the cambium region or inner bark.

Trees are attacked in early spring and summer; resulting broods emerge in the fall and re-attack the same log or a new one. This second generation overwinters under the bark as larvae and new adults. At high altitudes there may be only one generation per year.

Discussion.—***Hylurgops subcostulatus*** is one of our most common species found in dead pines but is not of economic importance.

This reddish to reddish-brown scolytid is easily recognized by the strongly elevated first, third, fifth, seventh, and ninth declivital interspaces. The upper surface of the pronotum and elytra are thickly clothed with small white or light yellow scales with stout, erect setae on the interspaces.

Hylurgops porosus (LeConte)
(Map 9)

Hylastes porosus LeConte, 1868, Trans. Am. Entomol. Soc., 2: 175. Type (Sex?), California (MCZ).
Hylurgops porosus: Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):82.
Hylurgops lecontei Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):16. Holotype ♀ (?), Colorado (CNC). (Syn. by Wood, 1971*b*.)

Geographical distribution and host range.—*H. porosus* apparently attacks all pine species in western North America.

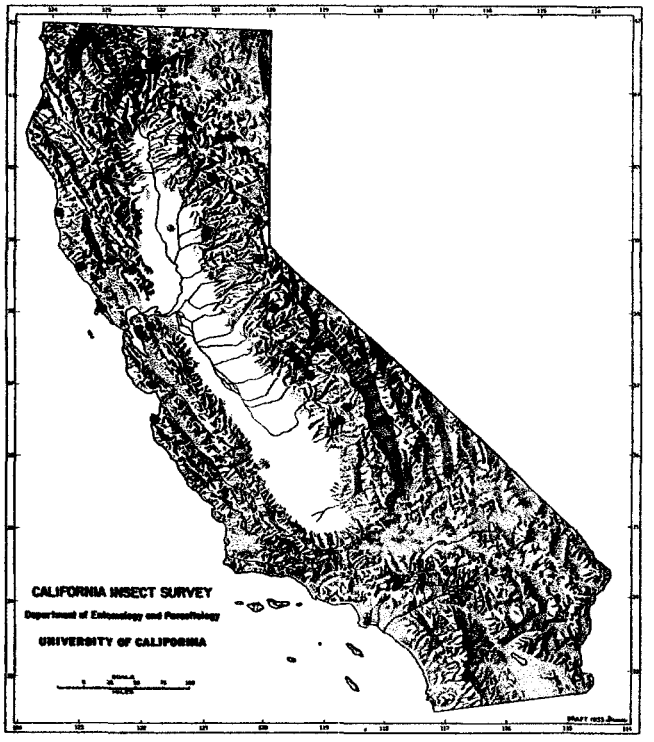
California records (map 9).—Numerous localities in the following counties: Alameda, Contra Costa, El Dorado, Fresno, Humboldt, Inyo, Lassen, Los Angeles, Lake, Madera, Marin, Mariposa, Mendocino, Modoc, Mono, Monterey, Nevada, Plumas, San Diego, Santa Cruz, Shasta, Siskiyou, Sonoma, Tehama, Trinity, Tulare, and Tuolumne.

Biology.—There is no specific information available.

Discussion.—The adults are black and measure up to 5 mm in length. They are rather easily distinguished since the pronotum is longer than wide and is widest at or just in front of the middle. The pubescence of the elytral declivity consists of small recumbent scales with much longer erect setae on all interspaces. The interspaces on the elytral disk are rather strongly rugose.

Hylurgops reticulatus Wood

Hylurgops reticulatus Wood, 1971, Great Basin Nat. 31(2):71. Holotype ♂, Summit Lake, Shasta Co., California (SLW).



Map 9. California distribution of *Hylurgops porosus* LeConte.

Geographic distribution and host range.—*H. reticulatus* is known from *Pinus ponderosa* and *P. jeffrey*; from central British Columbia to Arizona and New Mexico, east into Idaho.

California records.—Lassen Co.: Butte Mdws. (CNC); Goumaz, on *Pinus jeffreyi* (CNC). Los Angeles Co.: Big Pines (CNC). Mariposa Co.: Miami Ranger Station (SLW). Monterey Co.: Carmel (CAS). Shasta Co.: Burney, on *P. ponderosa* (SLW); Cypress Camp, on *P. jeffreyi* (SLW); Summit Lake, on *P. ponderosa* (SLW).

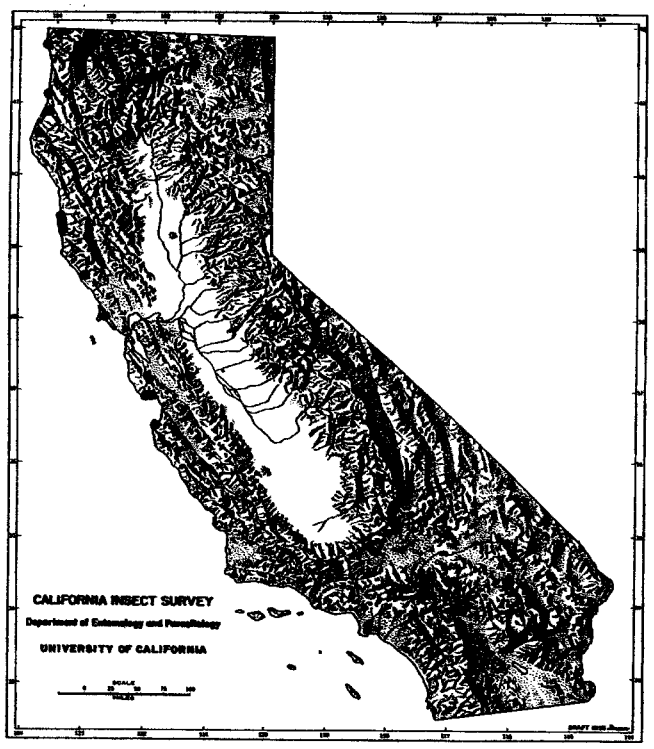
Biology.—Unknown.

Discussion.—Adults of this species are most easily recognized by the dull, densely reticulate surface of the elytra and pronotum. It closely resembles and, presumably has habits similar to those of ***Hylurgops porosus*** and ***Hylastes macer*** Le Conte. It has been misidentified in collections as either of the two above-mentioned species.

Hylurgops pinifex (Fitch)
(Map 10)

Hylastes pinifex Fitch, 1851, Trans. N.Y. Agric. Soc., p. 43. Type material unknown.
Hylurgops pinifex: LeConte, 1876, Proc. Am. Philos. Soc., 15: 390.

Geographical distribution and host range.—*H. pinifex* attacks various *Pinus* species throughout North America.



Map 10. California distribution of *Hylurgops pinifex* (Fitch), O; *Hylurgops rugipennis* (Mannerheim), ●.

California records (map 10).—Fresno Co.: Mt. Brewer, on *Pinus balfouriana* (CAS). Mariposa Co.: Yosemite Valley (CAS). Mono Co.: Blanco's Corral, White Mtns., 10,000' (CNC). Tulare Co.: nr. Mt. Brewer, on *P. balfouriana* (CAS); Scaffold Meadows, on *P. jeffreyi* (PSW). Tuolumne Co.: Pinecrest, on *P. ponderosa* (CIS); Strawberry, flight trap (PSW).

Biology.—Penetration of the host is made at the base of the trunk and egg galleries may extend below the surface of the ground. Galleries are short, curved, and longitudinal or subtransverse. The larvae honeycomb the inner bark and cambium layers.

There are possibly two generations per year and successive generations may breed in the same tree.

Discussion.—This name is applied, with some reservation, to several small series of a *Hylurgops* sp. from the Sierra Nevada. Additional specimens of the same species (?) have been seen from isolated localities in several western states and provinces; usually not more than four specimens were seen from each locality. The western specimens agree in almost all respects to typical eastern specimens of *H. pinifex*. It intergrades with *H. pinifex* in British Columbia and Alberta and is probably not distinct from *H. pinifex* in the Black Hills.* Until a revision of *Hylurgops* is available, it seems best to continue using *H. pinifex* as the name for this form.

The adults can be distinguished from those of *H. rugipennis* by the intermixed large and small punctures on the pronotum, by the usually less rugose elytral interspaces, by the black ventral surface, and by the distribution.

Hylurgops rugipennis (Mannerheim)
(Map 10)

Hylurgus rugipennis Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:297. Type (sex?), Sitka, Alaska (University of Helsingfors, Finland).

Hylurgops rugipennis: LeConte, 1876, Proc. Am. Philos. Soc., 15:390.

Geographic distribution and host range.—H. rugipennis is a predominately coastal species occurring from Alaska to Central California along the coast, extending westward to Alberta in Canada. Adults attack various pines and Sitka spruce.

California records (map 10).—Various localities in the following counties: Del Norte, Humboldt, Marin, Mendocino, Monterey, Santa Cruz, Siskiyou, and Sonoma.

Biology. (Reid, 1955)

The biology of *H. rugipennis* in California has not been recorded. The following notes were made from observations in Alberta. The biology of this species in California is probably similar except that the generation time and the number of generations per year differ due to the more favorable conditions.

Primary attacks occur in the spring and early summer. By September, most of the progeny from these first attacking adults are still in the larval stage; a small percentage have pupated. The original attacking adults may emerge and produce a second brood but this fact has not been firmly established. The brood remain as larvae throughout most of the second summer. During late summer, most of these larvae will have pupated and some will have reached the adult stage. The young adults commonly emerge but do not establish broods until the following year. Thus, the life cycle may vary from 1½ to 2½ years resulting in a flight period of adults throughout most of the summer.

Adults attack the base of stumps, just above the duff. Adult galleries extend several cm above and below the entrance hole. Eggs are deposited in depressions along the sides of the galleries. The entire brood mines in congress in the early stages, becoming separated later and, at maturity are found singly or in small groups. Larvae have been found in the large lateral roots and also in the tap root several feet from the egg gallery.

Head capsule measurements indicate four larval instars.

* S. L. Wood, personal communication to senior author.

Discussion.—This is a stout beetle from 4 to 5 mm in length, red dorsally and usually black ventrally. The pronotum is narrower than the elytra, with deep, close punctures. The elytral interspaces are convex, about as wide or slightly wider than the striae, roughened, and clothed with yellowish setae which are wider on the declivity.

Genus *Hylastes* Erichson

Hylastes Erichson, 1836, Arch. Naturgesch., 2:47. Type-species: *Bostrichus ater* Paykull (Westwood, 1840).

Blackman (1941) lists 21 species of this genus in North America. Since that time, one species has been removed from synonymy (Schedl, 1951/52) and eight species have been placed in synonymy (Wood, 1957*a* and 1971*b*). Of the 14 species, six are known to occur in California.

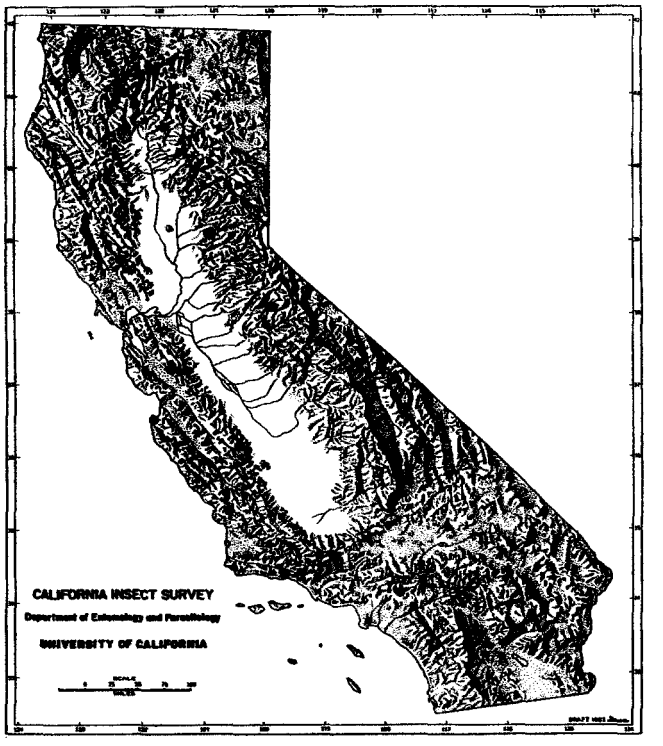
The taxonomy and nomenclature of this genus is quite complicated. The reader is referred to Blackman (1941) for a discussion concerning the proper generic name for this group of insects and for a more complete discussion of the various species.

Members of this genus are distributed throughout the Holarctic region in the coniferous forests where they are generally found in stumps and roots of dying and dead trees where the moisture content is high. Only the biology of *H. nigrinus* is known and it is believed that the life histories of the other western species are similar. Egg galleries are short and slightly curved or winding. The larvae completely riddle the inner bark without making distinct mines. Adults are apparently attracted to pitch or odors from sawdust or deteriorating trees.

Where concentrations of dead host trees occur, such as in logged, cleared, or blowdown areas, *Hylastes* beetles may emerge in large swarms and feed on tender bark of young trees. Small trees or regeneration may be killed by beetles girdling the bark at or below the root collar. Such instances are not common, however, and species of this genus are considered to be of minor economic importance.

KEY TO THE SPECIES OF HYLASTES IN CALIFORNIA

1. Body size smaller, less than 3 mm in length; epistoma not divided by smooth, raised carina; elytral interspaces clothed with hairlike setae about as long as width of interspace, and a few stout scalelike setae on the declivital interspaces ..... *tenuis* Eichhoff
   Body size larger, more than 3 mm in length; epistoma divided by a distinct raised carina; elytral vestiture variable 2
2(1). Body length more than 5 mm; pronotum rather distinctly and roughly punctured ..... *macer* LeConte
   Body length from 3.0–5.0 mm; pronotum more finely punctured 3
3(2). Mature body color bright reddish-brown; body moderately stout, 2.8 times longer than wide... *ruber* Swaine
   Mature body color reddish-brown to black; body more slender 4
4(3). Body more than 4.1 mm long, less than 3.0 times longer than wide ..... *nigrinus* (Mannerheim)
   Body usually less than 4.1 mm long, more than 3.0 times longer than wide 5
5(4). Pronotum less than 1.2 times longer than wide, slightly narrower than elytra; elytral interspaces equal to or wider than striae; pubescence scanty on disc (fig. 68) ..... *gracilis* LeConte
   Pronotum slender, more than 1.27 times longer than wide, distinctly narrower than elytra; elytral interspaces narrower than striae on disc; pubescence longer and more abundant on elytral disc..... *longicollis* Swaine



Map 11. California distribution of *Hylastes tenuis* Eichhoff.

Hylastes tenuis Eichhoff
(Map 11)

Hylastes tenuis Eichhoff, 1868, Berl. Entomol. Z., 12:147. Holotype, sex?, Amerique borealis (lost in bombing of Hamburg Museum).

Hylastes pusillus Blackman, 1941, U.S. Dep. Agric. Misc. Publ., 417:23. Holotype ♀, Florida (USNM). (Syn. by Wood, 1971*b*.)

Hylastes parvus Blackman, 1941, U.S. Dep. Agric. Misc. Publ., 417:24, Holotype ♀, Williams, Arizona (USNM). (Syn. by Wood, 1971*b*.)

Hylastes minutus Blackman, 1941, U.S. Dep. Agric. Misc. Publ., 417:25. Holotype ♀, Lake Tahoe, Nevada (USNM). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—*H. tenuis* attacks various species of pines in California. The single record from incense cedar is probably accidental. It apparently occurs in pines throughout the United States.

California records (map 11).—Lake Co.: 4 mi. S. Middletown, on *Pinus sabiniana* (CWOB). Los Angeles Co.: Brown's Flat, San Gabriel Mtns. (LBSC); San Dimas Exp. Forest (LBSC). Modoc Co.: Buck Creek (PSW). Monterey Co.: Carmel (OSU); Carmel Highlands, on *P. radiata* (CDA). Nevada Co.: Grass Valley (SLW). San Diego Co.: Mt. Laguna, on *P. jeffreyi* (PSW). San Luis Obispo Co.: 2 mi N.W. La Cuesta Pass (DEB). Santa Barbara Co.: Santa Barbara, on Monterey pine (CDA). Santa Clara Co.: Isabella Creek, Mt. Hamilton (CIS). Shasta Co.: La Moine (PSW); Oak Run, on apple (?) (CDA). Trinity Co.: Carrville (OSU). Tuolumne Co.: Pinecrest, on *Libocedrus decurrens* (PSW).

Biology.—Unknown.

Discussion.—The adults of this species are the smallest of any species in the genus in California. They may easily be distinguished from the adults of other species in California by the characters given in the preceding key.

Hylastes macer LeConte
(Map 12)

Hylastes macer LeConte, 1868, Trans. Am. Entomol. Soc., 2:175. Syntypes ♂ ♂, California and Nebraska (MCZ).

Geographic distribution and host range.—Since none of the collectors recorded the host and the biology is unknown, we can only speculate what the hosts of *H. macer* are. It is known to occur throughout western North America as far east as Nebraska. In California its hosts are probably pines but it is also believed to breed in Engelmann spruce (Chamberlin, 1939).

California records (map 12).—Numerous localities in the following counties: Alpine, Amador, Butte, Calaveras, El Dorado, Fresno, Humboldt, Inyo, Kern, Lake, Lassen, Los Angeles, Madera, Mariposa, Mendocino, Modoc, Mono, Monterey, Nevada, Placer, Plumas, Riverside, Sacramento, San Bernardino, San Luis Obispo, Shasta, Sierra, Siskiyou, Trinity, Tulare, Tuolumne, Ventura, and Yolo.

Biology.—Unknown.

Discussion.—This species is from 5.0 to 6.5 mm in length and is the largest species of *Hylastes* found in California.

Hylastes ruber Swaine

Hylastes ruber Swaine, 1915, Can. Entomol., 47:367. Holotype (sex?), Golden, British Columbia (CNC).

Geographic distribution and host range.—The sole recorded host of *H. ruber* is Douglas fir, *Pseudotsuga menziesii* and it should occur throughout the western range of this tree species.

Map 12. California distribution of *Hylastes macer* LeConte.

California records.—El Dorado Co.: Tallac (CAS). Humboldt Co.: Greenpoint (CIS). Plumas Co.: Chester (CNC).

Biology.—Unknown.

Discussion.—The adults of this red species are easily identified by the color alone. The species is not common in California but should be encountered in various areas of northern California where Douglas fir grows.

Hylastes nigrinus (Mannerheim)
(Map 13)

Hylurgus nigrinus Mannerheim, 1852, Bull. Soc. Imp. Nat. Moscou, 25:356. Type ♀, Sitka, Alaska (University of Helsingfors, Finland).

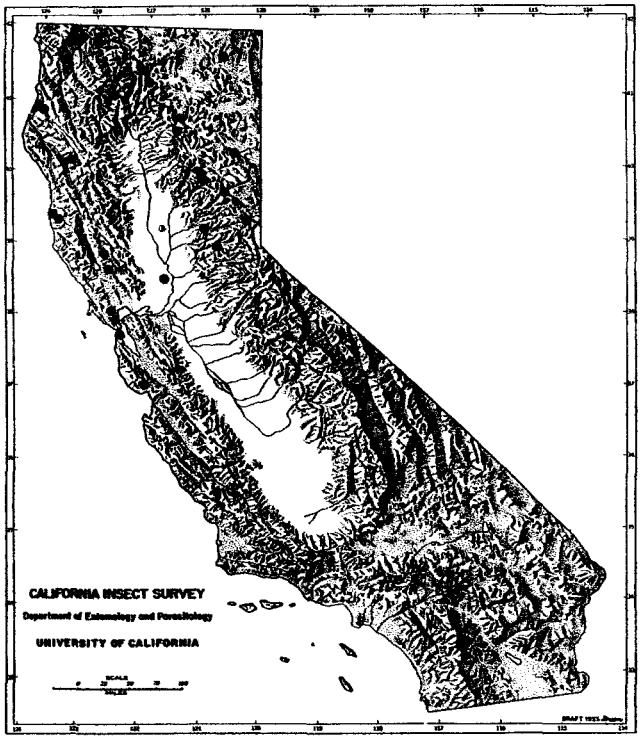
Hylastes nigrinus: LeConte, 1868, Trans. Am. Entomol. Soc., 2:174.

Hylastes yukonis Fall, 1926. Pan-Pac. Entomol., 2:207–208. Holotype ♂, Whitehorse, Yukon Territory (MCZ). (Syn. by Wood, 1957.)

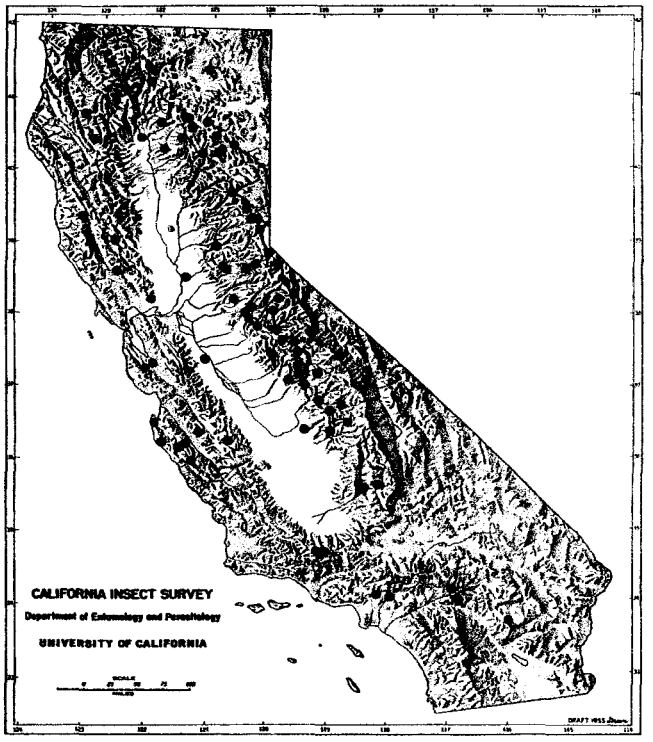
Geographic distribution and host range.—*H. nigrinus* occurs throughout western North America as far north as Alaska. It has a wide host range including *Abies* spp., *Picea* spp. *Pinus* spp., *Pseudotsuga menziesii*, and *Tsuga* spp.

California records (map 13).—Various localities in the following counties: Humboldt, Lake, Marin, Mariposa, Mendocino, Modoc, Nevada, Placer, Plumas, San Francisco, Santa Cruz, Shasta, Siskiyou, Trinity, and Yolo.

Biology. (Daterman et al., 1965; Rudinsky and Zeth-



Map 13. California distribution of *Hylastes nigrinis* (Mannerheim).



Map 14. California distribution of *Hylastes gracilis* LeConte.

ner-Moller, 1967; and Zethner-Moller and Rudinsky, 1967)

The biology on Douglas fir in Oregon is as follows. Adults begin emergence in late March, continuing through May with maximum emergence and flight in late April and early May. Maturation feeding on small roots of dead, old Douglas fir and roots of young Douglas fir, weakened after replanting, takes place prior to invasion of the host. There is an obvious attraction to stumps, freshly cut trees and to trees killed by the Douglas fir beetle, particularly to the latter. Whole oleoresin, α-pinene, and β-pinene, components of resin, have been shown to be attractive to *H. nigrinus*. Adults dig through the sawdust or soil around the host to reach the roots; they also enter at the base of the stem at the soil line.

Egg galleries are initiated by the females; the males enter later and copulation takes place within the gallery as well as outside. Egg galleries are long (average 9 cm) and winding, running parallel with the grain in one direction from the entrance hole. The part close to the entrance hole is almost always angled and wider than the rest of the gallery. One or more branches and forked mines are common. Eggs are laid in distinct, evenly spaced niches about 1 to 1.5 mm apart. Where eggs are present, the gallery is packed with frass. From 20 to 40 eggs are laid per gallery; the maximum is about 63. There is no re-emergence of parent adults.

Larvae feed more or less communally, forming no distinct larval galleries. Pupal chambers are found at all depths in the bark but mostly at the cambial layer. Adult beetles as well as full grown larvae overwinter in the gallery. The majority of the population completes development in one year but a portion may require two years to complete development. These overwinter as adults the second year.

Discussion.—Adults of this species are about 4.1 to 4.9 mm in length and display considerable variation in size, sculpture, shape of pronotum, and in elytral characters. Specimens from California may be most easily distinguished from other species of *Hylastes* in California by their pronotal shape and by their larger size.

Hylastes gracilis LeConte

(Fig. 68; map 14)

Hylastes gracilis LeConte, 1868, Trans. Am. Entomol. Soc., 2: 174. Syntypes ♂, ♀, Taho [sic] Valley, California (MCZ).

Hylastes vastans Chapuis, 1869, Synopsis des Scolytides, p. 17. Holotype ♀, Mexico (Brussels Mus.). (Syn. by Wood, 1971*b*.)

Hylastes nitidus Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):19. Holotype ♀(?), Las Vegas, New Mexico (CNC). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—In California, *H. gracilis* has been recorded from *Pinus aristata*, *P. coulteri*, and *P. sabiniana* but it probably occurs on most pines. It will probably be found throughout the pine forests of western North America.

California records (map 14).—Numerous localities in the following counties: Alpine, Calaveras, El Dorado, Fresno, Inyo, Kern, Lake, Lassen, Los Angeles, Madera, Mariposa, Mendocino, Modoc, Mono, Monterey, Nevada, Placer, Plumas, Riverside, Sacramento, San Benito, San Bernardino, San Diego, Santa Clara, Shasta, Sierra, Siskiyou, Solano, Sonoma, Stanislaus, Tehama, Trinity, Tulare, and Tuolumne.

Biology.—Unknown.

Discussion.—*H. gracilis* is one of the most variable species found in California. There is no easily observed single character which can be utilized in identifying the adults of this species. A combination of characters such as size (3.4 to 4.5 mm), shape of pronotum, vestiture, and other characters given in the key will aid in recognizing them.

Hylastes longicollis Swaine
(Map 15)

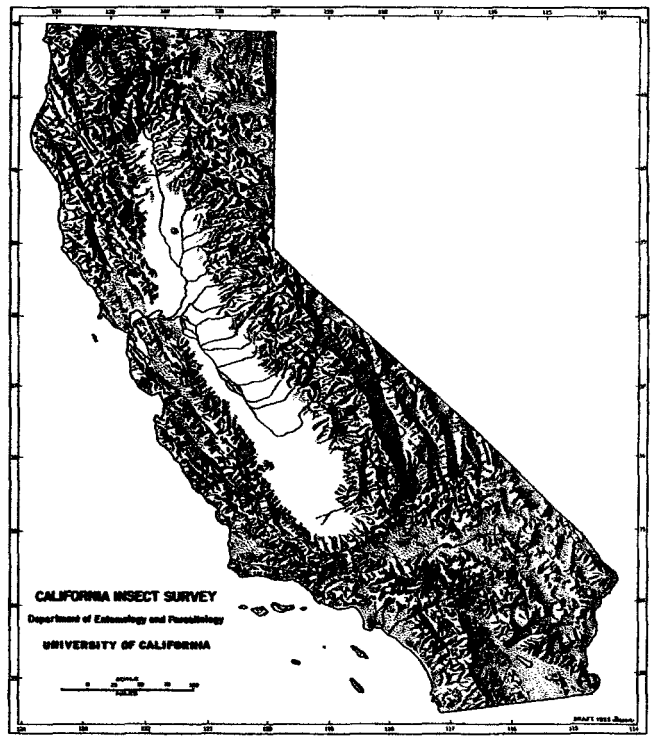
Hylastes longicollis Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):79. Holotype (sex?), Atlanta, Idaho (CNC).

Geographic distribution and host range.—The recorded distribution is throughout western North American as far east as Alberta and Montana. The hosts of *H. longicollis* are unknown but it is believed that Ponderosa pine may be attacked by this species.

California records (map 15).—El Dorado Co.: Huckleberry Meadow (CAS); Kings River Canyon (UCD). Madera Co.: Bass Lake, on yellow pine stump, in pitch (PSW). Placer Co.: Forest Hill (CAS); Tahoe City (CAS). Plumas Co.: 10 mi S. Johnsville (UCD); Meadow Valley (OSU). Santa Cruz Co.: Big Basin (USNM). Siskiyou Co.: McCloud (CAS). Tulare Co.: Giant Forest (CAS); Sequoia Natl. Park (UCD).

Biology.—Unknown.

Discussion.—This species is apparently widespread but not common in California. The adults may be readily recognized by the pronotum being obviously narrower than the elytra; otherwise they closely resemble *H. gracilis*.



Map 15. California distribution of *Hylastes longicollis* Swaine.

Tribe Hylurgini

Genus *Dendroctonus* Erichson

Dendroctonus Erichson, 1836, Arch. Naturgesch., 2(1):52. Type-species: *Bostrichus micans* Kugelann (Hopkins, 1909).

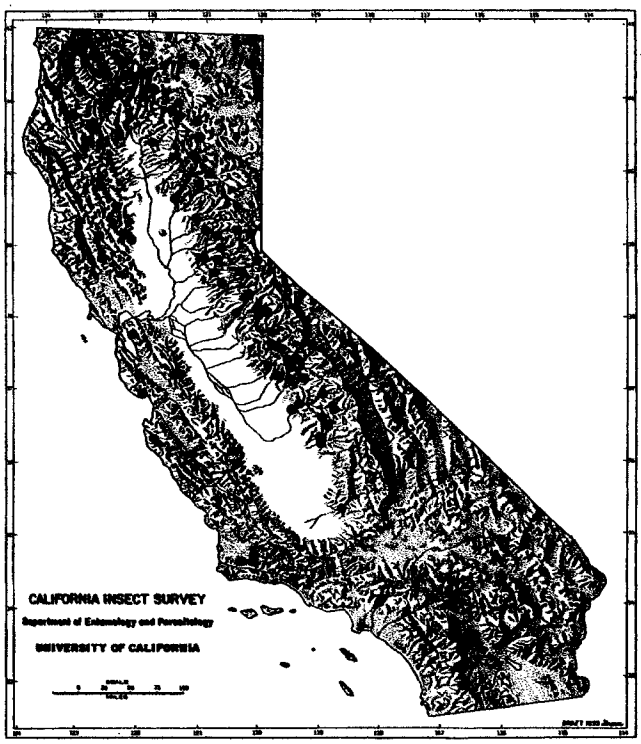
This genus is represented in the Holarctic region by 17 species, 6 of which occur in California. The genus was revised by S. L. Wood (1963) who included 14 species. One species has since been described from Russia, one from Mexico, one of Wood's synonyms has been reinstated (Lanier and D. L. Wood, 1968), and several additional name changes have taken place.

Dendroctonus is not closely related to any known genus but it has affinities with several Eurasian, Australian, and South American genera. It can easily be recognized by the characters given in the key to genera.

The larvae of the species of *Dendroctonus* were described by Thomas (1965).

KEY TO THE SPECIES OF DENDROCTONUS IN CALIFORNIA
(After S. L. Wood, 1963)

1. Frons with a longitudinal frontal groove extending from epistomal margin to upper level of eyes, lateral areas usually protuberant in male; vestiture of elytra much shorter than width of interspace with no evidence of longer hairs; body size usually smaller, 3.2 to 5 mm (fig. 69) ..... *brevicomis* LeConte
   Frons convex, without a median groove; vestiture of elytra with most hairs longer than width of interspace; body size larger..... 2
2(1). Declivital interspaces opaque (rugulose) or shining, if shining, them almost all punctures granulate in both sexes and strial punctures distinct and larger; in pines 3
   Declivital interspaces smooth and shining, usually with median row of granules; strial punctures on declivity



Map 16. California distribution of *Dendroctonus brevicomis* LeConte.

about the size of interstrial punctures; in spruce or Douglas fir 5

3(2). Mature color reddish; declivital interspaces shining with almost all punctures granulate; body size larger, 5.4 to 9.0 mm (figs. 29, 33, 36)..... *valens* LeConte

Mature color black or dark brown; declivital interspaces opaque and usually rugulose; body size smaller, 3.7 to 8.0 mm..... 4

4(3). Average size smaller, 3.7 to 7.0 mm; in pines other than *Pinus jeffreyi* ..... *ponderosae* Hopkins

Body size larger, 6.0 to 8.0 mm; in *Pinus jeffreyi*..... *jeffreyi* Hopkins

5(2). Epistomal process broad, concave, not reaching margin; second declivital interspace wider than first or third; in spruce..... *rufipennis* (Kirby)

Epistomal process flat, narrowly extended past epistomal margin; second declivital interspace much narrower than first or third; in Douglas fir..... *pseudotsugae* Hopkins

Dendroctonus brevicomis LeConte

(Figs. 5, 69; map 16)

Dendroctonus brevicomis LeConte, 1876, Proc. Am. Philos. Soc., 15:386. Holotype ♂, Middle California (MCZ).

Dendroctonus barberi Hopkins, 1909, U.S. Dep. Agric. Bur. Entomol. Tech. Ser., 17(1):85. Holotype ♀, Williams, Arizona (USNM). (Syn. by Wood, 1963.)

Geographic distribution and host range.—*D. brevicomis* occurs throughout western North America within the range of *Pinus ponderosa* and *P. coulteri*, its hosts. Attacks are made on other pines during massive outbreaks but broods are never successful in such trees.

California records (map 16).—Numerous localities in the following counties: Alameda, Butte, Calaveras, El Dorado, Fresno, Glenn, Humboldt, Kern, Lake, Lassen, Los Angeles, Madera, Mariposa, Modoc, Mono, Monterey, Nevada, Placer, Plumas, Riverside, San Bernardino, San Diego, Santa Barbara, Santa Cruz, Shasta, Siskiyou, Tehama, Trinity, Tulare, Tuolumne, and Yuba.

Biology. (Johnson, 1966; Miller and Keen, 1960; Silverstein et al., 1968; Stark, 1966; Stark and Dahlsten (eds.), 1970; Vité, 1961; Vité and Gara, 1962; Vité and Pitman, 1968; Vité and Wood, D. L., 1961; Wood, S. L., 1963)

The adult female of *D. brevicomis* initiates attack at mid-bole just below crown level, boring through the bark at right angles to the stem axis until it reaches the phloem-cambial layer. Selection and attack of uninjured, healthy trees apparently occurs at random but lightning-struck trees, trees injured by air pollutants, and those infested by root pathogens or injured in other ways appear to be more susceptible to attack. They seldom attack trees less than 30 cms in diameter. Following successful invasion by 1 or more females a powerful secondary attractant or pheromone is produced which causes a "mass attack" and the entire length of the bole is "filled in." The attacking beetles introduce a blue stain fungus which apparently aids the beetle in gallery establishment.

The foliage color of mass-attacked trees changes in rather a characteristic manner. The normal dark green fades to a pale green, gradually changes to a lemon-yellow, then to a straw, sorrel, and finally a dark red hue. Following abandonment of the tree by the beetle progeny the foliage slowly turns brownish-black and falls. This sequence of color change is extremely variable and often is not well synchronized with the insects' life cycle.

The egg gallery in the phloem-cambial region is long and winding (fig. 5). The male joins the female while she is boring-in or during the early stages of gallery construction. Egg niches are cut in the wall at more-or-less symmetrical intervals from 10 mm to 8 cm apart. Eggs (from 35 to 60) are laid one to a niche separated from the main gallery by a plug of frass. Oviposition may last up to 6 weeks in spring and summer. Overwintering females may lay a portion of their egg complement in the fall; the remainder the following spring. Except for a few cm near the entrance hole, the galleries are packed with frass.

Eggs hatch in 2 or 3 weeks and the early instar larvae bore at right angles to the parent gallery, in the same plane for about 3 cm. Then, the larvae turn out-

ward into the bark at right angles to the bole axis. The remainder of the developmental cycle is spent in the bark. Only larvae, prepupae, or adults overwinter, never pupae. When adults are mature they bore out of the bark and take flight. There is a diurnal flight periodicity corresponding roughly to the daily temperature range. The flight capacity is not known but it is suspected that *D. brevicomis* is capable of flying at least 3 km and up to 12 km when wind currents are utilized.

The number of generations per year and the length of any generation in a particular locality are variable depending on climate. Generally in the northern and higher parts of its range there is one complete generation per year and a partial overwintering generation. In the central part and at medium altitudes there are two complete generations per year and a partial overwintering one, and in the extreme southern parts of its range there may be three complete generations in a season with a partial fourth. Because of variability in the length of the attack period and development times, overlapping generations are common and some *D. brevicomis* adults may be in flight at almost any time during the summer and fall.

Discussion.—Commonly known as the western pine beetle, the adults of this species are the smallest of the genus in California, averaging around 4 mm in adult body length. The species is considered by many to be the most destructive forest pest known. Estimates for the period 1921 to 1945 place the total loss of ponderosa pine in the Pacific States at 25 billion board-feet. Losses have been at least as high as this since 1945. In addition to actual losses, the introduction of the fungus which stains the wood blue lowers the desirability and hence economic return of the salvaged wood. This problem is common to all timber species attacked by all species of the genus.

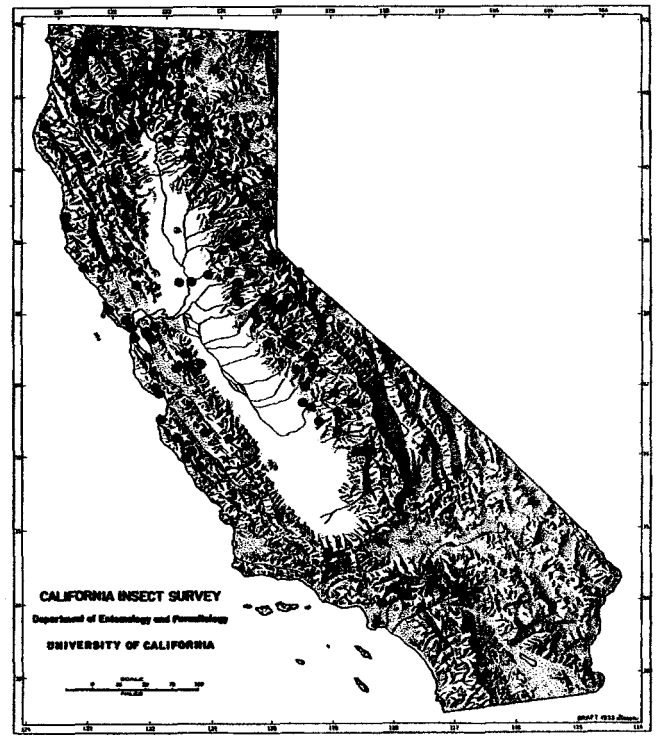
The small size usually suffices to distinguish the beetle at once. Other useful characters are the presence of a longitudinal groove of varying depth on the frons of both sexes and the uniformly short elytral setae. The gallery pattern is unique among California *Dendroctonus* (fig. 5).

Dendroctonus valens LeConte
(Figs. 29, 33, 36; map 17)

Dendroctonus valens LeConte, 1860, Pac. R. R. Explor., 5(2):59. Holotype ♂, California (MCZ).

Dendroctonus beckeri Thatcher, 1954, Coleopt. Bull., 8:4. Holotype ♀, Totonicapan, Guatemala (USNM). (Syn. by Wood, 1963.)

Geographic distribution and host range. — *D. valens* occurs throughout the coniferous forests of North America (except in southeastern United States) and in Mexico and Central America. It apparently attacks all or most species of pines.



Map 17. California distribution of *Dendroctonus valens* LeConte.

California records (map 17).—Numerous localities in the following counties: Alameda, Alpine, Amador, Butte, Calaveras, Contra Costa, El Dorado, Fresno, Glenn, Humboldt, Inyo, Kern, Lake, Lassen, Los Angeles, Madera, Marin, Mariposa, Mendocino, Modoc, Mono, Monterey, Napa, Nevada, Placer, Plumas, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Francisco, San Luis Obispo, Santa Clara, Santa Cruz, Shasta, Sierra, Siskiyou, Sonoma, Tehama, Trinity, Tulare, Tuolumne, Ventura, Yolo, and Yuba.

Biology. (Rudinsky, 1962; Smith, R. H., 1961; Wood S. L., 1963)

The red turpentine beetle, *Dendroctonus valens*, is attracted by whole oleoresin. Attacks are most common in stumps of freshly cut trees, and injured, weakened, or dying trees. However, apparently healthy trees are often attacked. Attacks may occur up to a height of 6 m on the tree trunk but are usually concentrated at or near ground level. Beetle flight and attacks occur throughout the warm season.

The female constructs the entrance tunnel and after reaching the cambium region usually turns upward for a short distance. Gallery shape is variable but is usually linear from 1 to 3 cm wide. Branched galleries and

irregular "cave type" galleries are common. The gallery is usually packed with characteristic granular reddish frass.

No egg niches are cut. Eggs are deposited along the sides of the galleries either loose in the frass or in layers of 10 to 40 or more. The total number of eggs laid per gallery may exceed 100. Following oviposition, the parent beetles may feed for a time, emerge to initiate new attacks or die in the gallery.

Eggs hatch in 1 to 3 weeks depending on the time of year. The larvae feed gregariously in the phloem tissue, often enlarging the initial gallery and killing a patch of phloem up to 20 to 30 cm across. The larval period varies from a few months to over a year depending on the climate of the area.

Mature larvae excavate separate cells in the sapwood or bark in which to pupate. Emerged adults are strong fliers capable of flights up to 16 km or more.

The rate of development of a generation and the number of generations per year varies widely. In central California a generation may complete development in 3 months. In northern latitudes and at higher elevations 2 years may be required for a generation. In southern latitudes and lower elevations two or three generations may be completed per year. Overlapping generations are typical and beetles may be found in flight throughout the summer.

Discussion.—The red turpentine beetle is not considered to be a destructive species by itself but may predispose trees to attack by other scolytids which in concert with *D. valens* cause the death of trees.

The adults of this species are the largest bark beetles found in California. The large size, the red color, and the morphological features given in the key easily distinguish them from other members of the genus.

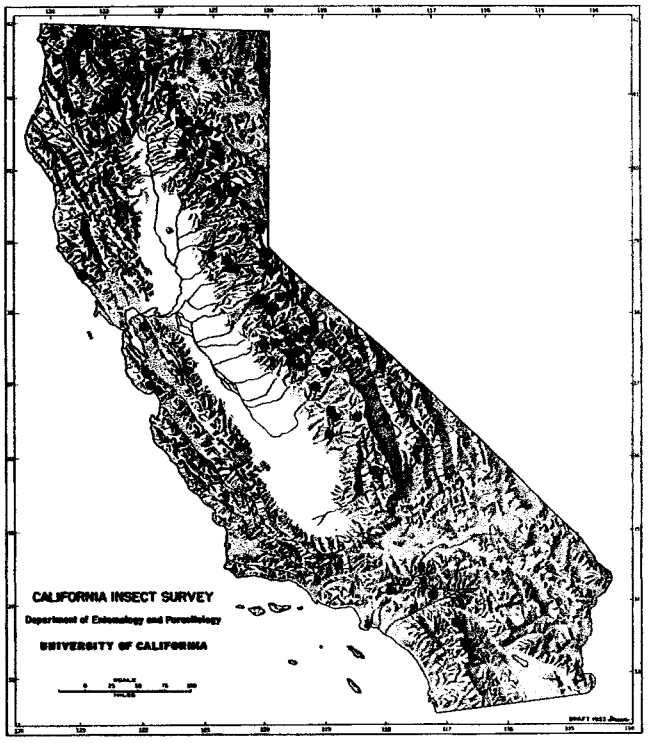
Dendroctonus ponderosae Hopkins
(Fig. 6; map 18)

Dendroctonus ponderosae Hopkins, 1902, U. S. Dep. Agric. Div. Entomol. Bull., 32:10. Holotype ♀, Spearfish, South Dakota (USNM).

Dendroctonus monticolae Hopkins, 1901, Proc. Soc. Promot. Agric., 22:67. Holotype ♀, Kootenai, Idaho (USNM). (Syn. by Wood, 1963.)

Geographic distribution and host range.—The mountain pine beetle is distributed throughout western North America and probably attacks all species of pines. Its preferred hosts in California are *Pinus contorta, P. lambertiana, P. monticola,* and *P. ponderosa.*

California records (map 18).—Numerous localities in the following counties: Alpine, Calaveras, Contra Costa, Del Norte, El Dorado, Fresno, Glenn, Humboldt, Inyo, Kern, Lassen, Los Angeles, Madera, Mariposa, Modoc, Mono, Nevada, Placer, Plumas, Riverside, San Bernardino, Santa Cruz, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.



Map 18. California distribution of *Dendroctonus ponderosae* Hopkins.

Biology. (McCambridge, 1967; Powell, 1966; Shepherd, 1965, 1966; Struble, 1965; Struble and Johnson, 1955; Vité and Pitman, 1968; Wood, S. L., 1963)

Parent adults usually attack during June, July, and August. They bore through the bark to the phloem-cambial region, turn upwards and excavate egg galleries up to 75 cm or longer (fig. 6). Galleries are usually longitudinal with the stem axis of the tree but may be somewhat sinuous in sugar pine and in other hosts when obstructions such as knots or branch stubs are encountered. The nuptial chamber may be offset from the egg gallery to form an extended "J" pattern.

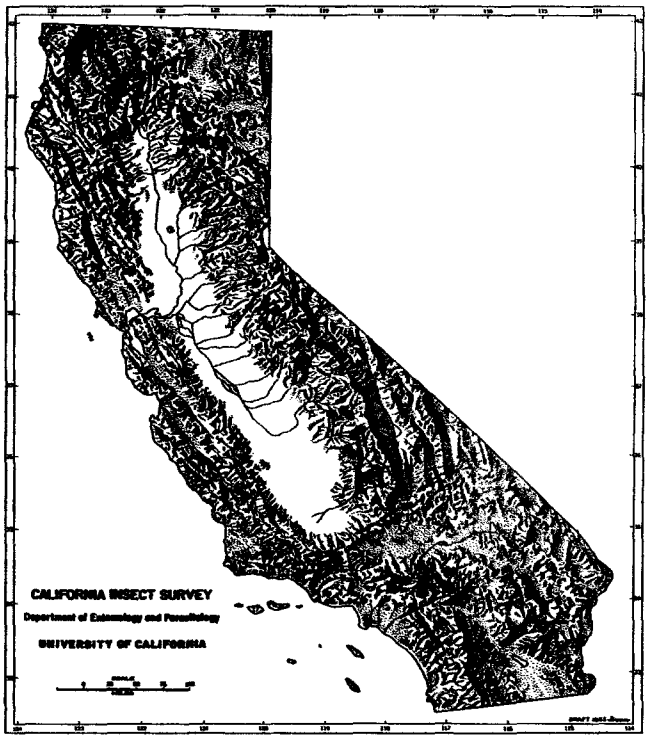
Beetles are attracted to trees under attack, lightning-struck trees, overmature trees with decadent crowns, mechanically injured trees, suppressed second-growth, diseased trees, and freshly killed trees. They are apparently less able to overcome trees with visible oleoresin flow than the western pine beetle. There is evidence to suggest that once successful attack by a few beetles is initiated, an attractant is produced which encourages mass attack. Partial attacks which do not kill the tree outright are fairly common but such trees usually succumb eventually. Pitch tubes or pitch "streamers" are common evidence of attack.

Eggs are placed along each side of the gallery in individual niches 2 to 5 cm apart and tightly packed in with frass as is the egg gallery behind the ovipositing female.

Upon hatching, the larvae feed in the phloem-cambial region in individual tunnels. These feeding galleries extend 2 to 14 cm at right angles to the egg gallery. Usually in late fall, the mature larva excavates a shallow, oval pit for pupation. The brood may overwinter in any stage except pupae, from young larvae to young adults, depending on the time of attack and climatic conditions.

There is one generation per year throughout most of the beetle's range. Two generations and often the beginning of a third may occur in warm climates at elevations below 2,000 m south of latitude 40° N.

Discussion. – This is one of the most destructive species in the pine forests of western North America. Severe economic damage is most common in lodgepole, western white, sugar, and ponderosa pine stands. Morphologically the adult is very similar to the adult of *D. jeffreyi*. It may be recognized by the evenly convex frons, by the shallowly emarginate epistomal margin, by the rugulose elytral interstriae, and by its gallery pattern.



Map 19. California distribution of *Dendroctonus jeffreyi* Hopkins, ● ; *Dendroctonus rufipennis* (Kirby), O .

Dendroctonus jeffreyi Hopkins
(Map 19)

Dendroctonus jeffreyi Hopkins, 1909, U. S. Dep. Agric. Bur. Entomol. Tech. Ser., 17(1):114. Holotype ♀, Little Yosemite, California (USNM).

Geographic distribution and host range.—The distribution of the Jeffrey pine beetle follows that of its host, from southwest Oregon, south through the Sierra Nevada of California and western Nevada, through the mountains of southern California into northern Baja California, Mexico. Occasional attacks occur on ponderosa pine.

California records (map 19).—Numerous localities in the following counties: Amador, El Dorado, Fresno, Humboldt, Lassen, Los Angeles, Madera, Marin, Mariposa, Mono, Placer, Plumas, San Bernardino, Santa Barbara, Shasta, Siskiyou, Tulare, and Tuolumne.

Biology. (Eaton, 1956; Smith, 1965; Wood, S. L., 1963)
The life cycle of this species is similar to that of the mountain pine beetle except that Jeffrey pine is apparently the only host in which it breeds successfully. The adults cannot tolerate the resin vapors of other pines.

There is usually only one generation per year, but one and a partial second and two generations per year may occur in the southernmost part of the range and at lower elevations. Principal attack periods are June and July and late September and early October.

Discussion.—On occasion, this beetle may be extremely destructive but normally is restricted to a single tree or small group kills in decadent forests of retarded vigor.

Because of the morphological and biological similarities of this species to *D. ponderosae*, S. L. Wood (1963) placed *D. jeffreyi* in synonymy under *D. ponderosae*. Considerable interest was focused on these two species because of the economic implications of this action. Smith (1965) recognized a biological difference between the adults of these two species and recommended their continued distinction. Recently, cytological and mating experiments showed that the two species were distinct (Lanier and D. L. Wood, 1968).

The adults of *D. jeffreyi* can be distinguished from those of other members of the genus in California by the same characters given for *D. ponderosae*. From *D. ponderosae* they can be distinguished by their larger average body size (from 6.0 to 8.0 mm), by a pronotal width of 2.5 to 2.9 mm, by the less densely punctured pronotum, and by the host.

Dendroctonus rufipennis (Kirby)
(Map 19)

Hylurgus rufipennis Kirby, 1837, *in* Richardson, Fauna Boreali Americana, 4:195. Type (sex ?), Boreal, North America (BM).
Dendroctonus rufipennis: LeConte, 1868, Trans. Am. Entomol. Soc., 2:173.

Hylurgus obesus Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:296. Type (sex ?), Sitka, Alaska (University of Helsingfors, Finland). (Syn. by S. L. Wood, 1969*b*.)

Dendroctonus obesus: LeConte, 1968, Trans. Am. Entomol. Soc., 2:173.

Dendroctonus similis LeConte, 1860, Pac. R. R. Explor., 5(2): 59. Holotype (sex ?), Oregon (MCZ). (Syn. by LeConte, 1868.)

Dendroctonus piceaperda Hopkins, 1901, U. S. Dep. Agric. Div. Entomol. Bull., 28:16. Holotype ♀, Camp Caribou, Maine (USNM). (Syn. by S. L. Wood, 1963.)

Dendroctonus engelmanni Hopkins, 1909. U. S. Dep. Agric. Bur. Entomol. Tech. Ser., 17(1):130. Holotype ♀, Capitan, New Mexico (USNM). (Syn. by S. L. Wood, 1963.)

Geographic distribution and host range.—*D. rufipennis*, the spruce beetle, occurs throughout the spruce forests of North America, where it attacks all species of spruce.

California records (map 19).—Various localities in the following counties: Del Norte, Humboldt, Siskiyou, and Trinity.

Biology. (Dyer and Taylor, 1968; Grant and Cottrell, 1968; Massey and Wygant, 1954; Wood, S. L. 1963)

Attack periods, length of development, and consequently the number of generations per year vary considerably because of the wide range of this species. The life history in British Columbia, described below, is probably comparable to that in California.

Females attack first; windfall, freshly cut logs, and shaded slash are preferred, but standing trees are attacked when populations are high. In prostrate trees only the lower half next to the ground is attacked. In standing trees, the lower one-third of the bole is preferred and is the first attacked but attacks may occur up to a 20 cm top. The rate of attack is slow, unlike the sudden "mass attack" of such species as *D. brevicomis*. Stands over 120 years of age are most susceptible.

The female bores into the cambial region, is joined by the male, and they commence to excavate the egg gallery. Parent adults may re-emerge for a second attack. Galleries are vertical and straight with an average length of 13 cm (maximum 23 cm). There is commonly a bend, 1 to 2 cm above the entrance tunnel. Eggs occasionally are placed individually in separate niches but more commonly they are laid in greater numbers in egg grooves up to 8 cm in length. The grooves are formed on alternate sides of the gallery. Up to 200 eggs per female may be deposited.

For about the first third of their development larvae feed communally but then form individual feeding galleries which may cross. Pupal cells are formed at the ends of larval mines or in previously excavated areas either next to the cambium or entirely in the bark.

D. rufipennis commonly has a 2-year life cycle in British Columbia but some populations or parts thereof may mature in 1 year or take 3 years to mature. Regardless of the length of the life cycle, this species must overwinter as an adult before it can attack. This hibernation habit has not been recorded for any other *Dendroctonus* species.

In the 2-year cycle adults emerge and attack in midsummer. The resulting larvae overwinter and the brood adults may overwinter in the pupal cells or may emerge in late fall and re-enter the tree at the root collar where they excavate hibernating chambers in the thick bark. The 1-year cycle populations become adults by late fall, overwinter as described and emerge and attack in late June or early July. The 3-year cycle beetles overwinter twice as larvae and once as adults.

Discussion.—This species, under the name *engelmanni*, was responsible for tremendous losses of Engelmann spruce in the Rocky Mountain region from 1948 to 1955. Such outbreaks usually follow from populations which increased in large volumes of windthrow or logging slash. It remains the most dangerous forest pest in this region. In California, it has not reached such destructive proportions.

From 1963 to 1969 this species was known by the name *D. obesus*. S. L. Wood (1969*b*) changed the name to *D. rufipennis* after examining the types of the various names involved. The adults may be distinguished from those of other members of the genus by the reddish elytra and black pronotum, by the weakly impressed declivital striae, by the shining declivital interspaces, and by the host and gallery pattern.

Dendroctonus pseudotsugae Hopkins
(Map 20)

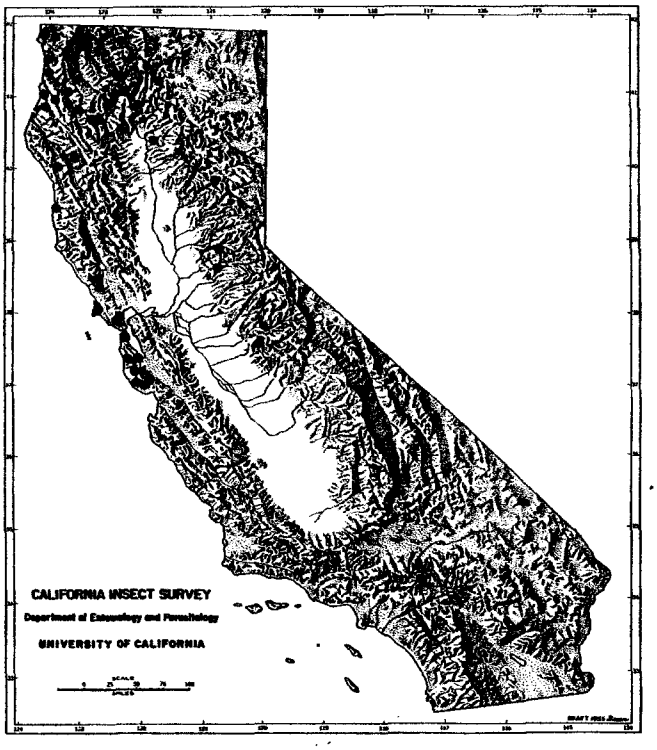
Dendroctonus pseudotsugae Hopkins, 1905, U. S. Dep. Agric. Bur. Entomol. Bull., 56:11. Holotype ♀, Grants Pass, Oregon (USNM).

Geographic distribution and host range.—Occurs throughout western North America within the range of its host, Douglas fir.

California records (map 20).—Numerous localities in the following counties: Alameda, Del Norte, El Dorado, Humboldt, Lake, Marin, Mariposa, Mendocino, Placer, Plumas, San Francisco, San Mateo, Santa Clara, Santa Cruz, Shasta, Siskiyou, Sonoma, and Trinity.

Biology. (Borden, 1968; Furniss, 1965; Rudinsky, 1966; Skovsgaard, 1968; Wood, S. L., 1963)

The first flight and attack period occurs in late April or May. Attacking females chew through outer bark into the phloem-cambial region where they excavate the egg galleries. This dispersal flight is oriented toward fresh windthrown, fire-injured, or cut trees when present. Apparently, the beetles are attracted by fresh oleoresin. Although trees of subnormal physiological



Map 20. California distribution of *Dendroctonus pseudotsugae* Hopkins.

condition are preferred, under epidemic conditions and in attractive attack centers, even vigorous trees may be invaded. When concentrations of susceptible material are lacking, beetles tend to be distributed uniformly throughout forest stands.

A second concentration of beetles occurs in attacked trees. The frass produced by attacking females is attractive to other beetles of this species up to a period of 2 weeks. At close range, oleoresin repels the Douglas fir beetle. The secondary insect-produced attraction is thus stronger or "masks" the repellent action of oleoresin.

Egg galleries are simple, parallel to the grain of the wood, and range from 12 to 75 cm in length (average 20 to 25 cm). A single male joins the female in the gallery and helps eject the boring dust and frass during initial gallery construction. Later, the frass is packed in the gallery behind the pair. After completion of egg-laying, the beetles may emerge to attack additional trees. From 6 to 24 eggs are laid in grooves on alternate sides of the gallery. Females lay from 20 to 100 eggs.

Larvae mine out more or less at right angles to the gallery but gradually spread out to form a characteristic fan-shaped feeding gallery. They feed in the inner bark but when mature may bore into the bark to pupate. Most of this brood overwinter as young adults. Development from egg to adult requires from 7 to 10 weeks depending on temperature.

Some of the progeny of the spring attacking brood may develop by July and emerge to form part of a second or summer attack. However, the majority of the beetles comprising the second brood are progeny from the previous summer attack which overwintered as larvae. Thus, the life cycle of the Douglas fir beetle is about 1 year long with two overlapping broods produced in each generation. Adults often congregate in hibernating galleries to overwinter. Some adults may live over a second winter.

Discussion.—Dendroctonus pseudotsugae is the most destructive insect enemy of Douglas fir throughout the range of that tree. Although its depredations are usually restricted to felled, injured, or weakened trees, populations frequently build up in areas of extensive windthrow, flood, fire, defoliation, and logging to epidemic proportions, causing extensive losses.

The adults of this unique species are easily recognized by the narrow, elongate epistomal process, by the impressed declivital striae and by the host.

Tribe Hylesinini

Genus *Xylechinus* Chapuis

Xylechinus Chapuis, 1869, Synopsis des Scolytides, p. 36. (Preprint of Mem. Soc. R. Sci. Liege, 2(3):244, 1873.) Type-species: *Dendroctonus pilosus* Knoch, monotypic.

Two species of this genus occur in North America, *X. montanus* Blackman in the western United States and *X. americanus* Blackman in the east. Numerous species are known from Central and South America and one species occurs in Europe.

Xylechinus montanus Blackman

Xylechinus montanus Blackman, 1940, Proc. Entomol. Soc. Wash., 42:123. Holotype ♀, Sula, Montana (USNM).

Geographic distribution and host range.—X. montanus apparently attacks only Engelmann spruce and is found throughout western North America where this tree species occurs.

California record.—Siskiyou Co.: 7 mi N.E. of Callahan, on *Picea engelmanni* (CIS).

Biology.—This bark beetle apparently attacks the main stem of small, suppressed trees which are weakened, dying or recently dead, and large broken limbs which have fallen to the ground.

The species is polygamous. Galleries are irregularly radiate with 2 to 4 egg tunnels containing a total of 10

to 30 eggs. The galleries are formed in the phloem-cambial region.

Discussion.—*X. montanus* is a rare species in California, having been found only in the extreme northern portion of the state in Engelmann spruce and is not considered even of potential economic importance.

This species is easily recognized since it is the only one in which the adults bear scaly vestiture and occur in Engelmann spruce. An erect row of flattened scales in the middle of each elytral interspace will separate it from species of *Pseudohylesinus*, the only genus with which it could possibly be confused.

Genus *Pseudohylesinus* Swaine

Pseudohylesinus Swaine, 1917, Can. Dep. Agric. Entomol. Bull., 14:11. Type-species: *Pseudohylesinus grandis* Swaine, original designation.

Ten species and four subspecies of this genus occur in North America and Mexico, the majority in the Pacific Northwest states. Of these, seven species and three subspecies occur in California (Bright, 1969).

Species of this genus are easy to distinguish from those of other genera occurring in coniferous trees by the densely scaly pronotum and elytra. They are somewhat more difficult to separate than species in other genera of comparable size due to their morphological similarities. Host and gallery pattern combined with morphological characters should be adequate in most cases.

KEY TO THE SPECIES OF PSEUDOHYLESINUS IN CALIFORNIA
(After Bright, 1969)

1. Frons of both sexes about as long as wide; antennal club with first segment equal to or slightly longer than second; body slender, usually more than 2.2 times longer than wide 2
   Frons definitely longer than wide; antennal club with first segment distinctly longer than second, sometimes as long as second and third; body stout, usually less than 2.2 times longer than wide except *P. granulatus* 4
2(1). Elytral bases with serrations high, sharp and prominent, more so at sides; ninth interspace strongly elevated and distinctly serrate; body size smaller, less than 3.6 mm; parent galleries longitudinal 3
   Elytral bases with serrations low, blunt; ninth interspace not strongly elevated nor distinctly serrate; body size larger, 2.8–4.0 mm; parent galleries transverse ..... *dispar dispar* Blackman
3(2). Elytral declivity with first and third interspaces slightly elevated with small inconspicuous tubercles; second declivital interspace about as wide as on disk; serrations of ninth interspace less strongly developed; body size 2.2–2.9 mm (fig. 70) ..... *nebulosus nebulosus* (LeConte)
   Elytral declivity with first and third interspaces strongly elevated with prominent, sharp tubercles; second declivital interspace strongly narrowed posteriorally; serrations of ninth interspace strongly developed; body size 3.0 to 3.5 mm ..... *nebulosus serratus* Bruck
4(1). Body size larger, up to 5.5 mm; body more slender, 2.4 times longer than wide; pronotum and frons strongly granulate-punctate; elytral striae about as wide as interspaces, punctures deep ..... *granulatus* (LeConte)
   Body size smaller, less than 4.6 mm; body stout, about 2.25 times longer than wide; frons not strongly granulate-punctate; elytral striae narrower than interspaces 5
5(4). Pronotal scales narrow, hairlike in female; elytral striae of both sexes wider, interspaces appearing convex; interstrial setae in females shorter than width of interspace ..... *tsugae* Swaine
   Pronotal scales broader, not hairlike in either sex; elytral striae narrower and interspaces flat; interstrial setae coarser and longer than width of interspaces in both sexes 6
6(5). Frons with arcuate impression not distinct in either sex; frons of male broad (.76 to .51 mm, ave. .54 mm); elytral scales of female nearly circular on disk ..... *grandis* Swaine
   Frons with arcuate impression deep and distinct in both sexes; frons of male narrower; elytral scales of female longer than wide on disc 7
7(6). Frons of male broader (.55 mm to .48 mm, ave. .49 mm); in Sitka spruce ..... *sitchensis* Swaine
   Frons of male narrower (.43 mm to .32 mm, ave. .33 mm); in coastal pines ..... *sericeus* (Mannerheim)

Pseudohylesinus dispar dispar Blackman
(Map 21)

Pseudohylesinus dispar Blackman, 1942, U. S. Dep. Agric. Misc. Publ., 461:11. Holotype ♀, Vernonia, Oregon (USNM).
Pseudohylesinus dispar dispar: Bright, 1969, Univ. Calif. Publ. Entomol., 54:20.

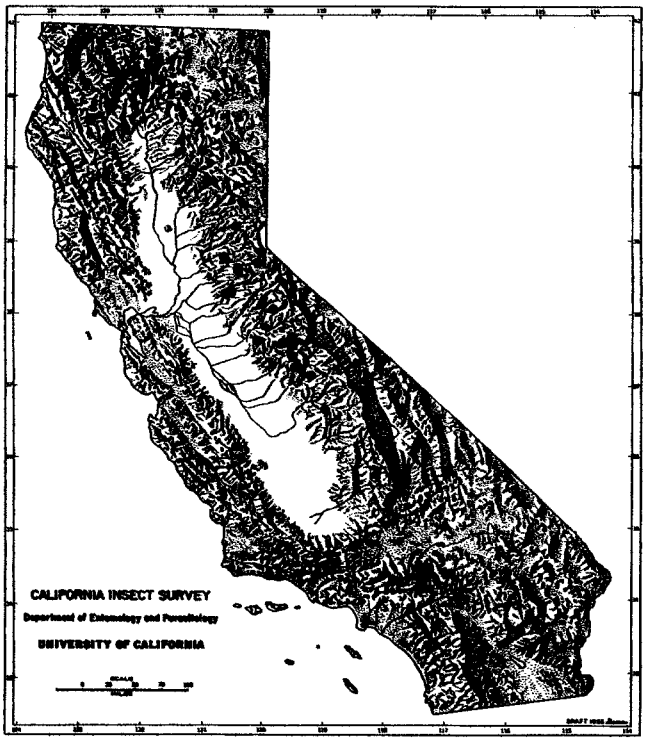
Geographic distribution and host range.—This species occurs from central California to central Washington attacking various species of fir.

California records (map 21).—Numerous localities in the following counties: Amador, El Dorado, Fresno, Humboldt, Lassen, Madera, Mariposa, Modoc, Placer, Plumas, Shasta, Siskiyou, Trinity, and Tuolumne.

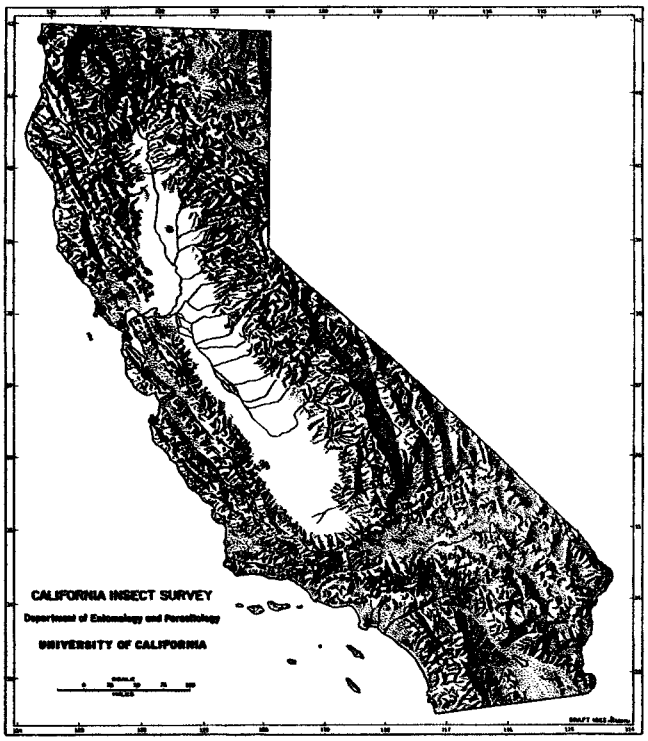
Biology. (Bright, 1969)

Attacks are made in the bole of felled or decadent trees or in trees previously attacked or killed by other insects. In California this species has been found only in windthrown trees.

Egg galleries are excavated in the phloem region and consist of two straight arms, transversely oriented, extending from the entrance chamber. Obstructions such as knots or pitch pockets may cause irregularities. The galleries are kept free of frass and up to 72 eggs (ave. 57) are laid in individual niches on both sides. Eggs



Map 21. California distribution of *Pseudohylesinus dispar dispar* Blackman.



Map 22. California distribution of *Pseudohylesinus nebulosus nebulosus* (LeConte), ● ; *Pseudohylesinus nebulosus serratus* Bruck, O .

are packed in with frass and the gallery wall smoothed. After egg deposition, adults may emerge and make a second attack and occasionally even a third.

Early larval feeding is usually in the inner bark, not scoring the sapwood; but later instar larvae usually do engrave the sapwood. Feeding galleries are at right angles to the egg gallery at first, but later they may diverge or cross. Pupation occurs in enlarged cells either in the phloem-cambial region or in the bark.

There is one generation per year but because of the multiple attacks and variable emergence times, overlapping generations are common and attacks may occur throughout the summer period.

Discussion.—P. dispar dispar is a very common species in white fir throughout the Sierra Nevada of California, but because of its preference for dead or dying trees is not considered to be economically important.

The adults of this species can be distinguished by the light brown and white color pattern, by the body size (2.8 to 4.0 mm), by the relatively broad frons, and by the gallery pattern.

Pseudohylesinus nebulosus nebulosus (LeConte)

(Figs. 7, 31, 70; map 22)

Hylesinus nebulosus LeConte, 1859, Proc. Acad. Nat. Sci. Phila., 5:285. Holotype (Sex ?), Table Mountain, California (MCZ).

Pseudohylesinus nebulosus: Swaine, 1918, Can. Dep. Agric. Entomol. Bull., 14(2):75.

Pseudohylesinus nebulosus nebulosus: Bright, 1969, Univ. Calif. Publ. Entomol., 54:16.

Geographic distribution and host range.—P. n. nebulosus occurs throughout western North America on a wide variety of conifers including Douglas fir, true firs, hemlock, cedars, spruce, and pine.

California records (map 22).—Various localities in the following counties: Del Norte, El Dorado, Humboldt, Marin, Mariposa, Monterey, Napa, Placer, Plumas, San Francisco, Shasta, Siskiyou, Sonoma, and Trinity.

Biology. (Bright, 1969; Daterman et al., 1965; Stoszek and Rudinsky, 1967; Walters and McMullen, 1955)

Attack is usually confined to thin-barked slash of saplings, poles or limbs, and tops of large trees. It is capable of killing small diameter, suppressed, or weakened trees, saplings and tops of live, apparently healthy, Douglas fir. This species is one of the earliest bark beetles attacking trees. Attacks begin as early as May 5 and continue throughout May. Later, the Douglas fir beetle, *Dendroctonus pseudotsugae*, commonly attacks the same material. Numbers of *P. nebulosus* are often so dense as to inhibit establishment by the Douglas fir beetles.

Attacking adults bore through to the cambium where an enlarged nuptial chamber is formed. The beetles work in pairs (monogamous) to excavate a short (2 to 5 cm) longitudinal egg gallery which does not score the sapwood (fig. 7). This and the reddish boring dust serve to distinguish it from *Scolytus unispinosus* whose gallery (fig. 4) is similar. Eggs are laid singly in niches cut on both sides of the gallery at intervals of 1 to 1.5 cm. The maximum number of eggs laid is over 40, the average about 18. After oviposition, the parent adults often emerge in June but do not make another attack; apparently, they die after emergence.

Larvae hatch in about 2 weeks and mine for a short distance at right angles to the egg gallery and then turn up or down. Average feeding gallery length is 2.3 cm. The larvae develop in about 41 days. Late instar larvae bore into the inner bark and prepare a pupal cell which is usually not visible from the inside bark surface. The pupal period lasts about 8 days.

Teneral adults emerge as early as July 26 in some warmer areas but the more common emergence period is from August 15 to September 22, with the peak emergence occurring about August 27. Maturation feeding is apparently necessary and this may cause considerable damage. This feeding occurs in healthy twigs of Douglas fir of any age. Short, irregular galleries are excavated which may cause the twigs to break off; at best, callous or canker growth forms over the feeding area. More commonly, feeding niches and galleries up to 2.5 cm are cut into the bark. As many as four adults have been found in one gallery. These feeding niches are also used as overwintering sites and some may be extended as egg galleries the following spring. Some authors claim they also overwinter in moss and forest litter.

The number of generations per year varies from one in interior British Columbia and Oregon to two or more per year in California.

Discussion.—Damage by *Pseudohylesinus nebulosus nebulosus* is usually negligible but occasionally damage to regeneration is a problem.

The small body size, color pattern, host, and gallery pattern will distinguish this subspecies from other species in the genus. It may be distinguished from *P. nebulosus serratus* by the declivital characters brought out in the key and by its host and distribution.

Pseudohylesinus nebulosus serratus Bruck
(Map 22)

Pseudohylesinus serratus Bruck, 1936, Bull. S. Calif. Acad. Sci., 35:37. Holotype ♀ ?, Los Angeles Co., California (OSU).
Pseudohylesinus nebulosus serratus: Bright, 1969, Univ. Calif. Publ. Entomol., 54:18.

Geographic distribution and host range.—This subspecies is restricted to big-cone spruce in southern California.

California records (map 22).—Los Angeles Co.: Big Pines (CIS); Big Tujunga Canyon (SFVSC); W. Fork San Gabriel Canyon, on *Pseudotsuga macrocarpa* (LASM); Switzers Camp, Angeles Natl. For., on *P. macrocarpa* (CIS).

Biology.—The biology of this subspecies is largely unknown but is probably similar to *P. nebulosus nebulosus*. It is suspected to have several generations per year in southern California.

Discussion.—The adults of this subspecies can be distinguished from those of *P. nebulosus nebulosus* by the presence of prominent granules on the strongly elevated first and third declivital interspaces and by the host and distribution. Size and color pattern will further assist in distinguishing it from the other species of the genus.

Pseudohylesinus granulatus (LeConte)
(Map 23)

Hylastes granulatus LeConte, 1868, Trans. Am. Entomol. Soc., 2:175. Holotype (sex ?), Oregon (MCZ).
Pseudohylesinus granulatus: Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):74, 75.

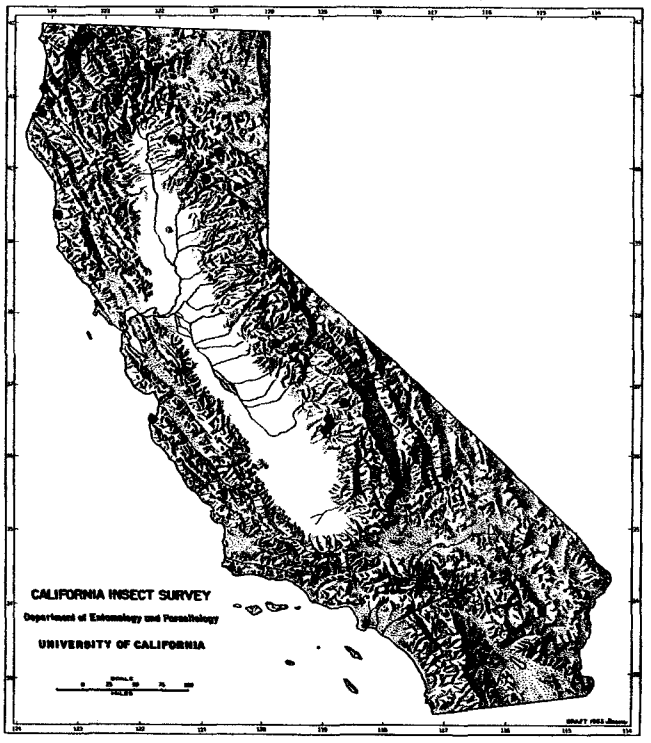
Geographic distribution and host range.—*P. granulatus* attacks all species of true firs and is distributed from southern California to Washington, and east to Idaho.

California records (map 23).—Alpine Co.: Alpine Lake (CAS). El Dorado Co.: Fallen Leaf Lake (CAS). Fresno Co.: Paradise Valley (CAS). Humboldt Co.: Eureka (USNM); Fieldbrook (PSW); Trinidad (PSW). Lassen Co.: Facht (PSW). Mariposa Co.: Badger Pass, Yosemite Natl. Park (CIS); Boundary Hill (CDA). Mendocino Co.: Mendocino (CWOB). Monterey Co.: Carmel (PSW). Plumas Co.: Meadow Valley (CIS). Shasta Co.: Shingletown (CIS). Siskiyou Co.: Trinity Center, on *Abies magnifica* (HSC). Tulare Co.: Kaweah (PSW); Round Meadow, Giant For. (CDA); Sequoia Natl. Park (CIS).

Biology. (Bright, 1969; Dyer and Nijholt, 1965; Thomas and Wright, 1961)

P. granulatus commonly attacks windthrown, felled, injured, suppressed trees and poles, and saplings in dense stands. However, extensive attack and killing of mature silver fir can also occur.

Attack by this species characteristically occurs in the basal part of the tree from several centimeters below ground level up to about 5 meters. It usually attacks in conjunction with *P. grandis* but the latter attacks the upper portions of the stem. Usually more than 1 year of attack is required for death of a mature tree to occur. Attack may develop in patches, not girdling the tree. Trees may recover from scattered attacks but more frequently recurrent attacks over a period of years



Map 23. California distribution of *Pseudohylesinus granulatus* LeConte.

eventually overcome such trees. Brown-stain fungi introduced by the beetles apparently aid in overcoming tree resistance. The foliage of dying trees passes through color changes in a manner common to most bark-beetle-killed trees.

There are two types of attack. In late May or early June, overwintering adults emerge and make egg-laying attacks. In late July or early August some of these re-emerge, construct more galleries, and lay a second batch of eggs. The second type occurs in August when new adults emerge and make hibernating attacks. They select *Abies* bark and bore nearly straight galleries, 6 to 15 mm long into the bark but *not* to the cambium. As many as four may enter the same hole and make separate niches in the bark. These hibernating attacks are concentrated near the ground up to about 2.5 m and in trees within 25 m of the forest edge. Apparently none hibernate in the ground. It is these adults emerging in the spring which make the egg-laying attack.

The entrance holes of the beetle are inconspicuous as the beetles bore in dark crevices and under bark scales, mosses, and lichens. The reddish-brown boring dust from the entrance hole may form a conspicuous ring around the base of the tree.

The egg gallery is excavated in the phloem-cambium region at right angles to the stem axis. Length varies from 2 to 18 cm. Eggs are laid in niches cut in either side.

Larvae hatch in 10 to 14 days and mine at right angles to the egg gallery, usually following the grain. Parallel at first, the larval mines diverge and wander, often crossing as the larvae grow. The larval stage lasts 12 to 14 months; feeding stops during the winter. Due to overlapping generations, both larvae of one generation and hibernating adults of another are present at this time. Mature larvae construct pupal cells in July in the inner bark. Emergence begins in August.

Discussion. – *Pseudohylesinus granulatus* and *P. grandis* are together referred to as silver fir beetles. Although normally non-destructive they have, in one extended period (1947–1955), killed over 1 million cubic meters of mature Pacific silver fir on 405,000 hectares.

This species has the largest adults of any species in the genus north of Mexico. The adults can be separated from those of other species by their large size (up to 5.5 mm), by the roughly sculptured elytral interspaces, and by the strongly and deeply punctured frons.

Pseudohylesinus tsugae Swaine

Pseudohylesinus tsugae Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):11. Holotype ♀, Vancouver, British Columbia (CNC).

Pseudohylesinus obesus Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):15. Holotype ♀, Inverness, British Columbia (CNC). (Syn. by Bright, 1969.)

Pseudohylesinus keeni Blackman, 1942, U. S. Dep. Agric. Misc. Publ., 461:17. Holotype ♀, Cannon Beach, Oregon (USNM). (Syn. by Bright, 1969.)

Geographic distribution and host range.—*P. tsugae* occurs in the Pacific Coast mountain ranges from Alaska to California. It attacks both species of hemlock within its range.

California record.—DEL NORTE CO.: Crescent City, on *Tsuga heterophylla* (CIS).

Biology. (Bright, 1969: McGehey, 1967; McGehey and Nagel, 1969)

Attacks by this bark beetle extend from early May to late August. The beetles prefer stumps of recently cut trees and fresh slash for brood establishment, but maturation feeding does occur in live standing trees. Attacks occur from ground level to the upper bole just below live crown level (about 9 m). Adults usually re-emerge and make a second attack before dying.

Females initiate the attack and are joined by the male just before or during entrance. Copulation takes place on the bark or in a nuptial chamber excavated just inside the bark. The beetles work in pairs to construct a transverse egg gallery ranging in length from 19 to 75

mm (ave. 42 mm). The gallery may extend in one direction, or both, from the entrance hole. The sapwood is scored to various depths, up to 1.0 mm.

Eggs are laid in niches cut on opposite sides of the gallery at about 0.5 mm intervals. About 30 eggs are laid per gallery. Eggs are present in the field from May through August; the incubation period is about 30 days.

The larvae mine at right angles to the parent gallery, just scoring the sapwood. Under crowded conditions late instar larvae may reverse direction. Larvae in stumps may mine into the upper roots, often pupating at depths of 10 cm beneath ground level. Larval mines reach 26 cm in length. Larvae are present in the field from June to May of the following year, hibernating in almost any larval stage. Pupation begins in April and is completed by mid-July. A total of 12 to 17 months is required to complete a single generation.

Females attack the bark of standing trees, apparently to feed prior to sexual maturity. The feeding galleries extend 5 to 8 mm into the bark of standing trees and are abandoned 3 to 11 days after initiation. Late emerging adults may overwinter in these maturation feeding galleries. If a feeding gallery only, males are not found but if used as a hibernation site males frequently join the female.

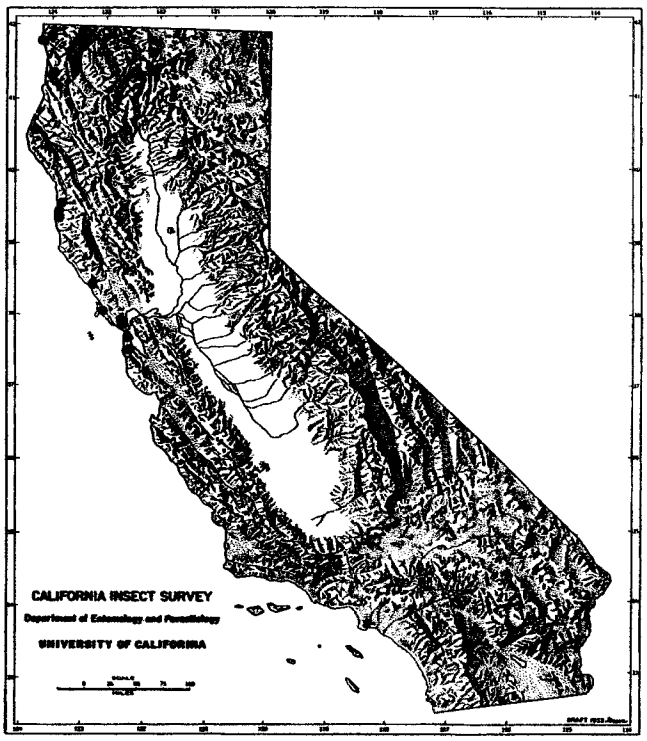
Discussion.—No economic damage from attacks by *P. tsugae* has been reported. This is the only species in this genus in which the adults possess very narrow hairlike scales on the pronotum of both sexes. This character combined with the lack of stout erect hairlike setae, the very narrow (almost hairlike) elytral setae of the female, and the reddish body color will distinguish them at once.

Pseudohylesinus grandis Swaine
(Fig. 8; map 24)

Pseudohylesinus grandis Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):13. Lectotype ♀, Saanichton, British Columbia (CNC).

Geographic distribution and host range.—*P. grandis* occurs in Pacific Coast forests from southeastern Alaska to central California. Hosts include various species of fir, Douglas fir, hemlock, and Sitka spruce. The record from Monterey cypress is probably accidental.

California records (map 24).—DEL NORTE CO.: Crescent City, on *Tsuga heterophylla* (CIS); Gasquet Ranger Sta., on *Pseudotsuga taxifolia* (USNM). HUMBOLDT CO.: Ferndale, on *P. taxifolia* (CIS); 5 mi E. Orick, on *P. taxifolia* (CIS); 11 mi S. Orick, on *P. taxifolia* (CIS). MARIN CO.: 1 mi S. E. Inverness (CWOB); 2 mi S. E. Inverness, on *P. taxifolia* (CWOB); Lagunitas (CIS); Mt. Tamalpais (CIS); Mill Valley (CIS); 7 mi S. Olema (CWOB). MENDOCINO CO.: Fort Bragg (CAS); Mendocino (CWOB); Noyo River (CAS). SAN FRANCISCO CO.: San Francisco, on *Cupressus macrocarpa* (CDA). SAN MATEO CO.: Lake Pilarcitos (CAS). SONOMA CO.: Duman's Mill (CAS).



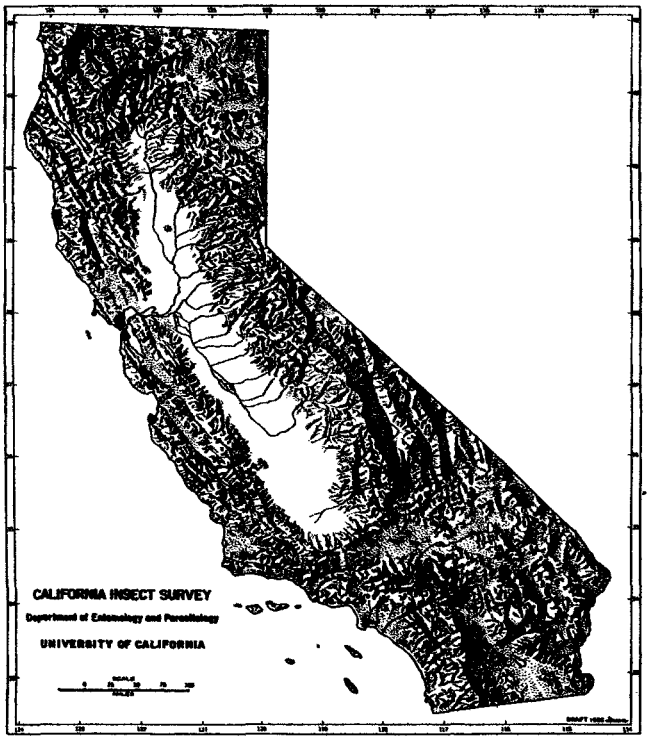
Map 24. California distribution of *Pseudohylesinus grandis* Swaine.

Biology. (Bright, 1969; Daterman et al., 1965; Dyer and Nijholt, 1965; McGehey, 1967; McGehey and Nagel, 1969; Thomas and Wright, 1961)

P. grandis attacks are usually associated with *P. grandulatus* and their biologies are generally the same. A major difference is that the former attacks along the entire bole of its hosts but mainly in the upper parts and in branches, whereas *P. granulatus* generally attacks the lower bole.

The development time of both species depends considerably upon temperature and because attacks are spread out over long periods almost any stage of each species may be present in the field at any particular time. The development time of *P. grandis* is, however, generally less than that of *P. granulatus*. Early spring attacks will yield brood which completes development to teneral adult by fall. These adults overwinter in hibernation niches in the bark and attack the following year. Thus, the cycle may be complete in 12 months rather than the 24 months reported for *P. granulatus*.

Discussion.—Although causing no economic damage, *Pseudohylesinus grandis* is one of the two most common species in Douglas fir in coastal regions of California. The adults may be distinguished from those of the



Map 25. California distribution of *Pseudohylesinus sitchensis* Swaine, ○ ; *Pseudohylesinus sericeus* (Mannerheim), ●.

other common species, *P. nebulosus nebulosus*, by their larger, stouter body, by the very different pronotal shape, by the scale and color pattern, and by the gallery.

This species seems to occupy an intermediate position in the genus between *P. tsugae* and its relatives and the *P. sericeus–sitchensis* group. *P. grandis* is most easily recognized by the wide pronotal scales of both sexes; they are not hairlike as in the female of *P. tsugae*. The different pronotal shape, the broad elytral scales, and the long interstrial setae of the female will further aid in separating this species from *P. tsugae*. *P. grandis* may be distinguished from *P. sitchensis* and *P. sericeus* by the nearly circular elytral scales of the female, by the shorter frons of both sexes, by its hosts, and by the gallery pattern.

Pseudohylesinus sitchensis Swaine
(Map 25)

Pseudohylesinus sitchensis Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):12. Holotype ♂, Menzies Bay, British Columbia (CNC).

Geographic distribution and host range.—*P. sitchensis* occurs in coastal forests from southern Alaska to northern California. The preferred host is Sitka spruce but Engelmann spruce is occasionally attacked. Should selection of the latter as a host increase, the distribution of this scolytid will likely spread inland.

California records (map 25). — Del Norte Co.: Klamath (PSW). Humboldt Co.: Eureka (USNM); Ferndale, on *Picea sitchensis* (CIS); Trinidad, on *P. sitchensis* (CIS). Siskiyou Co.: Callahan, Sugar Creek, on *P. engelmanni* (HSC).

Biology.—No details of the biology of this species are known other than the gallery pattern. The galleries range from 1.8 to 3.0 cm in length and run parallel to the stem axis. The only other *Pseudohylesinus* species with this type of gallery is *P. sericeus*.

Discussion.—This is the only species of *Pseudohylesinus* that occurs in Sitka spruce (*P. grandis* occurs rarely in Sitka spruce in Oregon). This fact, and the longitudinal galleries, will immediately distinguish it from other species. Morphologically the adults closely resemble those of *P. grandis* but the characters mentioned in the discussion of *P. grandis* will adequately separate the two.

Pseudohylesinus sericeus (Mannerheim)
(Map 25)

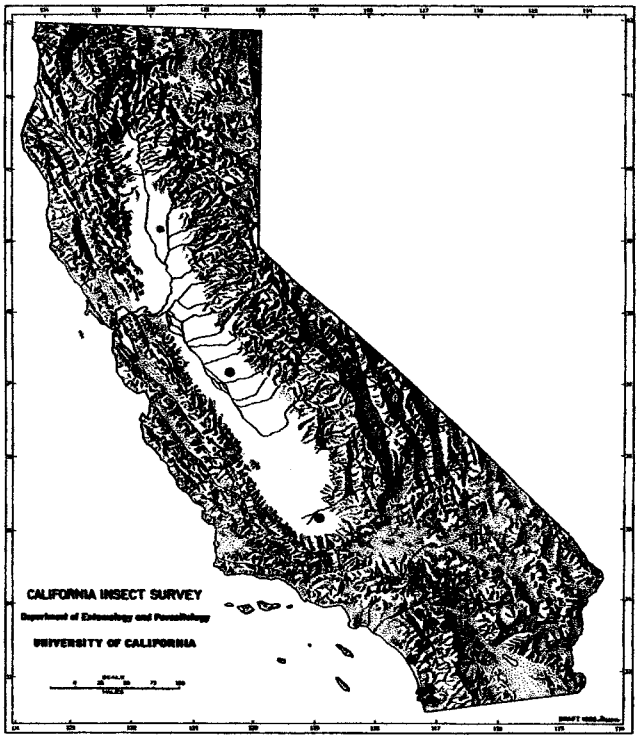
Hylurgus sericeus Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:296. Lectotype ♀, Sitka, Alaska (MCZ).
Pseudohylesinus sericeus: Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):14.
Pseudohylesinus pini Wood, 1969, Great Basin Nat., 29(3):122. (Syn. by Bright, 1970.)

Geographic distribution and host range.—*P. sericeus* is sympatric with *P. sitchensis*, occurring from southeast Alaska to Monterey, California. Its hosts are those pines growing in coastal mountains, that is beach, Bishop, and Monterey pine.

California records (map 25).—Marin Co.: Carson Creek (CIS); Cypress Ridge (CAS). Mendocino Co.: 2 mi E. Casper, on *Pinus contorta* (DEB); Fort Bragg (SJSC); Mendocino (CWOB). Monterey Co.: Albion, on *P. radiata* and *P. muricata* (CIS); Monterey, on *P. radiata* (CIS). San Francisco Co.: San Francisco (PSW). Santa Cruz Co.: 14 mi N. Santa Cruz, on *P. radiata* (CIS).

Biology.—No details of the biology are known except for gallery pattern. This is similar to that of *P. sitchensis* except that the longitudinal gallery of *P. sericeus* almost invariably shows a pronounced hook or curve at the entrance hole which is lacking in the former's gallery. This hook may be enlarged to serve as a nuptial chamber.

Discussion.—Adults of *P. sericeus* closely resemble those of *P. sitchensis* in general shape and color pattern. In addition to the characters given in the key, the adults of *P. sericeus* may be recognized by the more strongly constricted male pronotum, by the broader elytral scales of the female, and by the galleries and host.



Map 26. California distribution of *Leperisinus californicus* Swaine.

Genus *Leperisinus* Reitter

Leperisinus Reitter, 1913, Wien. Entomol. Z. Beih., 32:41. Type-species: *Hylesinus fraxini* Panzer (Swaine, 1918).

There are no published keys to the North American species of *Leperisinus* except for one by Swaine (1918) for Canadian species. Underhill (1951) in an unpublished Ph.D. thesis revised the genus. He recognized eight species from North America; only one of these occurs in California.

In the European literature, *Leperisinus* species are frequently included in the genus *Hylesinus*.

Leperisinus californicus Swaine
(Figs. 9, 38, 71; map 26)

Leperisinus californicus Swaine, 1916, Can. Entomol., 48:190. Holotype ♀, San Diego, California (CNC).

Leperisinus californicus Essig, 1958, Insects and Mites of Western North America, p. 519. No type material. See Bright, 1966.

Leperisinus hoferi Blackman, 1943, Proc. U. S. Natl. Mus., 94: 394. Holotype ♀, Arizona (USNM). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—Although *L. californicus* is now widely established on cultivated olives, its native hosts are thought to be species of chaparral. Its distribution is uncertain but extends as far north as Washington.

California records (map 26).—KERN CO.: Greenfield, on ash (CDA). MERCED CO.: Merced (CNC). RIVERSIDE CO.: Riverside, on olive (UCR); Hemet, on olive (CDA). SAN DIEGO CO.: El Cajon, on olive (CDA); La Mesa, on olive (CDA); Mission Valley (UCD); National City, on olive (CDA). San Diego, on olive (CIS); San Luis Rey, on *Olea* sp. (CDA). SANTA CLARA CO.: Palo Alto, on *Fraxinus* (CIS). TULARE CO.: Lindsey, on ash (CDA).

Biology. (Underhill, 1951)

Adults are in flight throughout July and August, attacking the limbs and trunks of healthy, injured, and dead host trees of all ages. The short entrance tunnel extends up the tree or limb and serves as a turning niche. The uniform, distinctive gallery is two-armed (fig. 9). The arms extend across the grain etching the sapwood deeply. If unobstructed, they are of equal length, from 11 to 73 mm, but usually 25 to 30 mm.

Eggs are laid in deep, closely spaced niches on both sides of the gallery. Between 11 and 133 eggs are laid; the average is about 50. The larvae mine the inner bark and cambium etching the sapwood lightly. Larval mines are nearly straight and run with the grain. Although usually about 50 mm long, they may extend to 154 mm.

There is one generation per year. Following establishment in the host in July or August, egg deposition continues until winter. Incubation requires about 2 weeks, the larvae overwinter and pupation occurs from April through June.

Discussion.—Although *Leperisinus californicus* may attack apparently healthy trees, it has never been abundant enough to be considered a pest.

The abundant scalelike vestiture, the broadly sloping elytral declivity, and the slightly elevated first and third declivital interspace will distinguish the adults of this species.

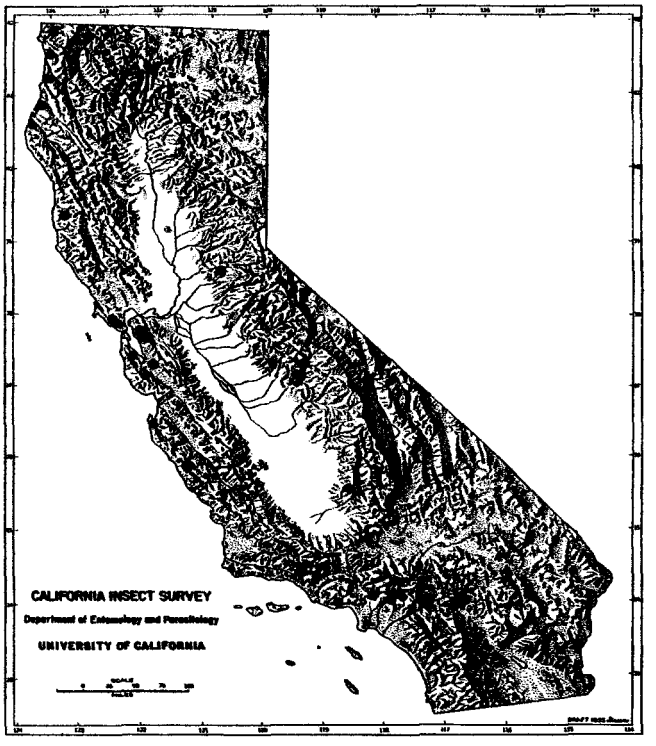
Genus *Alniphagus* Swaine

Alniphagus Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):73. Type-species: *Hylesinus aspericollis* LeConte, monotypic.

This genus contains two species, both of which occur in California. The hosts of both species are *Alnus* spp. These two species and *Gnathotrichus alni* are the only species of Scolytidae in North America which regularly inhabit these hosts.

KEY TO THE SPECIES OF ALNIPHAGUS IN CALIFORNIA

1. First and third declivital interspaces with conspicuous tubercles; body length, 3.0 mm to 3.8 mm..... *aspericollis* (LeConte)
   First and third declivital interspaces devoid of tubercles, pubescence slightly more abundant; body length 2.1 to 3.2 mm ..... *hirsutus* Schedl



Map 27. California distribution of *Alniphagus aspericollis* (LeConte).

Alniphagus aspericollis (LeConte)

(Figs. 10, 39, 72; map 27)

Hylesinus aspericollis LeConte, 1876, Proc. Am. Philos. Soc., 15:380. Holotype (sex ?), California (MCZ).

Alniphagus aspericollis: Swaine 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):73.

Geographic distribution and host range.—*A. aspericollis* occurs from California to British Columbia on various species of alder.

California records (map 27).—Numerous localities in the following counties: Alameda, Contra Costa, Del Norte, El Dorado, Humboldt, Kern, Los Angeles, Madera, Marin, Mendocino, Monterey, San Bernardino, Santa Clara, Shasta, and Ventura.

Biology. (Borden, 1969)

Adults of *Alniphagus aspericollis* may be found throughout the year but there are only two main flight periods, in May and from mid-July to August. Attacks are commonly made on trees weakened by other agents and slash caused by windthrow, snow breakage, or logging. Trees of all ages may be attacked; the entire tree may be killed or only portions of the stem.

The female initiates attack and is joined soon after by the male, suggesting the presence of a sex attractant. Entrance holes are found under lichens, in bark crevices, at the base of branches, and very commonly near wounds on the stem. Externally, the entrance hole is bordered by a tighly packed rim of frass and the bark surrounding each hole becomes darkly stained.

Egg galleries are constructed in the phloem-cambial region, scoring the sapwood lightly. Four gallery patterns have been observed. The most common is elongate, extending up or down the bole about 8 cm (fig. 10). The others are: a wide, irregularly shaped somewhat "cave" type; a two-branched form with egg tunnels extending up and down the bole; and a V-shaped type with two branches extending in the same direction facing up or down the bole. Eggs are laid on both sides of the gallery in niches about 1 mm apart. Up to 69 eggs per gallery have been reported. Re-emergence of parent adults is common following oviposition and these presumably make additional attacks.

The larvae mine at right angles to the egg gallery for a short distance, then turn and mine with the grain leaving upright septa between their mines in the inner bark. Like most scolytids, the larvae pack the gallery behind them with frass. The mature larva constructs a chamber in the inner bark for pupation.

A. aspericollis has two generations per year. The first main attack occurs in early May in southern British Columbia (probably earlier in California) and the second from mid-July to early August. However, fresh attacks may be found throughout the growing season, the result of re-emergence of parent adults and variations in development time.

Overwintering of the second generation occurs in at least three life stages. Brood adults emerge in early September and fly to healthy trees where they construct hibernation chambers in the bark. These chambers may have numerous finger-like projections extending up or down from a large center or they may be short, straight galleries; they do not contact the wood. That portion of the second generation brood which does not mature overwinters as late instar larvae, pupae, or callow adults.

Discussion.—*Alniphagus aspericollis* is very common throughout the western states and is occasionally destructive.

The adults may be recognized by the features given in the preceding key.

Alniphagus hirsutus Schedl

Alniphagus hirsutus Schedl, 1949, Can. Entomol., 81:236. Syntypes (sex ?), Copper Mountains, British Columbia (Schedl Coll.).

Geographic distribution and host range.—*A. hirsutus* is distributed throughout northwestern North America on various species of *Alnus*.

California record.—SISKIYOU CO.: Cliff Lake, on *Alnus tenuifolia* (CIS).

Biology.—Not known but probably similar to *A. aspericollis.*

Discussion.—The differences that separate the adults of this species from those of *A. aspericollis* are not generally very prominent. Chamberlin (1958) states that size is not a criterion, except that the adults of *A. hirsutus* are generally smaller. Specimens from California, however, seem to be much smaller than the typical *A. aspericollis* from California. The lack of granules on the first and third declivital interspaces of *A. hirsutus* is the most evident character for distinguishing the adults of the two species.

Genus *Phloeosinus* Chapus

Phloeosinus Chapuis, 1869, Synopsis des Scolytides p. 37. (Preprint of Mem. Soc. R. Sci. Liege, 2(3):245, 1873.) Type-species: *Hylesinus thujae* Perris (Hopkins, 1914).

About 23 species of *Phloeosinus* occur in North America, making it the fourth largest genus for this region. In California, it is represented by 14 species.

All members of this genus except one breed in trees of the Taxodiaceae and Cupressaceae, and it is the only genus of Scolytidae commonly found in trees of these families. By preference they breed in weakened or dying trees and shrubs but at times they can become very destructive, especially in ornamentals.

Members of this genus are easy to recognize by the stout, oval body, by the generally reddish elytra and black pronotum, by the elongate, acuminate antennal club, and by the variously tuberculate declivital interspaces. The host species will usually distinguish them.

For a complete revision of this genus, see Blackman (1942*b*).

KEY TO THE SPECIES OF PHLOEOSINUS IN CALIFORNIA

1. Second declivital interspace of female with from one to many small tubercles (occasional specimens devoid of tubercles); first and third declivital interspaces of male with large recurved serrations, smaller on third; size large, 3.0 to 3.6 cm; in *Juniperus* species ..... *serratus* LeConte
   Second declivital interspace of female devoid of tubercles in all specimens; declivital armature variable; size variable 2
2(1). Smaller species, about 2.0 mm or less, except some species of *P. setosus* may be larger 3
   Larger species, 2.0 to 4.5 mm, except some specimens of *P. vandykei* may be smaller 7
3(2). First and third declivital interspaces with dense white scales and small tubercles; frons of male shallowly concave with elevated median carina reaching middle of concavity, granulate at sides; in *Cupressus sargentii* ..... *setosus* Bruck
   First and third declivital interspaces with yellowish scales; frons of male deeply and more broadly concave 4
4(3). First and third declivital interspaces of male with coarse, stout recurved serrations, serrations of females much smaller; frons of male with carina elevated on lower half; most commonly in *Libocedrus*, occasionally in *Juniperus* and *Cupressus* ..... *hoppingi* Swaine
   First and third declivital interspaces with few slender, sharp serrations, these larger in male, or with small blunt tubercles 5
5(4). Declivital serrations rather blunt and numerous in both sexes (more than 6 serrations on each interspace), smaller in female; in *Libocedrus* and *Cupressus* ..... *antennatus* Swaine
   Declivital serrations sparse in male (less than 6 serrations on each interspace), sharp-pointed in both sexes but much smaller in female 6
6(5). Mature color black with yellowish hairlike setae; frontal cavity of male moderately deep, granulate at sides and above; in *Cupressus goveniana* in central coast ranges ..... *swainei* Bruck
   Mature color black with reddish elytra, vestiture yellowish, scalelike; frontal cavity of male very deep, punctate above; southern California ..... *frontalis* Bruck
7(2). First declivital interspace of male with serrations throughout 8
   First declivital interspace of male devoid of serrations or serrate only at the top 11
8(7). First and third declivital interspaces with minute tubercles in both sexes 9
   First and third declivital interspaces distinctly serrate, teeth larger 10
9(8). First and third declivital interspaces appearing devoid of tubercles, actually tubercles very small; body size smaller 1.8 to 2.3 mm; mature color black with reddish elytra ..... *vandykei* Swaine
   First and third declivital interspaces with larger, more prominent tubercles; body size larger, 2.0 to 2.8 mm; mature color usually uniformly black .... *fulgens* Swaine
10(8). Elytra brightly shining, appearing glabrous but actually with minute, scanty, interstrial hairs; striae nearly as wide as interspaces with large coarse punctures ..... *punctatus* LeConte
   Elytra less brightly shining; declivity with scalelike setae; striae definitely narrower than interspaces .... *rugosus* Swaine
11. Elytral striae nearly as wide or wider than interspaces; male with first interspace serrate only at top of declivity; female with serrations of first and third declivital interspaces not quite equally developed 12
   Elytral striae distinctly narrower than interspaces; male with first interspace devoid of serrations; female with serrations of third declivital interspace much more strongly developed than first 13
12(11). Elytral striae much wider than interspaces, punctures coarse, deep and close; body size larger, 3.0 to 4.0 mm; epistomal tooth on male frons strongly

elevated; in *Cupressus goveniana* . . *variolatus* Bruck

Elytral striae narrower than interspaces, punctures finer; body size smaller, 2.1 to 3.6 mm; epistomal tooth on male frons weakly elevated if at all; in various hosts (fig. 73) . . . . . *cupressi* Hopkins

13(11). Elytral interspaces generally smooth, faintly rugose with few sparse hairs; male more than 2.0 times longer than wide; male frons with indistinctly elevated median carina . . . . . *sequoiae* Hopkins

Elytral interspaces densely and finely rugose, densely clothed with hairlike setae, broader toward declivity; male less than 2.0 times longer than wide; male frons with distinct, elevated median carina . . . *cristatus* (LeConte)

Phloeosinus serratus LeConte
(Map 28)

Hylesinus serratus LeConte, 1868, Trans. Am. Entomol. Soc., 2:169. Holotype ♂, "Middle States" (MCZ).

Phloeosinus serratus: LeConte, 1876, Proc. Am. Philos. Soc., 15:381.

Phloeosinus utahensis Swaine, 1915, Can. Entomol., 47:363. Lectotype ♀, Stockton, Utah (CNC). (Syn. by Wood, 1971*b*.)

Phloeosinus juniperi Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):10. Lectotype ♀, Scaffold Meadow, Tulare Co., California (CNC). (Syn. by Wood, 1971*b*.)

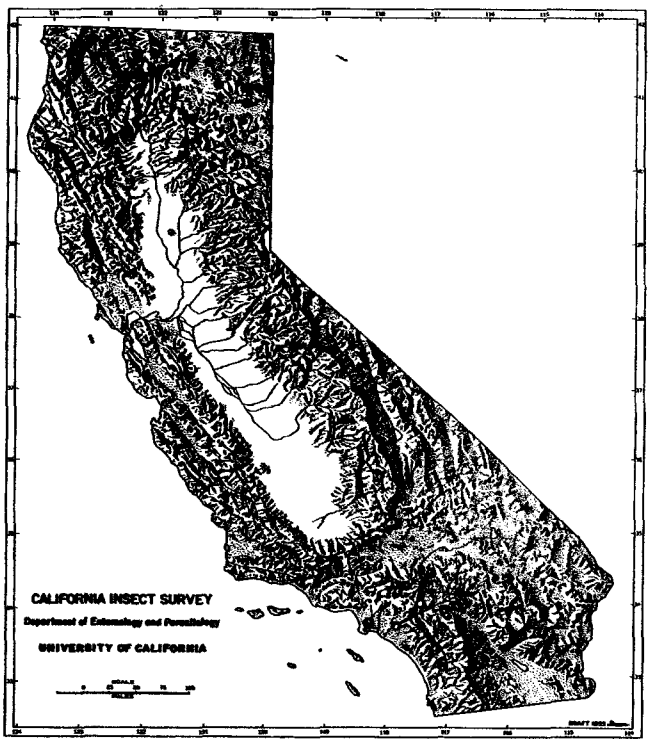
Phloeosinus aciculatus Bruck, 1931, Pan-Pac. Entomol., 7:127. Holotype ♂, Arizona (CAS). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—*P. serratus* occurs from Washington to southern California, east to Utah, and probably further north and south. Its hosts are various species of juniper.

California records (map 28).—EL DORADO Co.: Fallen Leaf Lake (CAS). LASSEN Co.: Madeline, on juniper (CAS). MARIPOSA Co.: Yosemite Valley, on juniper (CAS). MODOC Co.: Adin Summit, on *Juniperus occidentalis* (CIS); Alturas, on *J. occidentalis* (OSU); Buck Creek, N. Warner Mtns. (OSU); Hackamore (OSU); Likely, on *J. occidentalis* (CIS); 10 mi E. Likely, on *Juniperus* sp. (CDA); Willow Ranch, on *Juniperus* sp. (CIS). SAN BERNARDINO Co.: Fawnskin, (OSU); 8 mi N.E. Fawnskin, on *J. occidentalis* (CIS). SISKIYOU Co.: 7 mi E. Callahan, on *J. occidentalis* (CIS). TULARE Co.: Scaffold Meadow, on juniper (CAS). County unknown: Yosemite Natl. Park, on *Juniperus* sp. (CIS).

Biology.—*Phloeosinus serratus* adults attack the main trunk and larger limbs of their host tree; occasionally fresh juniper fence posts and poles are attacked. Weakened and dying trees are preferred but large numbers of living trees have been killed on occasion.

Rather large egg galleries, 5 to 9 mm long, are excavated vertically in the phloem-cambial region both up and down the bole from a large chamber. Egg niches are closely spaced—up to 100 eggs per gallery have been noted. The larval mines engrave the sapwood and bark equally, but pupation usually occurs in the wood.



Map 28. California distribution of *Phloeosinus serratus* LeConte, ●; *Phloeosinus frontalis* Bruck, ○ .

The life cycle and number of generations per year are not known.

Discussion.—This is the only California species of *Phloeosinus* in which the adult almost always possesses tubercles on the second declivital interspaces of the female. The declivity of the male has large, dark teeth on the first and third interspaces with only one or two small tubercles at the apex of the second interspace. This is also the largest species found in juniper in the state.

Phloeosinus setosus Bruck
(Map 29)

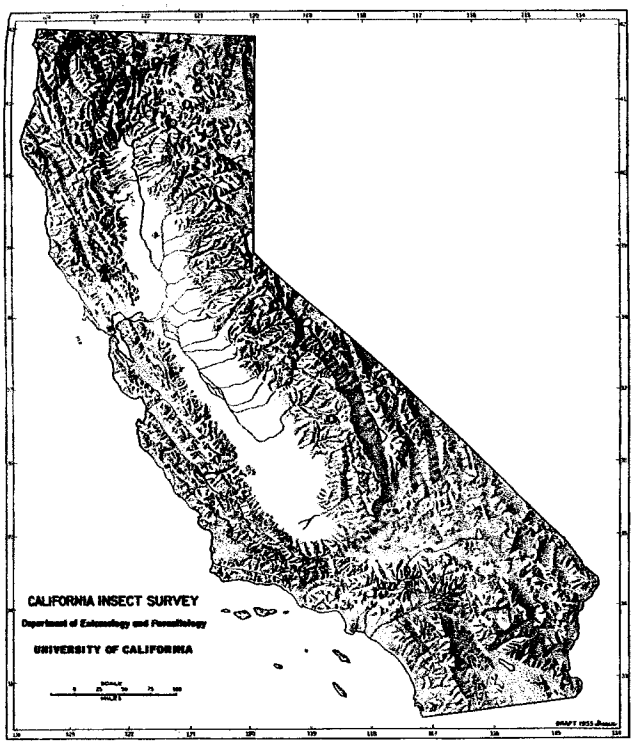
Phloeosinus setosus Bruck, 1933, Can. Entomol., 65:54. Holotype ♂, Mt. St. Helena, California (OSU).

Geographic distribution and host range.—To date, Sargent cypress is the only recorded host of *P. setosus*. This cypress is distributed in the central Coast Ranges from Santa Barbara to Mendocino counties. However, this scolytid may be found in other *Cupressus* species in other locations.

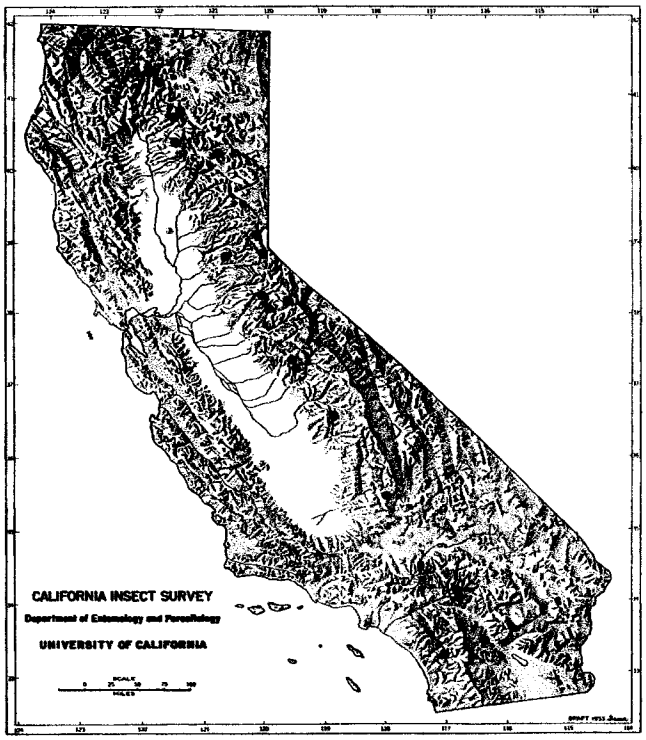
California records (map 29).—LAKE Co.: 3 mi S. Middletown, on *Cupressus sargentii* (CIS). NAPA Co.: Mt. St. Helena, on *C. sargentii* (CIS).

Biology.—Unknown.

Discussion.—This is one of three endemic species of



Map 29. California distribution of *Phloeosinus setosus* Bruck, ▲; *Phloeosinus rugosus* Swaine, O.



Map 30. California distribution of *Phloeosinus hoppingi* Swaine.

Scolytidae encountered in Sargent cypress. The nearly white setae which are most abundant on the first declivital interspace, the small teeth on the first and third declivital interspaces, the small size (1.5 to 2.5 mm), and the host will immediately identify the adult of this species.

Phloeosinus hoppingi Swaine
(Map 30)

Phloeosinus hoppingi Swaine, 1915, Can. Entomol., 45:364. Lectotype ♀, "Camp 6," California (CNC).
Phloeosinus woodi Bright, 1966, Pan-Pac. Entomol., 42:296. Holotype ♂, Hat Creek, California (SLW). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—*P. hoppingi* has been recorded from *Libocedrus decurrens* and *Cupressus* spp. in California but also from western juniper elsewhere (Chamberlin, 1939). The distribution probably includes all western coastal forests where trees of these genera grow.

California records (map 30).—Numerous localities in the following counties: Calaveras, El Dorado, Kern, Lassen, Madera, Mariposa, Placer, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Stanislaus, Tulare, and Tuolumne.

Biology. (Burke, 1966)

The biology is poorly known. Attacks are limited to branches less than 5 cm in diameter.

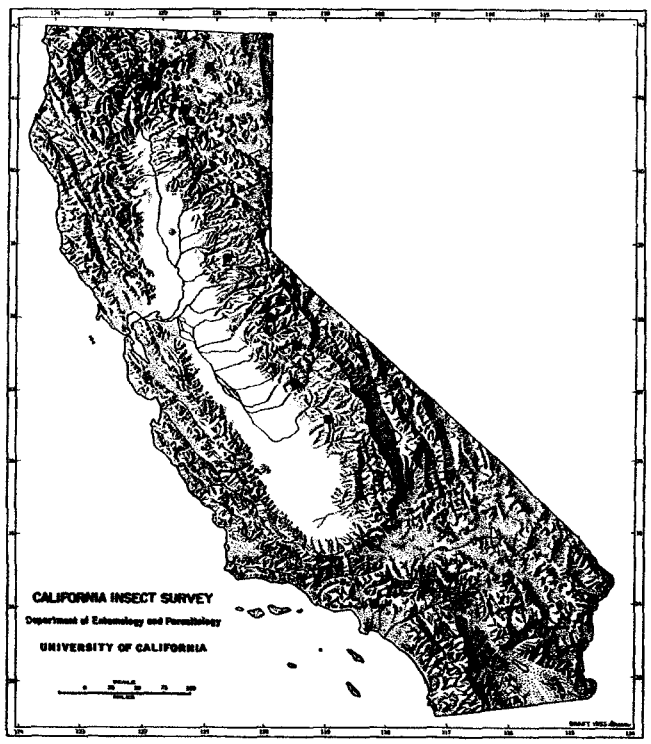
Egg galleries are variable. They may be straight or winding, single or branched, and from 1.5 to 4 cm in length. The nuptial chamber is merely a widening of the gallery. Eggs are deposited in niches sealed with frass; up to 15 eggs per cm have been noted. Following egg deposition the adults frequently excavate feeding galleries. Pupation is largely in the sapwood. The life cycle or number of generations per year are unknown.

Discussion.—The adults of *Phloeosinus hoppingi* are rather small, measuring from 1.5 to 2.1 mm in length. They are easily recognized as they are the only species of *Phloeosinus* in California in which the adults possess stout, blunt, recurved teeth on the first and third declivital interspaces of the male and a toothlike carina on the lower half of the cavity on the frons of the male.

Phloeosinus antennatus Swaine
(Map 31)

Phloeosinus antennatus Swaine, 1924, Can Entomol., 57:146. Holotype ♂, Strawberry, California (CNC).
Phloeosinus pseudotsugae Chamberlin, 1955, Pan-Pac. Entomol., 31:117. Holotype (sex?), Tiller, Oregon, (OSU). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—The distribution of *P. antennatus* will probably follow that of its only host, incense cedar, from Baja California to Oregon and east to Nevada.



Map 31. California distribution of *Phloeosinus antennatus* Swaine.

Map 32. California distribution of *Phloeosinus swainei* Bruck, ○ ; *Phloeosinus punctatus* LeConte, ● .

California records (map 31).—Various localities in the following counties: El Dorado, Humboldt, Los Angeles, Madera, Modoc, Placer, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology. — Limited knowledge is available. Adults commonly attack twigs and branches but they have been observed in small incense cedar trees. In trees, parent (egg) galleries are short (1 to 2.5 cm) and extend straight down from the entrance hole. At the base there is a short lateral spur (1 to 1½ mm) used as a turning niche.

Eggs are deposited in well-separated niches, from 12 to 25 in each gallery. Larval mines are irregular and run more or less obliquely. All tunnels, egg and larval, lie almost entirely in the bark, scarcely engraving the wood.

The life cycle and number of generations per year are unknown.

Discussion.—Although recorded only from incense cedar in California, *Phloeosinus antennatus* is found on Douglas fir in Oregon so it may be found on that host in California. The adults of this species have much smaller, more slender declivital teeth compared with the adults of the preceding species and have a sharply elevated carina on the male frons.

Phloeosinus swainei Bruck
(Map 32)

Phloeosinus minutus Swaine, 1917 (nec Blandford, 1894), Can. Dep. Agric. Entomol. Branch Bull., 14(1):9. Lectotype ♀, Fairfax, Cypress Ridge, Marin Co., California (CNC).
Phloeosinus swainei Bruck, 1933, Can. Entomol., 65:56.

Geographic distribution and host range.—P. swainei has been collected only from Sargent cypress. If this is its only host, then its distribution is restricted to coastal California, from Santa Barbara to Mendocino County.

California records (map 32).—Lake Co.: Mt. St. Helena, on *Cupressus sargentii* (OSU). Marin Co.: Cypress Ridge (CIS); Fairfax, on *C. sargentii* (OSU). Sonoma Co.: 1 mi N.E. Occidental, on *C. sargentii* (CWOB); 2 mi N.E. Occidental, on *C. sargentii* (CIS).

Biology. (Burke, 1966)

Egg galleries are longitudinal with a nuptial chamber formed by widening the whole gallery. Galleries range from 1.5 to 3 cm in length and approximately 8 eggs are laid per cm. Pupal cells are formed partially in the sapwood. Life cycle and number of generations per year are unknown.

Phloeosinus frontalis Bruck
(Map 28)

Phloeosinus frontalis Bruck, 1933, Can. Entomol., 65:155. Holotype ♂, Rialto, California (USNM).
Phloeosinus granulatus Bruck, 1936, Bull. S. Calif. Acad. Sci., 35(1):33. Holotype ♂, Santa Ana Canyon, Orange Co., California (OSU). (Syn. by Bright, 1966.)

Geographic distribution and host range.—The distribution of *Phloeosinus frontalis* probably follows that of its hosts throughout California although current records would suggest it is restricted to southwestern California.

California records (map 28).—Los Angeles Co.: Los Angeles, on *Cupressus macrocarpa* (OSU). Orange Co.: Santa Ana Canyon, on *C. forbesi* branches (CWOB); Santa Ana Canyon, on *C. guadalupensis* (CIS). San Bernardino Co.: Redlands, on cypress (CDA); Rialto, on Arizona cupress (UCD); San Dimas, on *C. arizonica* (OSU). San Diego Co.: Guatay, on *C. guadalupensis* (CIS); 5 mi S. Palomar P. O., on *C. stephensonii* (CWOB).

Biology.—Unknown.

Discussion.—This is a rather common species and the adults are the smallest of the *Phloeosinus* species found in cypress in southern California.

Phloeosinus frontalis is closely related to *P. swainei* and they may prove to be one species. The characters given in the key combined with a knowledge of the host and distribution should separate adults of the two species.

Phloeosinus vandykei Swaine
(Map 33)

Phloeosinus vandykei Swaine, 1915, Can. Entomol., 47:366. Lectotype ♀, Millwood, California (CNC).
Phloeosinus russus Swaine, 1924, Can. Entomol., 56:148. Holotype ♀, San Bernardino Co., California (CNC). (Syn. by Blackman, 1942*b*.)

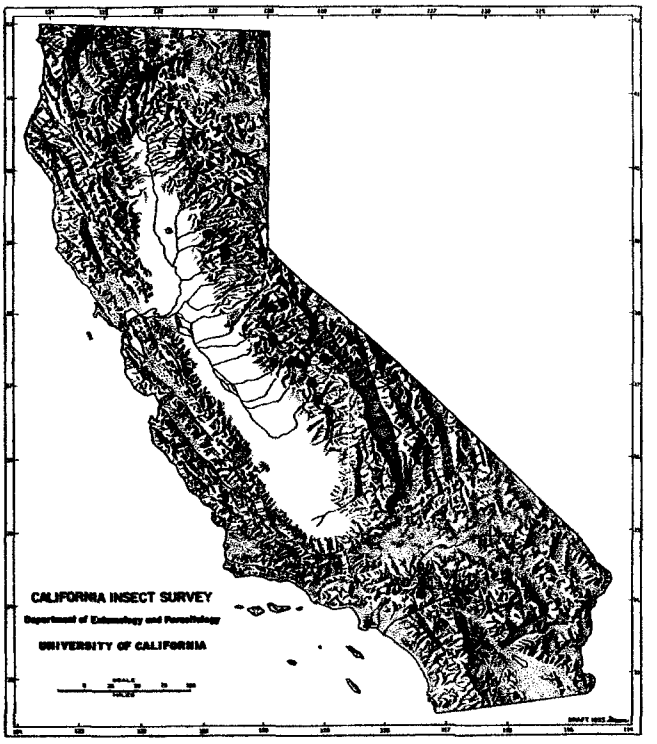
Geographical distribution and host range.—P. vandykei has been collected in California only from incense cedar. If restricted to this host, the distribution would be from southern California to Oregon.

California records (map 33).—Various localities in the following counties: El Dorado, Fresno, Madera, Mariposa, Nevada, Placer, San Bernardino, Siskiyou, Trinity, and Tuolumne.

Biology. (Burke, 1966)

Phloeosinus vandykei attacks the limbs of cedar up to 8 cm diameter. Egg galleries are longitudinal, 1.0 to 5.0 cm long and usually widened on one side to form a nuptial chamber.

Eggs are deposited in widely spaced, alternate niches, an average of four per cm of parent gallery. The larvae mine at right angles to the egg gallery for a short distance and then turn and mine with the grain. Pupation takes place partially or wholly in the wood.



Map 33. California distribution of *Phloeosinus vandykei* Swaine.

Pre-attack feeding for sexual maturation probably occurs on small twigs and may cause the death of the distal portion.

There are three generations per year at lower elevations (1,000 m). Due to variable development times, adults probably can be found throughout the growing season.

Discussion.—Flagging of tips during prematuration feeding causes some concern in ornamental plantings but is seldom extensive.

The adults of this species are readily distinguished by the small size and by the lack of teeth or serrations on the first or third declivital interspaces; occasionally very small granules may be present on these interspaces. *Phloeosinus vandykei* is closely related to *P. fulgens* but the adults of *P. vandykei* may be distinguished by the small, fine pronotal punctures and by the finer declivital sculpture.

Phloeosinus fulgens Swaine
(Fig. 11; map 34)

Phloeosinus fulgens Swaine, 1924, Can. Entomol., 56:147. Holotype ♂, Northfork, California (CNC).
Phloeosinus splendens Blackman, 1942, Proc. U. S. Natl. Mus.,

92:428. Holotype ♂, Pinehurst, Oregon (USNM). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—Phloeosinus fulgens adults apparently attack only incense cedar. The distribution ranges from southern California to Oregon.

California records (map 34).—El Dorado Co.: Blodgett Research Forest, 10 mi E. Georgetown, on *Libocedrus decurrens* (CIS). Humboldt Co.: Friday Ridge Road, on *L. decurrens* (HSC). Madera Co.: Northfork (CIS); 10 mi. N. Oakhurst (CIS). Modoc Co.: Willow Ranch (CAS). Nevada Co.: Grass Valley, on *L. decurrens* (CIS); Nevada City, on *L. decurrens* (HSC). San Diego Co.: 1 mi N. Palomar P. O., on *L. decurrens* (CWOB). Tulare Co.: Paradise Creek, Sequoia Natl. Park, on *L. decurrens* (CIS); Sequoia Natl. Park (OSU). Tuolumne Co.: Cow Creek, 5 mi N. Strawberry, on *L. decurrens* (CIS).

Biology. (Burke, 1966)

Attack is largely confined to the tops of small incense cedar but branches are probably attacked also. Prematuration feeding on twig tips probably occurs.

Egg galleries may be longitudinal and straight or transverse and two-armed (fig. 11). Length is from 1.4 to 5 cm and about 10 eggs per cm are laid. Larval mines turn and run with the grain from longitudinal egg galleries and proceed with the grain in the transverse. They etch the wood quite deeply and pupal cells are in the wood.

There are three generations per year at lower (<1,000 m) elevations. It is commonly associated with *Phloeosinus vandykei.*

Discussion.—Some top-killing and tip-pruning of young incense cedars occurs but this is generally of negligible importance. The adults of *Phloeosinus fulgens* are rather coarsely punctured, black throughout, and generally larger than those of *P. vandykei.*

Phloeosinus punctatus LeConte

(Figs. 12, 40; map 32)

Phloeosinus punctatus LeConte, 1876, Proc. Am. Philos. Soc., 15:382. Syntypes (sex ?), Oregon (MCZ).

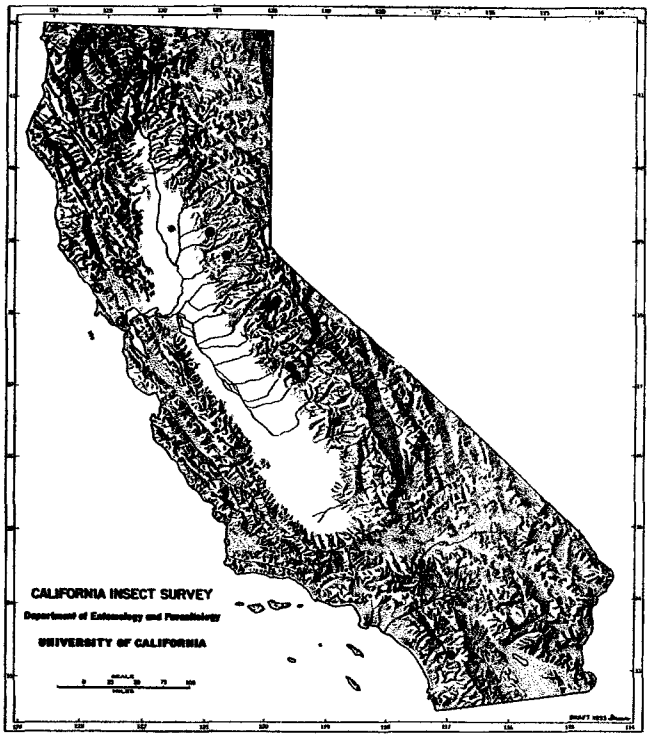
Phloeosinus buckhorni Blackman, 1942, Proc. U.S. Natl. Mus., 92:432. Holotype ♂, Portland, Oregon (USNM). (Syn. by Wood, 1966.)

Phloeosinus kaniksu Blackman, 1942, Proc. U.S. Natl. Mus., 92: 434. Holotype ♂, Metaline Falls, Washington (USNM). (Syn. by Wood, 1966.)

Phloeosinus rusti Blackman, 1942, Proc. U.S. Natl. Mus., 92:435. Holotype ♂, Metaline Falls, Washington (USNM). (Syn. by Wood, 1966.)

Phloeosinus rubicundulus Swaine, 1924, Can. Entomol., 56:144. Holotype ♀, Hossack Meadows, Tulare Co., Calif. (CNC). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—Phloeosinus punctatus occurs from southern California to British Columbia. It apparently attacks members of the Cupressaceae, particularly incense cedar, in California.



Map 34. California distribution of *Phloeosinus fulgens* Swaine, ●; *Phloeosinus variolatus* Bruck, ○.

California records (map 32).—Numerous localities in the following counties: Calaveras, Del Norte, El Dorado, Fresno, Humboldt, Lassen, Madera, Mariposa, Placer, Plumas, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology. (Burke, 1966)

Phloeosinus punctatus adults attack the trunks and limbs (>1 cm) of apparently healthy, injured, dead, and recently felled host trees. Prematuration feeding on twigs is believed necessary for sexual maturation as is the case with *P. fulgens, P. vandykei,* and probably other species.

The wide variation in attack sites causes considerable variation in egg gallery pattern. Most are short (1 to 5 cm) and longitudinal with the grain and score the sapwood slightly. These may be straight or sinuous. However, deep engraving of the wood does occur. Another common pattern is biramous, with the two arms angled forming a "V" (fig. 12). Turning niches are formed at the base of the V or in vertical single-armed galleries above the entrance hole.

Egg niches are widely spaced; the number of eggs varies from 12 to 40, averaging about 15 per gallery. Larval mines are irregular, running at all angles depending on the size of material infested. In longitudinal galleries they are typical of the genus starting at right

angles to the egg gallery, then turning up or down. However, they are usually winding and often cross. The larvae feed primarily in the inner bark.

Pupation occurs almost solely in the outer bark, particularly in biramous galleries. In longitudinal galleries pupation may occur in the sapwood and when this occurs the pupal cell lies obliquely in the wood, is longer than the pupa, and is plugged with white frass.

There are three generations per year at lower elevations (<1,000 m). Adults are probably in flight during the warmer periods of the year.

Discussion.—*Phloeosinus punctatus* is the most common species of *Phloeosinus* encountered in the forested regions of California and the Pacific Northwest. Damage is negligible, consisting of some twig pruning during maturation feeding and occasional killing of small trees.

It is quite a variable species but the adults can be recognized by the reddish shining elytra which seem devoid of pubescence except occasionally on the declivity. The first and third declivital interspaces are distinctly and strongly serrate and the frons of the male is concave with a fine raised carina on the lower portion while the female frons is convex with a distinct median carina. They vary in length from 2.0 to 3.5 mm.

Phloeosinus rugosus Swaine
(Map 29)

Phloeosinus rugosus Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):9. Lectotype ♀, Scaffold Meadow, Sequoia Natl. Forest, California (CNC).

Phloeosinus chamberlini Blackman, 1942, Proc. U.S. Natl. Mus., 92:470. Holotype ♂, Alturas, California (USNM). (Syn. by Bright, 1966.)

Geographical distribution and host range.—The host of *Phloeosinus rugosus*, western juniper, is widely distributed from southern California to Washington and east to Idaho and western Nevada in montane forests. Although recorded only from Oregon and California the scolytid will probably be found elsewhere in this range and perhaps on other junipers.

California records (map 29).—El Dorado Co.: Fallen Leaf Lake, on *Juniperus occidentalis* (OSU). Lassen Co.: Last Chance Creek, nr. Milford, 6000′, on *J. occidentalis* (CAS); Nubierer, on *J. occidentalis* (CIS). Modoc Co.: Adin Summit, on *J. occidentalis* (CIS); Alturas, on *J. occidentalis* (OSU). Shasta Co.: Hat Creek, on *J. occidentalis* (OSU). Siskiyou Co.: Red Rock Valley, on juniper (CAS). Tulare Co.: Scaffold Meadows, on *J. occidentalis* (CAS). Tuolumne Co.: Sonora Pass, on *Juniperus* (HSC).

Biology.—Little biological information is available. Egg galleries run with the grain of the wood, are from 4 to 7 cm long, and engrave the wood rather deeply. The turning niche is almost round and back from the entrance hole. From 19 to 64 egg niches occur, averaging 40.5 per gallery. Larval tunnels are irregular and engrave the wood.

Discussion.—This species measures from 2.0 to 3.0 mm in length and is a common species in juniper. The adults resemble those of *P. punctatus* in general shape and declivital armature but they are more rugose and duller.

Phloeosinus variolatus Bruck
(Fig. 13; map 34)

Phloeosinus variolatus Bruck, 1931, Pan-Pac. Entomol., 7:126. Holotype (sex ?), Mt. St. Helena, California (CAS).

Geographical distribution and host range.—The distribution of *P. variolatus* follows that of its host, Sargent cypress, in the coastal ranges of California from Alameda to Mendocino County.

California records (map 34).—Alameda Co.: Cedar Mtn. Ridge, on *Cupressus sargentii* (PSW). Lake Co.: 3 mi S. Middletown, on *C. sargentii* (CIS). Marin Co.: Carson Ridge (CWOB). Napa Co.: Mt. St. Helena, on *C. sargentii* (CIS); Pope Valley, on *C. sargentii* (CAS). Sonoma Co.: Occidental (UCD).

Biology. (Burke, 1966)

Only the egg gallery pattern is known. The galleries are longitudinal and extend up or down from the entrance tunnel forming a hook, extending a total distance of from 2 to 15 cm (fig. 13). The nuptial chamber is formed by widening both sides of the gallery.

Discussion.—The adults of *Phloeosinus variolatus* are the largest bark beetles found in Sargent cypress, measuring 3.0 to 4.0 mm in length. The outstanding morphological features which distinguish the adults of this species from those of *P. cupressi* are the very large strial punctures on the elytral and the interspaces which are narrower than the width of the punctures.

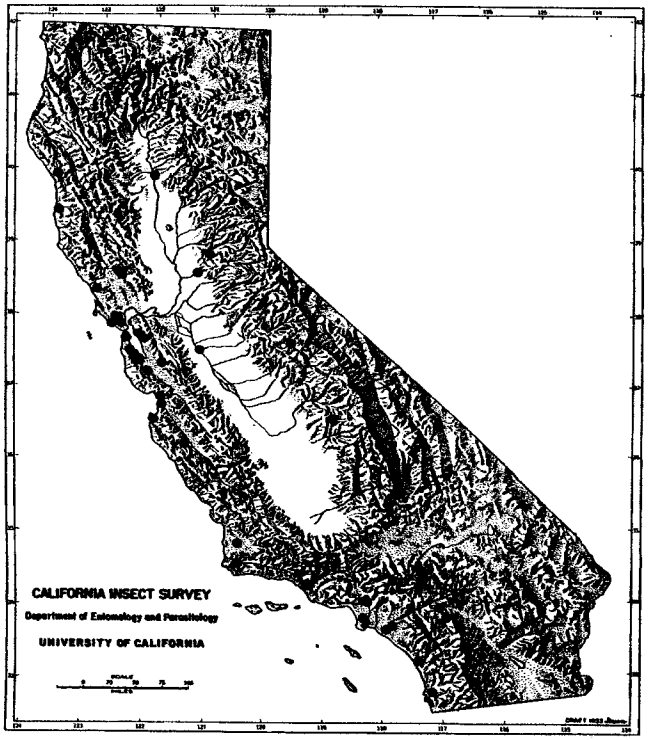
Phloeosinus cupressi Hopkins
(Figs. 14, 73; map 35)

Phloeosinus cupressi Hopkins, 1903, U.S. Dep. Agric. Bur. For. Bull., 38:35. Holotype ♂ (?), Golden Gate Park, San Francisco, California (USNM).

Phloeosinus nitidus Swaine, 1924, Can. Entomol., 56:145. Holotype ♂, Oregon (USNM). (Syn. by Wood, 1971*b*.)

Phloeosinus blackwelderi Blackman, 1943, Proc. U.S. Natl. Mus., 94:397. Holotype ♂, Canal Zone, Panama (USNM). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—Although the distribution records of *P. cupressi* indicate that it is restricted to the coastal areas of California its wide range of cupressine hosts and their wide use as ornamentals suggest that it may have a wider distribution and host range.



Map 35. California distribution of *Phloeosinus cupressi* Hopkins.

California records (map 35).—Numerous localities in the following counties: Alameda, Los Angeles, Marin, Monterey, Napa, Orange, Placer, Riverside, Sacramento, San Bernardino, San Benito, San Diego, San Francisco, San Mateo, Santa Barbara, Santa Clara, Sonoma, Stanislaus, Tehama, Tulare, and Ventura.

Biology. (Brown and Eads, 1967; Wohletz, 1931)

The climate of the range of *Phloeosinus cupressi* permits activity throughout most of the year. The number of generations and variations in developmental time give rise to overlapping generations so that adults may be in flight at any period of the year. However, three distinct flight and attack periods occur, March to April, June through July, and September. The midsummer flight is the heaviest.

Adults usually enter the bark of dying or recently felled trees. In standing trees any portion of the stem or branch system is attacked, but in fallen trees attacks are confined to the sides and shaded undersurface. Prior to entering the host, adult beetles attack small (<2 cm in diameter) living twigs. They enter the twig and hollow out the center for a short distance. The twig usually breaks and may hang on the tree causing the "flagging" characteristic of twig-pruning. This is particularly noticeable from July through September.

The female enters the host first, soon followed by the male. A lopsided nuptial chamber is constructed at the base of the entrance tunnel (fig. 14). From this a single, straight longitudinal tunnel 2 to 15 cm long (ave., 7.5 cm) is excavated. This egg gallery is kept free of frass.

From a few eggs to 150 or more (seldom more than 100), are deposited in egg niches evenly on both sides of the gallery at about 1 mm intervals. The larvae bore at right angles to the parent gallery but slowly diverge so that those furthest from the center are at an oblique angle. Larval gallery length seldom exceeds 10 cm. At the end of the gallery the pupal cell is constructed, engraving wood and bark about equally, but occasionally entirely in the bark. The axis of the pupal cell may be in any direction.

There are at least two complete generations and a partial third per year. Occasionally the third generation may be completed within the year. The seasonal history is generally as follows. Overwintering young adults emerge, excavate galleries, and deposit eggs from March through May. The larvae hatch in March, April, and May and develop until July. Pupae and adults are found from May through July. This generation is normally completed by late July.

The second generation adults fly and attack in June, July, and early August. Eggs hatch quickly, development is rapid and brood adults emerge in August and September. This generation is usually complete by early October.

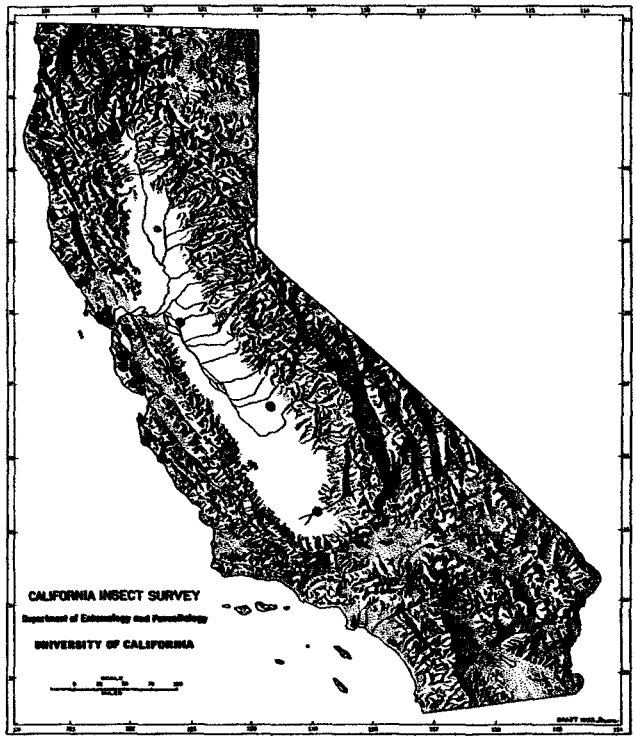
The third generation adults attack and oviposit in late August to October. Parent adults may overwinter and resume actvity in the spring. Eggs hatch from September through November and the mature larvae are the predominant overwintering stage, although some eggs, pupae, and teneral adults are found. The brood adults from this generation comprise the attacking adults of the first generation.

Discussion.—The principal damage caused by *Phloeosinus cupressi* is the unsightly flagging of ornamental trees. This may be severe enough to cause concern but rarely does the damage inflict serious lasting harm to healthy trees.

P. cupressi is closely related to *P. variolatus* and these are the only species in California in which the first declivital interspace of the male is serrate only at the top. The adults of *P. cupressi* are distinguished by the much smaller elytral punctures, by the wider interspaces and generally by the host.

Phloeosinus sequoiae Hopkins
(Map 36)

Phloeosinus sequoiae Hopkins, 1903, U.S. Dep. Agric. Bur. For. Bull., 38:33. Syntypes, Guerneville, California (USNM).
Phloeosinus squamosus Blackman (nec Schedl), 1942, Proc. U.S.



Map 36. California distribution of *Phloeosinus sequoia* Hopkins.

Natl. Mus., 92(3154):448. Holotype ♂, Naselle, Washington (USNM). (Syn. by Wood, 1957*a*.)

Phloeosinus blackmanni Schedl, 1950, Occas. Pap. Bernice P. Bishop Mus., 20:35. (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—Phloeosinus sequoiae is distributed from southern British Columbia to southern California and probably extends a considerable distance inland. It has been recorded from western red, incense, and Port Orford cedar but its principal host in California is redwood. With this wide a host range, it will probably be found on other species of Cupressaceae.

California records (map 36).—Numerous localities in the following counties: Alameda, Del Norte, Fresno, Humboldt, Kern, Marin, Mendocino, Monterey, San Mateo, San Joaquin, Santa Clara, Santa Cruz, and Sonoma.

Biology. (DeLeon, 1952; Wohletz, 1931)

Adults of *Phloeosinus sequoiae* are in flight as early as April and may be found throughout the warmer parts of the year. Peak flights occur in early and late summer. Attacks are normally confined to injured or fallen timber, but outside its natural range attacks are common on weakened and dying trees. In fallen timber, attacks are more-or-less confined to the sides and undersurface of the stem but in standing trees any portion of the main trunk and limbs as small as 2 cm may be attacked. There is no restriction due to tree size. The twig-pruning habit common to many *Phloeosinus* species is not so pronounced.

Females initiate the attack, excavate a nuptial chamber or turning niche 5 × 12 mm long, and tunnel upward parallel to the grain. The egg gallery may be straight or slightly winding and near the distal end a short spur (turning niche ?) is excavated. The parent gallery length is variable, up to 25 cm, average about 14 cm. Eggs are deposited in niches crowded closely together on both sides of the gallery. Reports on the numbers of eggs varies from a few to 200 but seldom exceeding 150 with an average of about 50 per gallery.

Larval galleries begin at right angles to the egg gallery but either turn upwards or diverge to various degrees. Pupal cells are usually constructed in the sapwood but in thick-barked areas may be in the inner bark scoring the sapwood lightly.

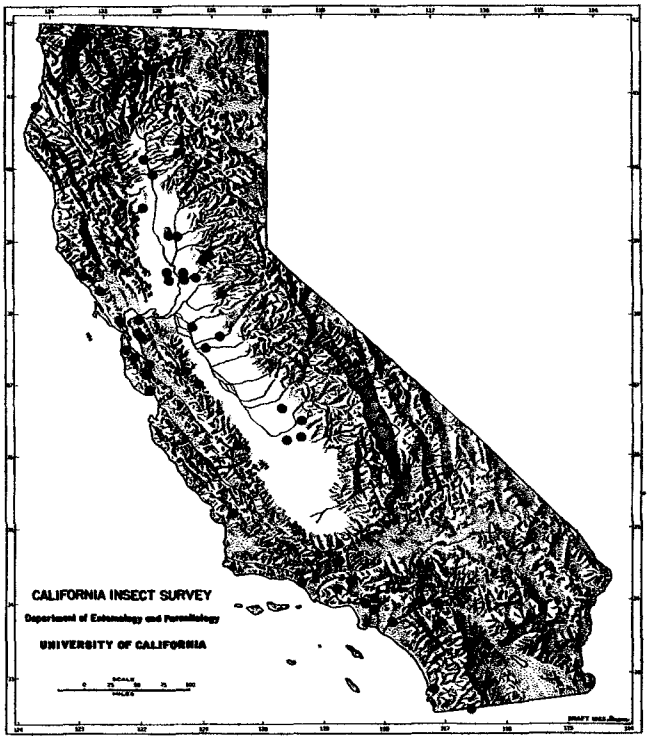
There is one complete generation per year and a partial second. Broods overwinter principally as mature larvae, frequently as young adults, parent adults, and immature larvae, and rarely as eggs or pupae. The overwintering parent adults extend their galleries and oviposit from March to May. This brood emerges in August or September. The overwintering teneral adults emerge from March through May and attack new hosts. The brood from these emerges slightly later than that from parent adults. Overwintering mature larvae complete development and the adults emerge in June and July; the adults from the young larvae may not emerge until August. This extended brood development gives rise to considerable overlap but two distinct generations can be distinguished.

The first generation is comprised of those broods from the mature overwintering larvae, pupae, teneral, and parent adults. Emergence of these extends from September through October.

The second generation begins in September. The first adults to emerge and attack establish broods which give rise to the overwintering mature larvae, pupae, and teneral adults. The later emergents give rise to overwintering parent adults, young larvae, and occasionally eggs.

Discussion.—Although common, the economic effects of *Phloeosinus sequoiae* are minimal. Their principal damage is to host trees planted as ornamentals outside of their natural ranges.

Phloeosinus sequoiae and *P. cristatus* are closely related and are often difficult to distinguish. Generally, the frontal carina of the adults of *P. sequoiae* is indistinct and faint but this may be true also in some specimens of *P. cristatus*. *P. sequoiae* is more commonly encountered in redwood and cypress while *P. cristatus* is common in incense cedar, juniper, red cedar, and



Map 37. California distribution of *Phloeosinus cristatus* LeConte.

cypress. The characters presented in the key plus information on the host will usually be adequate to distinguish the adults of the species.

Phloeosinus cristatus (LeConte)
(Fig. 15; map 37)

Hylesinus cristatus LeConte, 1868, Trans. Am. Entomol. Soc., 2:170. Syntypes ♀ ♀ and ♂ ♂, California (Carnegie Museum, Pittsburgh, Pa.).
Phloeosinus cristatus: Riley & Howard, 1893, Insect Life, 5:262.
Phloeosinus chiricahua Blackman, 1942, Proc. U.S. Natl. Mus., 92:444. Holotype ♂, Arizona (USNM). (Syn. by Wood 1971*b*.)

Geographic distribution and host range.—The recorded distribution of *Phloeosinus cristatus* is from central California to Arizona. However, since it attacks many species in the Cupressaceae the distribution is probably wider, extending into Oregon, Baja California, and Mexico. Species in the genus *Cupressus* are the favored hosts.

California records (map 37).—Numerous localities in the following counties: Alameda, Amador, Contra Costa, Fresno, Glenn, Humboldt, Kings, Lake, Los Angeles, Marin, Merced, Orange, Placer, Sacramento, San Bernardino, San Diego, San Joaquin, San Luis Obispo, San Mateo, Santa Cruz, Sonoma, Stanislaus, Sutter, Tehama, Tulare, Ventura, Yolo, and Yuba.

Biology. (Brown and Eads, 1967; Wohletz, 1931) The attack habits (fig. 15), seasonal history, and number of generations are almost identical to those of *P. sequoiae*. The only important difference is that *P. cristatus* attacks healthy twigs during prematuration feeding to a much greater extent. Twig-pruning resulting from such feeding occurs throughout the year but is particularly severe from July to September.

Discussion.—*Phloeosinus cristatus* is a very common species and is of concern in plantings, particularly of cypress. Twig-pruning is often so severe that the trees may be weakened and suffer fatal attack by this and other insects. Many reports of extensive killing of Monterey cypress have been made.

This species is related to *P. sequoiae* but the adults differ by the presence of a distinct, elevated carina (variable) on the male frons and the less rugose, more finely punctured elytral interspaces.

Genus *Chramesus* LeConte

Chramesus LeConte 1868, Trans. Am. Entomol. Soc., 2:168. Type-species: *Chramesus hicoriae* LeConte, monotypic.
Rhopalopleurus Chapuis, 1869, Synopsis des Scolytides, p. 46. (Preprint of Mem. Soc. R. Sci. Liege, 2(3):255, 1873.) Type-species: *Rhopalopleurus tuberculatus* Chapuis (Hopkins, 1914). (Syn. by LeConte, 1876.)

Two species of this genus have been taken in California. Both were previously known only from Arizona. Blackman (1938) recognizes eight species from North America. One additional species has been described recently (Wood, 1960).

Chramesus is a rather unique genus, not closely related to any other North American genus. Its closest relatives are in the Neotropical region. The antennal structure is distinctive (figs. 41, 42), and alone serves to distinguish this genus from all other California genera.

KEY TO THE SPECIES OF CHRAMESUS IN CALIFORNIA

1. Antennal scape without a tuft of long hairs in either sex; club large, 2.5 times longer than wide (fig. 41); epistoma smooth, without a prominent process . . *asperatus* Schaeffer
   Antennal scape with a tuft of long hair in male (fig. 43); club smaller, less than 2.25 times longer than wide (figs. 43, 42); epistoma of both sexes with an elevated process . . *dentatus* Schaeffer

Chramesus asperatus Schaeffer
(Fig. 41)

Chramesus asperatus Schaeffer, 1908, J. N. Y. Entomol. Soc., 16: 220. Lectotype ♀, Chiricahua Mountains, Arizona (USNM).
Chramesus gibber Blackman, 1938, J. Wash. Acad. Sci., 28:541. Holotype ♀, Cloudcroft, New Mexico (USNM). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—Chramesus asperatus has been found in the Chiricahua Mountains of Arizona, in New

Mexico, and in southern California. Its host in California is *Amorpha californica*; in Arizona, twigs of *Robinia neo-mexicanus*. It probably occurs on a wide variety of woody shrubs throughout southwestern North America.

California record.—San Bernardino Co.: San Bernardino Mtns. 6,000′, on *Amorpha californica* (LACM, CNC).

Biology.—Unknown.

Discussion.—Fourteen specimens of this species were examined from California. They were compared to specimens taken from several localities in southern Arizona and found to be identical in all respects. The adult can be easily recognized by the characters presented in the key.

Chramesus dentatus Schaeffer
(Figs. 42, 43)

Chramesus dentatus Schaeffer, 1908, J. N. Y. Entomol. Soc., 16:221. Lectotype ♀, Huachuca Mountains, Arizona (USNM).

Geographic distribution and host range.—Chramesus dentatus occurs in Arizona and southern California, and has been recorded only from oak. It probably has an extensive southwestern distribution on these hardwoods.

California record.—San Diego Co.: Warners [Hot Springs] (CAS).

Biology.—Unknown.

Discussion.—This species was not recorded from California by Blackman (1938); however, Bruck (1936*b*) states that it is found on twigs of oak in Arizona and California. Two specimens have been seen from southern California.

Besides the unsegmented antennal club (figs. 41–43), the adults of this species may be recognized by the bearded antennal scape of the male (fig. 41), by the sharp epistomal tooth in the concave frons of the male and by the median fovea on the female frons. The length of the adults is about 1.75 mm.

Tribe Hypoborini

Genus *Chaetophloeus* LeConte

Chaetophloeus LeConte, 1876, Proc. Am. Philos. Soc., 15:382. Type-species: *Hylesinus histrix* LeConte, monotypic.
Renocis Casey, 1886, Bull. Calif. Acad. Sci., 2:257. Type-species: *Renocis heterodoxus* Casey, monotypic. (Syn. by Schedl, 1963.)
Pseudocryphalus Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):20. Type-species: *Pseudocryphalus brittaini* Swaine, original designation. (Syn. by Blackman, 1940.)

This is a genus of small, scaly beetles found in a variety of woody shrubs. There are presently nine species known in the United States and Canada, seven of which occur in California.

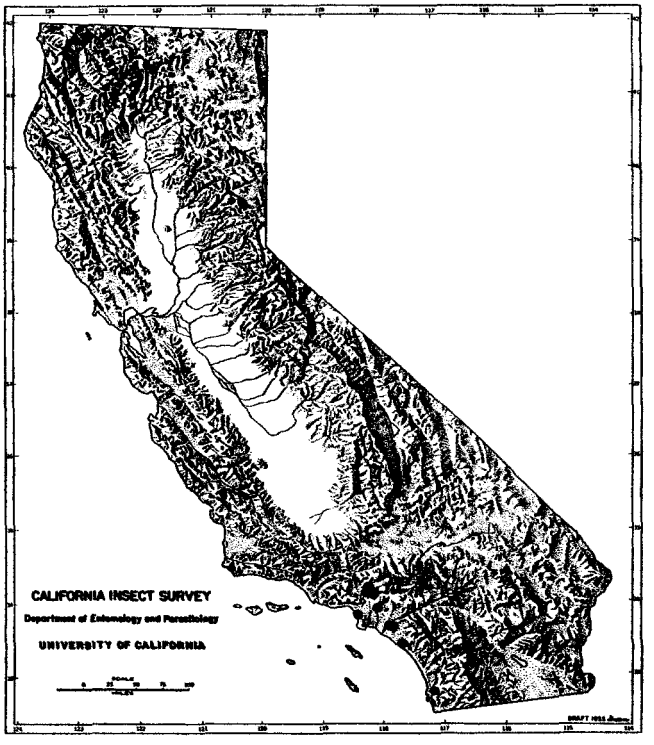
Since these beetles confine their attacks to shrubby material, their economic damage is usually nil. However, Bruck (1936*b*) states that many acres of valuable watershed in the San Gabriel Mountains were destroyed by fire and suggests that the killing of shrubs and bushes by insects increased the fire hazard. Blackman (1940) further suggests that erosion, landslides, and loss of browse for animals may result from the destruction of the plants by insects and fire.

Members of this genus may be recognized by their stout, oval body, by the presence of numerous scales, by the raised asperities on the base of the elytra close to the scutellum, and by the concave frons of the male with coarse setae at the sides and above.

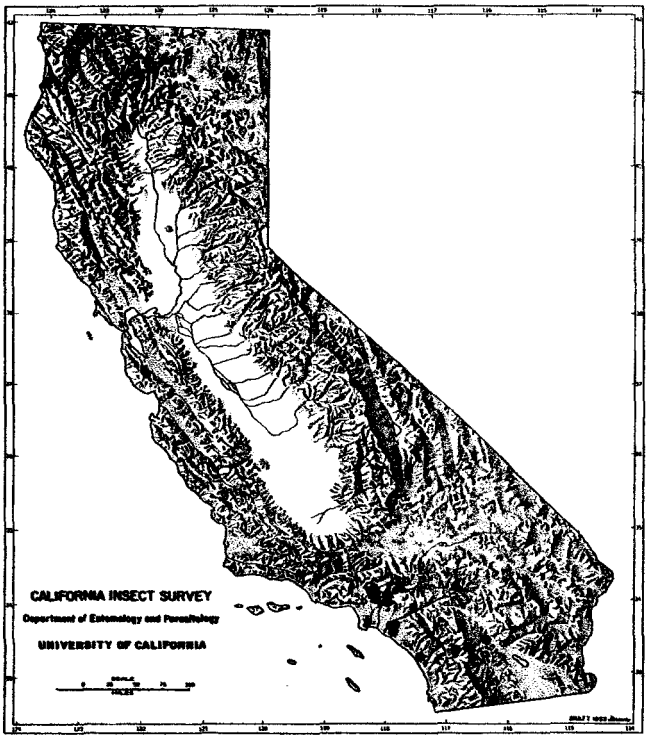
The genus was the subject of an extensive revision by Blackman (1940).

KEY TO THE SPECIES OF CHAETOPHLOEUS IN CALIFORNIA

1. Pubescence of elytra and pronotum entirely hairlike, none broad or scalelike; third declivital interspace raised and usually bearing 3 blunt tubercles..... *hystrix* (LeConte)
   Pubescence of elytra and pronotum almost entirely scalelike or at least with an interstrial row of broad scales; declivity variously sulcate or not, and devoid of blunt tubercles 2
2(1). Body size small, 1.1–1.6 mm; pronotum with a brush of long fine setae at each side of median emargination just behind anterior margin, these more conspicuous in male; declivity not impressed or sulcate in sutural region ..... *penicillatus* (Bruck)
   Body size over 1.4 mm; pronotum without long setae behind anterior margin; declivity very slightly to distinctly sulcate in sutural region..... 3
3(2). Elytral declivity obviously sulcate between the elevated third interspace, with the median rows of setae much reduced or lacking in first and second interspaces; fore tibia with 6 or from 9 to 14 teeth on outer margin 4
   Elytral declivity very weakly impressed in sutural area, with median row of setae present on all interspaces; fore tibia with 8 teeth on outer margin..... 6
4(3). Antennal club very large and slender, 3 times longer than wide, distinctly longer than scape and funicle combined (fig. 44); pronotum with 3 groups of small, slender asperities at each side; third declivital interspace distinctly raised, with setae in interspaces 3, 5, 7, and 9 more numerous, large and cylindrical; fore tibia with 9 to 14 teeth on outer margin (fig. 74) ..... *parkinsoniae* (Blackman)
   Antennal club shorter than scape and funicle combined (fig. 45); pronotum with 2 groups of sharp asperities at each side; declivity broadly, shallowly sulcate; fore tibia with 6 teeth on outer margin..... 5
5(4). Frons with a low, granulate tubercle on each side of median line; pronotum with dark brown scales form-



Map 38. California distribution of *Chaetophloeus hystrix* (LeConte).



Map 39. California distribution of *Chaetophloeus penicillatus* (Bruck), ● ; *Chaetophloeus heterodoxus* Casey, ▲ .

ing a diamond-shaped median marking and an oblong spot at each side of disk; elytra with sutural light stripe and alternate fasciae of brown and white scales; body twice as long as wide . . . *maclayi* (Bruck)

Frons with sides granulate-punctate, without tubercle; pronotum with cinereous and light brown scales, the latter forming an oblong spot at each side of disk; elytra with uniformly cinereous scales, with no evidence of fasciae; body stouter, about 1.85 times as long as wide . . . . . *pruinosus* (Blackman)

6(3). Smaller in size, 1.4 to 1.8 mm, about 1.75 times longer than wide; base of pronotum broadly, moderately deeply emarginate, with emargination bisinuate; front margin not bisinuate; frons without granule or tooth on each side of median line . . . . . *fasciatus* (Blackman)

Larger, 1.5 to 2.4 mm, about twice as long as wide; base of pronotum broadly procurved, with median portion not bisinuate; front margin bisinuate; frons usually with coarse granule or tooth on each side of median line . . . . . *heterodoxus* (Casey)

Chaetophloeus hystrix (LeConte)
(Fig. 45; map 38)

Hylesinus hystrix LeConte, 1858, Proc. Acad. Nat. Sci. Phila., 4:81. Holotype (sex ?), San Diego, California (MCZ).

Chaetophloeus hystrix: LeConte, 1876, Proc. Am. Philos. Soc., 15:382.

Geographic distribution and host range.—The present known distribution of *C. hystrix* is southern California but it probably is more widely spread than this.

California records (map 38).—Los Angeles Co.: Arroyo Seco, on *Rhus ovata* (CIS); El Segundo, on *R. integrifolia* (USNM); La Canada, on *R. ovata* (CIS); Montrose, on *R. ovata* (OSU); Whittier (PHT). Orange Co.: Laguna Beach, on *Photina arbutifolia* (CDA); Orange (PHT); Peters Canyon, on *R. integrifolia* (SLW). Riverside Co.: Aguanga, on *Rhus* (PSW); Pinyon Flat, 16 mi S. W. Palm Desert, on *R. laurina* (CIS). San Diego Co.: San Diego (UCD).

Biology.—Unknown.

Discussion.—The adults of *Chaetophloeus hystrix* are easily recognized by the sulcate elytral declivity and by the third elytral interspace which is raised and usually bears three blunt tubercles.

Chaetophloeus penicillatus (Bruck)
(Map 39)

Renocis penicillatus Bruck, 1933, Can. Entomol., 65:239. Holotype ♂ ?, Peters Canyon, Orange Co., California (OSU).

Geographic distribution and host range.—Throughout the southwestern United States, including Arizona, southern California, Colorado, Utah, and Baja California on various species of *Rhus*.

California records (map 39).—Los Angeles Co.: Arroyo Seco, on *Rhus ovata* (CIS); Azusa (CNC); Henniger Flat, Mt. Wilson, on *R. ovata* (USNM); Pasadena (CAS). Orange Co.: Costa Mesa (OSU); Orange, on *R. integrifolia* (CAS); Peters Canyon, on *R. integrifolia* (OSU). Riverside Co.: Aguange, on *R. ovata* (USNM); Pinyon Flat, 16 mi S. W. Palm Desert, on *R. laurina* (CIS). San Diego Co.: 4 mi N. W. Jacumba, on *R. ovata* (CNC); 11 mi S. San Matias Pass (LBSC).

Biology.—Unknown.

Discussion.—The adults of this common and widespread species are the smallest in the genus found in California, measuring from 1.1 to 1.6 mm in length. Besides their small size, they may be recognized by the two groups of long setae located just behind the anterior margin of the pronotum.

Chaetophloeus parkinsoniae (Blackman)
(Figs. 44, 74)

Renocis parkinsoniae Blackman, 1940, Proc. U.S. Natl. Mus., 88:378. Holotype ♀, Catalina Springs, Arizona (USNM).

Geographic distribution and host range.—C. parkinsoniae probably occurs throughout the southwest and into Mexico. Its hosts include species of Palo Verde.

California records.—Los Angeles Co.: Los Angeles (SLW). Riverside Co.: Chuckawalla Spr., Chuckawalla Mtns., on *Cercidium torryanum* (CNC).

Biology.—Unknown.

Discussion.—The unique characters of the declivity and antennae will easily serve to distinguish the adults of this species. They measure between 1.7 and 2.5 mm in length.

Chaetophloeus maclayi (Bruck)

Pseudocryphalus maclayi Bruck, 1936, Bull. S. Calif. Acad. Sci., 35(1):35. Holotype (sex ?), Westwood Hills, California (OSU).
Renocis maclayi: Blackman, 1940, Proc. U. S. Natl. Mus., 88:382.

Geographic distribution and host range.—Although recorded only from southern California on one species of *Encelia*, *C. maclayi* probably occurs throughout much of the range of this plant genus in the southwestern United States and Mexico.

California record.—Los Angeles Co.: Westwood, on *Encelia* sp. (OSU).

Biology.—Unknown.

Discussion.—Bruck (1936*a*) described this species from over 300 specimens, all collected from *Encelia californica*. Most were taken by beating but six were dug out from under the barklike epidermal layer. No additional specimens were collected during this study. The adults of *Chaetophloeus maclayi* are most readily distinguished by the presence of a low, blunt tubercle on the lateral margins of the frons.

Chaetophloeus pruinosus (Blackman)

Renocis pruinosus Blackman, 1940, Proc. U. S. Natl. Mus., 88: 383. Holotype ♀, Southern California (USNM).

Geographic distribution and host range.—C. pruinosus apparently has a distribution and host range similar to *C. maclayi*.

California records.—Riverside Co.: Indio (SLW). San Bernardino Co.: County record only (USNM).

Biology.—Unknown.

Discussion.—Chaetophloeus pruinosus is closely related to *C. maclayi* but the adults differ by the lack of the tubercles on the frons, by the different type of color pattern and by the stouter body size. They are 1.8–2.3 mm long.

Chaetophloeus fasciatus (Blackman)

Renocis fasciatus Blackman, 1940, Proc. U.S. Natl. Mus., 88:385. Holotype ♀, Tucson, Arizona (USNM).

Geographic distribution and host range.—The probable distribution of *C. fasciatus* is throughout southwestern United States and into Mexico. It attacks various species of woody shrubs.

California records.—Imperial Co.: Fish Springs, reared from mesquite (UCD). Los Angeles Co.: Mint Canyon, on *Prunus ilicifolia* (OSU).

Biology.—Unknown.

Discussion. — Chaetophloeus fasciatus, previously known only from Arizona, is probably rare in California. Only two series have been seen. The adult is about 1.4 to 1.8 mm long. It is related to *C. heterodoxus* but the adults can be distinguished most easily by the lack of a tubercle on each side of the frontal cavity of the frons and by their smaller size.

Chaetophloeus heterodoxus (Casey)
(Fig. 16; map 39)

Renocis heterodoxus Casey, 1886, Bull. Calif. Acad. Sci., 6:257. Holotype ♂, Reno, Nevada (USNM).
Renocis brunneus Blackman, 1940, Proc. U.S. Natl. Mus., 88:389. Holotype ♀, Cloudcroft, New Mexico (USNM). (Syn. by Wood, 1971*b*.)
Renocis fuscus Blackman, 1940, Proc. U.S. Natl. Mus., 88:391. Holotype ♀, Williams, Arizona (USNM). (Syn. by Wood, 1971*b*.)
Renocis commixtus Blackman, 1940, Proc. U.S. Natl. Mus., 88: 392. Holotype ♀, Williams, Arizona (USNM). (Syn. by Wood, 1971*b*.)

Geographic distribution and host range.—*C. heterodoxus* occurs throughout western United States as far east as Utah and probably occurs in Mexico. It attacks several species of woody shrubs.

California records (map 39).—HUMBOLDT Co.: Big Lagoon Bay (CIS). LASSEN Co.: Hat Creek, on *Cercocarpus ledifolius* (SLW). LOS ANGELES Co.: Big Pines Park, on *C. ledifolius* (OSU); Mint Canyon, on *Prunus ilicifolia* (OSU); Mint Canyon, on *P. ilicifolia* (OSU). MODOC Co.: Devils Garden, on *Cercocarpus ledifolius* (OSU). SAN BERNARDINO Co.: Bear Lake (CAS). SISKIYOU Co.: Bray, on mountain mahogany (PSW); Grass Lake, on *C. ledifolius* (CIS).

Biology.—The principal flight period in Oregon is late June but adults have been observed later in the year. These may be adults of a second generation or from overlapping generations.

Both sexes apparently enter the host at the same time. The species is monogamous. The nuptial chamber is roughly oval, 4 × 6 mm and engraves the wood deeply. From 3 to 6 short (1–3 mm) galleries extend from this chamber (fig. 16) and from 6 to 12 eggs are deposited at the end of each.

Larval galleries extend from the egg gallery about 2 cm, again engraving the wood deeply. Oval pupal chambers are constructed at the end about three-quarters in the wood, one-quarter in the bark.

There appears to be but one generation per year in the northern part of its range. Adults have been observed ovipositing in July and the parent adults as well as brood adults were still present in the host a year later. However, since overwintering adults have been found to lay eggs the following spring, the possibility of a second, overlapping generation exists.

Discussion.—*Chaetophloeus heterodoxus* is ordinarily considered of minor importance. However, on at least one occasion large populations have killed mountain mahogany over extensive areas. Since this shrub is an important browse species for deer, *C. heterodoxus* can pose a threat to wildlife food supplies.

C. heterodoxus is one of the most commonly collected species of the genus in California. Both males and females vary considerably in structure. The size of the adults ranges from 1.5 to 2.4 mm. The color pattern depends on the relative abundance and arrangement of the differently colored scales and may show considerable variety. The presence of an epistomal tooth and tubercles on the lateral portions of the frons are the most obvious distinguishing characters.

Tribe Polygraphini

Genus *Carphoborus* Eichhoff

Carphoborus Eichhoff, 1864, Berl. Entomol. Z., 8:27. Type-species: *Hylesinus minimus* Fabricius, monotypic.

Species of the genus *Carphoborus* are found throughout the Holarctic region. In North America they occur in Canada and the United States but apparently not into Mexico except in northern Baja California. Nineteen species occur in North America, and 10 of these are found in California.

The genus has been revised by Wood (1954*a*). Two North American species have been described since the revision: *C. perplexus* Wood (1960) and *C. tuberculatus* Bright (1964).

Little is known of the biology of the species occurring in California. Attacks are usually on dead limbs or small tops of dead trees. The species are polygamous and the parent galleries (five to eight) radiate from a central gallery which deeply etches the wood. Egg niches are closely spaced and the short larval mines lack a definite pattern, often doubling back and crossing.

KEY TO THE SPECIES OF CARPHOBORUS IN CALIFORNIA
(Modified from Wood, 1954*a*)

1. Antennal club large, broad, 1.2 or less times longer than as wide (fig. 46); female frons impunctate and glabrous on a rather large median area; transverse impression of male frons more conspicuous and extensive, the median elevation rather large and prominent 2
   Antennal club small, narrow, 1.3 or more times longer than wide (fig. 47); female frons punctuate or granulate, and pubescent over entire surface; male frons usually less strongly impressed below, the median elevation smaller, often absent..... 7
2(1). Female frons flattened and with long pubescence..... 3
   Female frons convex and with rather short pubescence. 6
3(2). Second declivital interspace as wide as first or third, usually convex; first, third, fifth, seventh, and ninth less strongly elevated, more finely serrate; in *Pseudotsuga macrocarpa*.....*blaisdelli* Swaine
   Second declivital interspace distinctly narrower than first or third, flat; alternate declivital interspaces usually more strongly elevated, the serrations usually larger 4
4(3). Antennal club smaller, narrower, about 1.2 times longer than wide; second interspace becoming obsolete on upper half of declivity; third declivital interspace more strongly elevated; in *Pinus*.....*simplex* LeConte
   Antennal club larger, broad, less than 1.2 longer than wide; second declivital interspace narrow but continuing to near apex; third declivital interspace only slightly elevated 5
5(4). Sutures of antennal club suboblique, rather strongly arcuate (fig. 46); third and ninth declivital interspaces usually less strongly elevated, the serrations smaller, less abundant; in *Pseudotsuga menziesii*.... *vandykei* Bruck
   Sutures of antennal club subtransverse, nearly straight; third and ninth declivital interspaces usually more strongly elevated, the serrations larger, more abun-

dant; in *Pinus* (fig. 75) ..... *pinicolens* Wood

6(2). Impunctate area of female frons as large as antennal club, smooth and shining with no indication of a tubercule; serrations of first and third declivital interspaces larger and more prominent; southern California, in pinyon pines ..... *frontalis* Wood

Impunctate area of female frons distinctly smaller than antennal club, sometimes with an elevated median tubercule; serrations of first and third declivital interspaces much smaller and inconspicuous; in subalpine pines ..... *tuberculatus* Bright

7(1). Second declivital interspace with small teeth; fourth, sixth and eighth declivital interspaces serrate..... *declivis* Wood

Second, fourth, sixth and eighth declivital interspaces devoid of distinct teeth or serrations..... 8

8(7). Vestiture of female frons nearly uniform in length; teeth of third declivital interspace larger, nearly equal to height of an interspace; in *Pinus*..... 9

Vestiture of female frons longer and incurved on periphery; teeth on third declivital interspace much shorter than height of an interspace; in *Picea*..... *intermedius* Wood

9(8). Female frons flattened, often with a deep median groove; male frons usually without tuberculate elevation; declivital teeth much larger and prominent.... *ponderosae* Swaine

Female frons broadly concave, never with a deep median groove; male frons with prominent tuberculate elevation; declivital teeth smaller and less conspicuous ..... *radiatae* Swaine

Carphoborus blaisdelli Swaine
(Map 40)

Carphoborus blaisdelli Swaine, 1924, Can. Entomol., 56:234. Holotype ♂, Camp Baldy, San Bernardino Co., California (CNC).

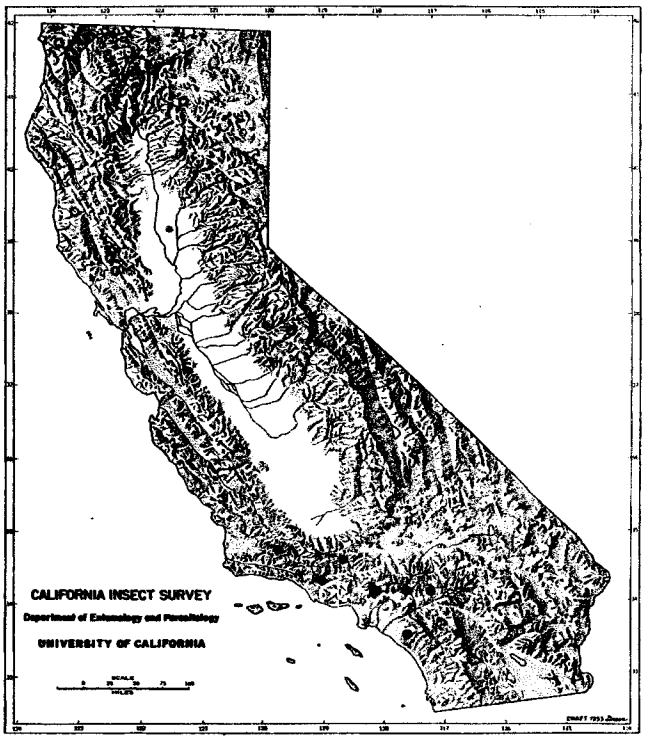
Carphoborus cressatyi Bruck, 1936, Bull. S. Calif. Acad. Sci., 35:36. Holotype ♂, Arroyo Seco, Los Angeles Co., California (OSU). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—*C. blaisdelli* is restricted to the distribution of its host, big-cone spruce, in southern California. The one record from deodar cedar is probably accidental.

California records (map 40).—Los Angeles Co.: Arroyo Seco, on *Pseudotsuga macrocarpa* (UCD); Lake Arrowhead, on *P. macrocarpa* (PSW); Mt. Wilson (CAS); Pasadena (CAS); Pine Canyon, on *Cedrus deodara* (CDA); Switzers Camp, on *P. macrocarpa* (CIS). Orange Co.: Silverado, on *P. macrocarpa* (HSC). Riverside Co.: Keen Camp, on *P. macrocarpa* (DEB). San Bernardino Co.: Camp Baldy (CNC). Santa Barbara Co.: Barley Flat, on *P. macrocarpa* (OSU); Sierra Madre Mtns. (CAS). Ventura Co.: Santa Paula Canyon (OSU).

Biology.—Unknown.

Discussion.—This rare species resembles *C. vandykei* and *C. pinicolens*. The adults may be distinguished by the relatively broad second declivital interspace and by the less strongly elevated third declivital interspace.



Map 40. California distribution of *Carphoborus blaisdelli* Swaine, ● ; *Carphoborus vandykei* Bruck, ○ .

The host and distribution will further characterize them.

Carphoborus simplex LeConte
(Map 41)

Carphoborus simplex LeConte, 1876, Proc. Am. Philos. Soc., 15: 383. Type (sex ?) Mojave Desert, California (MCZ).

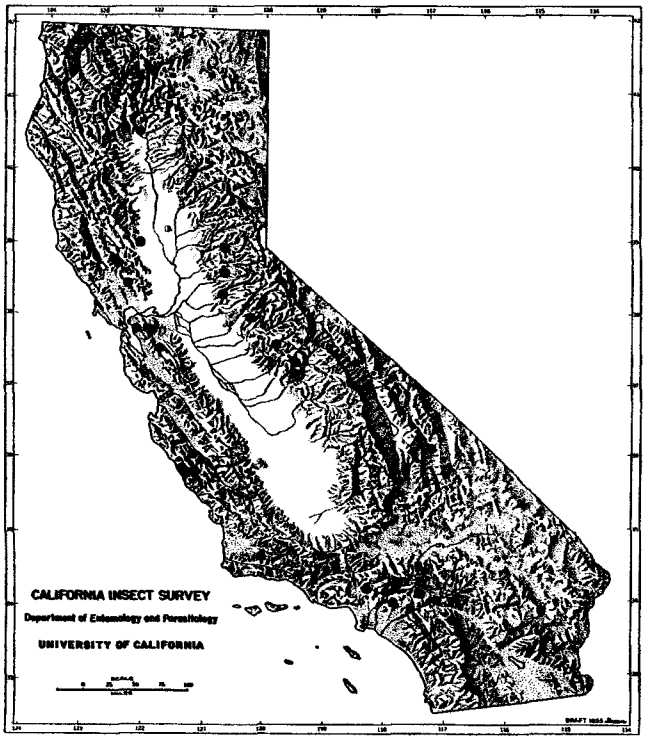
Carphoborus swainei Bruck, 1933, Can. Entomol., 65:105. Holotype ♂, Mt. Diablo, California (OSU). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—*Carphoborus simplex* probably occurs throughout the pine forests of southwestern United States at least as far north as Oregon and probably south into Mexico. Its recorded hosts include several species of pines and probably most pines are attacked.

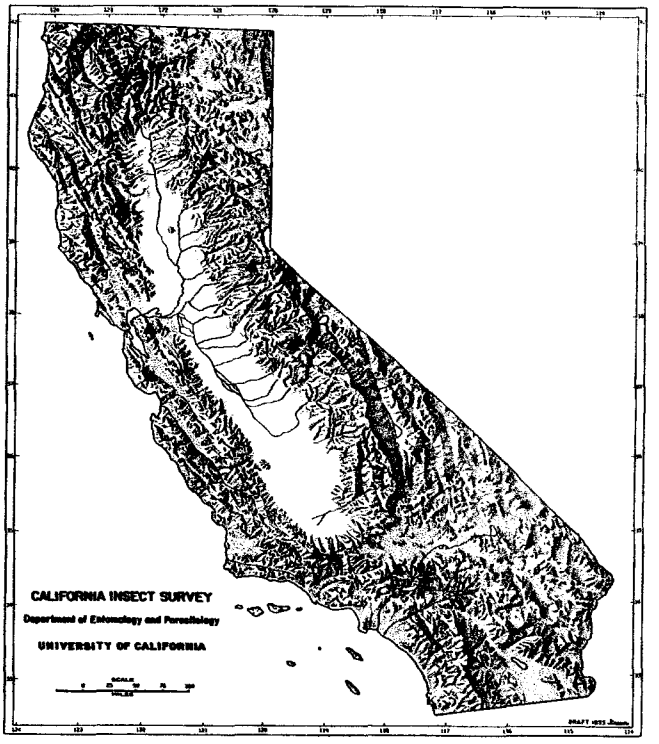
California records (map 41).—Numerous localities in the following counties: Alameda, Amador, Colusa, Contra Costa, El Dorado, Inyo, Lake, Los Angeles, Madera, Mariposa, Monterey, Napa, Placer, Riverside, Santa Barbara, San Bernardino, San Diego, Shasta, Tuolumne, and Ventura.

Biology.—Unknown.

Discussion.—The adults of this common species may be easily recognized by the narrowed second declivital interspace which is usually eliminated on the upper part of the declivity by the convergence of striae one and two. It is closely allied to *C. vandykei* and *C.*



Map 41. California distribution of *Carphoborus simplex* LeConte.



Map 42. California distribution of *Carphoborus pinicolens* Wood.

pinicolens but the adults of *C. simplex* may be easily distinguished by the character mentioned above, by the more strongly elevated first, third, and ninth declivital interspaces, and by the more slender antennal club.

Carphoborus vandykei Bruck
(Fig. 46; map 40)

Carphoborus vandykei Bruck, 1933, Can. Entomol., 65:104. Holotype ♂, Mt. St. Helena, California (OSU).

Geographic distribution and host range.—The distribution of *Carphoborus vandykei* follows that of its host, Douglas fir, from British Columbia south to central California in coastal forests and the Sierra Nevada. It is not known whether *C. vandykei* attacks the interior variety of Douglas fir. The single record on Sargent cypress is either an accident or misidentification of the host.

California records (map 40).—Del Norte Co.: County record only, on *Pseudotsuga taxifolia* (CNC). Lake Co.: Cobb, on *P. taxifolia* (CIS); Mt. St. Helena, on Sargent cypress (CIS); Whispering Pines, on *P. taxifolia* (CIS). Mendocino Co.: 6 mi N. Willits, on *P. taxifolia* (DEB). Plumas Co.: Quincy, on *P. taxifolia* (CIS). Shasta Co.: Burney, on *P. taxifolia* (SLW). Siskiyou Co.: Deadhorse Summit, on *P. taxifolia* (DEB). Trinity Co.: Willow Creek, on *P. menziesii* (HSC). County unknown: Yosemite Natl. Park, on *P. taxifolia* (CNC).

Biology.—Unknown.

Discussion.—In California, *C. vandykei* is the only species of *Carphoborus* found in Douglas fir. It is closely related to *C. pinicolens* and *C. blaisdelli*. The adults can with difficulty be distinguished from those of *C. pinicolens* by the reddish-brown color, by the less strongly elevated third and ninth declivital interspaces, by the smaller and less numerous declivital teeth, and by the more strongly arched sutures of the antennal club. They may be distinguished from the adults of *C. blaisdelli* by the second declivital interspace which is narrower than the first and third, by the more strongly elevated third interspace, and by the distribution.

Carphoborus pinicolens Wood
(Fig. 75; map 42)

Carphoborus pinicolens Wood, 1954, Can. Entomol., 86:512. Holotype ♀, Logan Dry Canyon, Utah (USNM).

Geographic distribution and host range.—*C. pinicolens* probably is distributed throughout western North America. It attacks most species of pines. The record on oak is considered accidental.

California records (map 42).—Alpine Co.: Markleeville, on *Pinus monophylla* (CIS). Contra Costa Co.: Russelmann Park, on *P. sabiniana* (CAS). El Dorado Co.: Kyburz (CIS). Glenn Co.: Cedar Ridge, on yellow pine (CAS); Self R. S., on yellow

pine twigs (CAS). Los Angeles Co.: Gorman, on *P. monophylla* (CIS); Mt. Hawkins, on *P. lambertiana* (OSU). Mariposa Co.: Anderson Valley, on *P. lambertiana* (CAS); Signal Peak, on *P. ponderosa* (SLW). Monterey Co.: Junipero Serra Peak, Santa Lucia Mtns., on *P. coulteri* (CAS). Plumas Co.: Chester (OSU). Santa Clara Co.: Los Gatos, on *Quercus agrifolia* (CIS). Tuolumne Co.: Tuolumne Meadows, on *P. murrayana* (CAS). Ventura Co.: Mt. Pinos, on *P. flexilis* (CIS).

Biology.—Unknown.

Discussion.—This is one of the most abundant and widespread species in the genus. It was erroneously called *C. simplex* by Bruck and others until Wood (1954*a*) unraveled the nomenclature of the genus and recognized this species as undescribed.

It is most closely related to *C. vandykei* and the adults may be distinguished with difficulty by the black color, by the more strongly elevated third and ninth declivital interspaces, by the larger and more numerous declivital teeth, and by the less strongly arched sutures of the antennal club.

Carphoborus frontalis Wood

Carphoborus frontalis Wood, 1954, Can. Entomol., 86:515. Holotype ♀, Ventura Co., California (USNM).

Geographic distribution and host range.—The known distribution of *C. frontalis* is southwestern California. However, its hosts, *Pinus monophylla* and possibly its associate, *P. edulis*, occur in drier areas of Arizona, New Mexico, Texas, Wyoming, and Utah and this may well be the ultimate range of *C. frontalis*.

California records.—Los Angeles Co.: Valyermo, on *Pinus monophylla* (OSU). San Bernardino Co.: Wrightwood, on *P. monophylla* (CIS). Ventura Co.: Frazier Mtn., on *P. monophylla* (OSU); Sandstone Camp, on *P. monophylla* (CIS).

Biology.—Unknown.

Discussion.—*Carphoborus frontalis* is closely related to *C. pinicolens* but the adults of *C. frontalis* differ by the presence of a raised median line on the frons of both sexes. The female also has a larger impunctate area on the frons than does the female of *C. pinicolens*.

Carphoborus tuberculatus Bright

Carphoborus tuberculatus Bright, 1964, Pan-Pac. Entomol., 40(3):165. Holotype ♀, Crooked Creek, White Mountains, California (CAS).

Geographical distribution and host range. — *Carphoborus tuberculatus* was described in 1964 from *Pinus aristata* in California. However, it attacks at least three species of pines so it is likely that it will eventually be found throughout western pine forests in comparable climatic zones.

California records.—Inyo Co.: ½ mi S. Onion Valley, on *Pinus balfouriana* (CNC). Mono Co.: Crooked Creek, White Mountains, on *P. aristata* (CIS); 10 mi N. Westgard Pass, on *P. aristata* and *P. flexilis* (CNC). Siskiyou Co.: Near Callahan, on *P. balfouriana* (CNC).

Biology.—Unknown.

Discussion.—This is the only species of *Carphoborus* in which the adult possesses a tubercle in the glabrous portion of the female frons. It is rather closely related to *C. pinicolens* and *C. frontalis* but the adults are easily recognized by the above character as well as the more prominent tubercles on the first, third, and ninth declivital interspaces and by the hosts.

Carphoborus declivis Wood

Carphoborus declivis Wood, 1954, Can. Entomol., 86:522. Holotype ♀, Lake Tenaya, Yosemite Natl. Park, California (USNM).

Geographic distribution and host range.—Although collected only in California, the distribution of *C. declivis* is probably much more extensive since the two recorded hosts, lodgepole and bristlecone pine occur in mountain areas throughout western North America.

California records.—Inyo Co.: 10 mi N. Westgard Pass, on *Pinus aristata* (CNC). Mariposa Co.: Lake Tenaya, Yosemite Natl. Park, on *P. murrayana* (USNM, CNC).

Biology.—Unknown.

Discussion.—The adults of this species are unique among the known species of *Carphoborus* in having small teeth on the second declivital interspace.

Carphoborus intermedius Wood

Carphoborus intermedius Wood, 1954, Can. Entomol., 86:523. Holotype ♂, New Castle, Colorado (USNM).

Geographical distribution and host range.—C. intermedius is distributed throughout the Pacific Northwest at least as far east as Colorado, probably in southwestern Canada, and south to northern California. It has been collected only from weeping spruce in California but it attacks Engelmann spruce elsewhere.

California records.—Siskiyou Co.: Etna, on *Picea breweriana* (HSC); 13 mi N. Happy Camp, on *P. breweriana* (CIS).

Biology.—Unknown.

Discussion.—The adults of this species are easily distinguished from those of other species of *Carphoborus* in California by the distinctly elevated third declivital interspace which has a row of small teeth, by the lack of a median elevation on the male frons, and by the host.

Carphoborus ponderosae Swaine

Carphoborus ponderosae Swaine, 1924, Can. Entomol., 56:236. Holotype ♀, Merritt, British Columbia (CNC).

Geographic distribution and host range.—*C. ponderosae* has been collected only from ponderosa pine and should occur throughout the range of this host; that is, from interior British Columbia south to San Diego county in California and east to the Rocky Mountains. It has been recorded from lodgepole pine elsewhere.

California record.—Modoc Co.: Hackamore, on *Pinus ponderosa* (PSW).

Biology.—Unknown.

Discussion.—Only one specimen of this rare species has been seen, but it probably occurs throughout northeastern California and in the Sierra Nevada.

This species is related to *C. radiatae* but the adults are most easily distinguished by the much more strongly elevated, coarsely serrate third and ninth declivital interspaces. The host and distribution will also aid in distinguishing them.

Carphoborus radiatae Swaine
(Fig. 47)

Carphoborus radiatae Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):57. Holotype ♀, Carmel, California (CNC).

Geographic distribution and host range.—*Carphoborus radiatae* is an endemic species occurring along the Pacific Coast near Monterey, California. However, its host, Monterey pine, is now planted throughout California and the distribution of *C. radiatae* may change accordingly.

California record.—Monterey Co.: Carmel, on *Pinus radiata* (CAS, CNC).

Biology.—Unknown.

Discussion.—*Carphoborus radiatae* is related to *C. ponderosae* but the adults are readily distinguished by the smaller declivital teeth and by the frontal characters of both sexes as presented in the key.

Tribe Micracini

Genus *Cactopinus* Schwarz

Cactopinus Schwarz, 1899, Psyche 8 (suppl.) 1:11. Type-species: *Cactopinus hubbardi* Schwarz, monotypic.
Cactopinorus Bright, 1967, Can. Entomol., 99:918. Type-species: *Cactopinus cactophthorus* Wood, original designation. (Syn. by Wood, 1969*a*.)

Adults of this remarkable genus are distinguished from adults of all other genera of Scolytidae by the usually elevated, V-shaped, asperate region of the pronotum and by the prominent hornlike process on the male epistoma.

Bright (1967) reviewed the genus and recognized seven species, distributed from the southwestern United States to central Mexico. Four species occur in California. Their life cycles and seasonal histories are unknown.

KEY TO THE SPECIES OF CACTOPINUS IN CALIFORNIA
(From Bright, 1967)

1. Second declivital interspace of both sexes with small granules or tubercules; from *Pinus* or *Rhus*..... 2
   Second declivital interspace of both sexes with a row of prominent teeth; from *Bursera* (fig. 76)...*desertus* Bright
2. Elytral suture depressed on declivity below elytral surface; declivity excavated and sulcate; third interspace definitely higher than suture and granulate; frons of female devoid of epistomal teeth..... 3
   Elytral suture not depressed on declivity; declivity not excavated or sulcate, first striae impressed on declivity to near apex of elytra; third interspace not definitely higher than suture; female frons with two epistomal teeth .....*koebelei* Blackman
3. Declivity shallow, second interspace not widened toward elytral apex, suture and second interspace granulate; horn of male generally very short, usually less than 0.3 mm long; in *Rhus* spp.....*rhois* Blackman
   Declivity much deeper, second interspace widened toward elytral open, suture and second interspace not granulate; horn of male generally much longer than 0.3 mm; in *Pinus* spp.....*pini* Blackman

Cactopinus desertus Bright
(Figs. 17, 76)

Cactopinus desertus Bright, 1967, Can. Entomol., 99:923. Holotype ♂, Anza-Borrego Desert State Park, California (CAS).

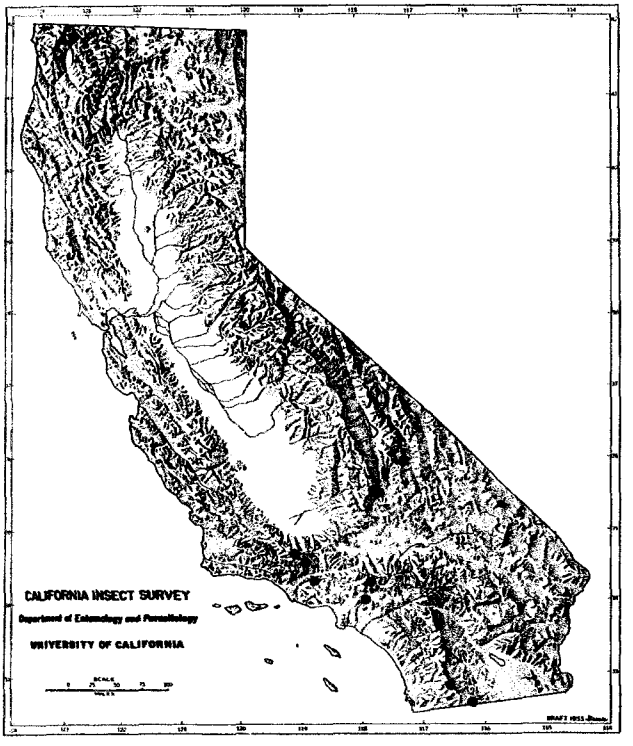
Geographic distribution and host range.—A desert species, *Cactopinus desertus*, has been found only in the elephant tree, *Bursera microphylla*. This plant grows in arid, rocky places in the western Colorado desert, Arizona, and Baja California and *C. desertus* may be found within this range.

California records.—San Diego Co.: 7 mi S. Ocotillo Wells, Anza-Borrego Desert State Park, on *Bursera microphylla* (CIS, CAS); Torote Canyon, Anza-Borrego Desert State Park, on *B. microphylla* (CIS).

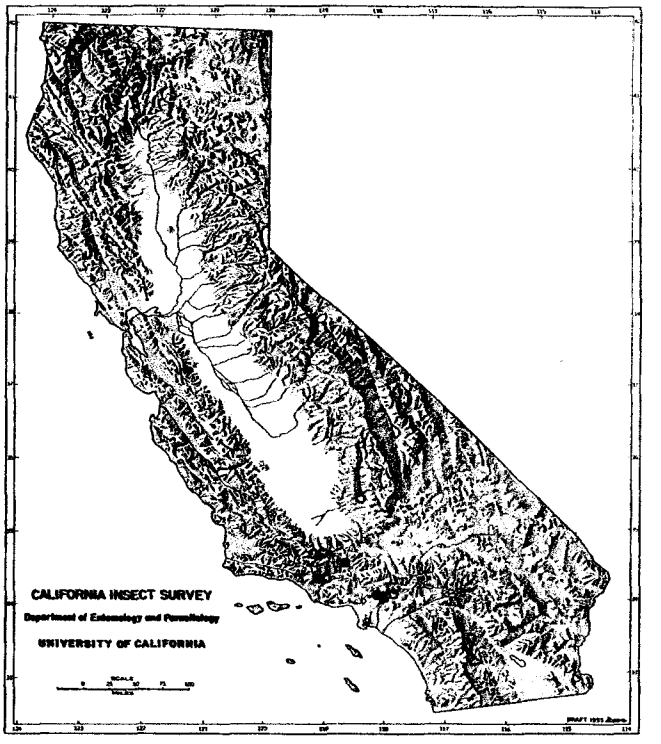
Biology. (Bright, 1967)

Attacks were noted on broken branches 4–7 cm in diameter, smaller branches, and the stem of the host. Galleries could be determined only where feeding was confined to the cambium or where the bark was thin. In thick bark, the beetles bore throughout the bark, apparently producing several generations, and obliterate any pattern.

The egg gallery consists of a large irregular chamber (fig. 17). Eggs are laid in large niches carved in the sides of the chamber, covered with frass and boring dust. Larval mines are not oriented in any particular



Map 43. California distribution of *Cactopinus koebelei* Blackman.



Map 44. California distribution of *Cactopinus rhois* Blackman, ● ; *Cactopinus pini* Blackman, ○ .

direction. Pupation occurs in enlarged cells at the end of larval galleries.

Discussion.—The very prominent teeth on the second declivital interspace, the very long male horn, and the host will easily distinguish the adults of this species.

Galleries, probably made by this species, were seen on *Bursera microphylla* in the Organ Pipe Cactus Natl. Monument near Ajo, Arizona, in 1968.

Cactopinus koebelei Blackman
(Map 43)

Cactopinus koebelei Blackman, 1938, Proc. Entomol. Soc. Wash., 40(6):156. Holotype ♂, Argus Mountains, Inyo Co., California (USNM).

Geographical distribution and host range.—The present known distribution of *C. koebelei* includes southern California, Baja California, and Utah. Since its hosts, single-leaf pinyon and sugar pine are distributed extensively throughout the southwest and California the range of *C. koebelei* is probably extensive. Additional species may also be attacked.

California records (map 43).—INYO Co.: Argus Mountains (USNM). KERN Co.: Walker Pass, 15 mi S. Inyokern (CNC). LOS ANGELES Co.: Mt. Hawkins, on *Pinus lambertiana* (OSU); Valyermo, on *P. monophylla* (CIS, CAS, OSU). SAN DIEGO Co.: Guatay (CIS); Jacumba (OSU). VENTURA Co.: Lockwood Creek, on *P. monophylla* (USNM); Mt. Pinos, on *P. monophylla* (OSU); Piru Creek (USNM).

Biology.—Unknown.

Discussion.—A pine-infesting species, the adults of *C. koebelei* can be most easily distinguished by the nearly convex, not distinctly sulcate elytral declivity with the sutural row of strial punctures impressed. Further, the epistoma of the female usually bears two, ventrally curved, sharply pointed tubercles.

Cactopinus rhois Blackman
(Fig. 18; map 44)

Cactopinus rhois Blackman, 1938, Proc. Entomol. Soc. Wash., 40(6):154. Holotype ♂, Ventura Co., California (USNM).

Geographical distribution and host range.—*Cactopinus rhois* attacks various species of *Rhus* whose overall distribution extends into the Pacific Northwest. Although found only in southern California, the distribution of *C. rhois* is probably much more extensive. We believe the single record in Digger pine is an error.

California records (map 44).—LOS ANGELES Co.: Montrose, on *Rhus ovata* and *R. diversiloba* (OSU); Henniger Flat, Mt. Wilson, on *R. ovata* (OSU); Mount Wilson (OSU); Hughes

Lake, on *Pinus sabiniana* (OSU). VENTURA Co.: County record only, on *Rhus integrifolia* (USNM).

Biology. (Bright, 1967)

C. rhois occurs under the bark of dying branches of *Rhus* species. The parent gallery is a broad, frass-filled chamber (fig. 18). Large egg niches are cut into the wall; larval mines are meandering and engrave the wood rather deeply. Pupae cells are constructed at the end of the larval mine and the resulting adults extend feeding galleries from them.

Discussion.—Cactopinus rhois resembles *C. koebelei* rather closely but the adults may be distinguished most easily by the deeper, more strongly sulcate declivity, by the less strongly impressed female frons which is devoid of epistomal teeth, by the generally smaller size, and by the hosts.

The unarmed, relatively shallow declivity will distinguish them from the adults of other species in the genus in California.

Cactopinus pini Blackman
(Map 44)

Cactopinus pini Blackman, 1938, Proc. Entomol. Soc. Wash., 40(6):153. Holotype ♂, Griffen, Kern Co., California (USNM).

Geographic distribution and host range.—The known distribution of *C. pini* is southern California but since one of its hosts, single-leaf pinyon pine occurs in the Sierra Nevada bordering the Mojave desert and north to Tuolumne County, and in Utah and Nevada, the actual distribution is probably much wider. *C. pini* also attacks Jeffrey pine and other related pines may also serve as hosts.

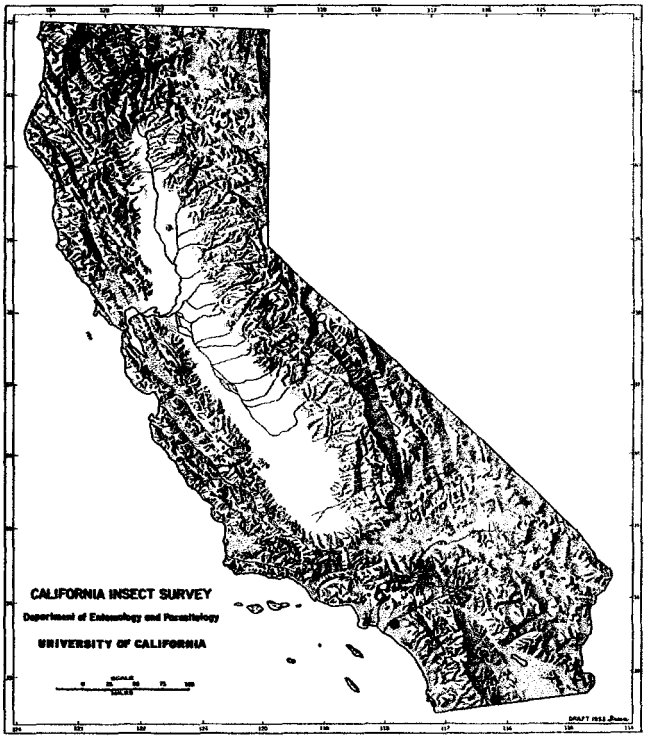
California records (map 44).—KERN Co.: on Jeffrey pine (USNM). LOS ANGELES Co.: Mt. Hawkins, on *P. monophylla* (OSU). RIVERSIDE Co.: Santa Rosa Peak, Santa Rosa Mtns. (LBSC); Santa Rosa Peak (CIS). VENTURA Co.: Frazier Mtn., on *P. monophylla* (OSU); Mt. Pinos, on *P. monophylla* (OSU); County record only, on Jeffrey pine (USNM).

Biology.—Unknown.

Discussion.—Cactopinus pini is another pine-inhabiting species in which the adults may be distinguished by the deeply excavated, more strongly sulcate declivity. It is most closely related to *C. hubbardi* from Arizona and *C. rhois* but the adults are intermediate in size between the two. They may be distinguished from the adults of *C. rhois* by the larger size, by the longer horn of the male, by the declivital characters, and by the hosts.

Genus *Stenoclyptes* Blackman

Stenoclyptes Blackman, 1943, Proc. U. S. Natl. Mus., 93(3165): 356. Type-species: *Stenoclyptes rhois* Blackman, original designation.



Map 45. California distribution of *Stenoclyptes rhois* Blackman, ● ; *Stenoclyptes sulcatus* (Bruck), ○ .

This genus seems to be rather closely related to *Cactopinus* Schwarz but is distinguished by the absence of the epistomal horn in the male, by the much smaller tuberculate area of the pronotum, and by the truncate elytral declivity.

The genus contains two species, both endemic to California.

KEY TO THE SPECIES OF STENOCLYPTES IN CALIFORNIA

1. Fore tibia with 2 submarginal teeth; elytral setae narrow, hairlike; in *Rhus* ..... *rhois* Blackman
   Fore tibia with 3 submarginal teeth; elytral setae broader, scalelike; in *Ceanothus* ..... *sulcatus* (Bruck)

Stenoclyptes rhois Blackman
(Map 45)

Stenoclyptes rhois Blackman, 1943, Proc. U. S. Natl. Mus., 93(3165):357. Holotype ♀, Orange Co., California (USNM).

Geographic distribution and host range.—Apparently *S. rhois* is restricted to the southern Californian species of *Rhus*. If, however, other species of *Rhus* are attacked the distribution could be much wider.

California records (map 45).—ORANGE Co.: Orange, on *Rhus integrifolia* (USNM). SAN BERNARDINO Co.: 1 mi S. Pinon Flat,

on *R. laurina* (CIS). SAN DIEGO CO.: 4 mi N. W. Jacumba, on *Rhus* sp. (CNC).

Biology.—Unknown.

Discussion.—Adults of *Stenoclyptes rhois* measure about 1.5 mm in length and closely resemble *S. sulcatus*. In addition to the characters given in the key, the fore tibia in *S. rhois* is 3.0 times as long as wide.

This species is commonly taken in association with *Chaetophloeus penicillatus* (Bruck).

Stenoclyptes sulcatus (Bruck)
(Map 45)

Pseudothysanoes sulcatus Bruck, 1936, Bull. S. Calif. Acad. Sci., 35:33. Holotype ♂, Mt. Wilson, California (OSU).
Stenoclyptes sulcatus: Wood, 1956, Can. Entomol., 88:240.
Stenoclyptes ceanothi Blackman, 1943, Proc. U. S. Natl. Mus., 93(3165):358. Holotype ♀, Yosemite Natl. Park, California (USNM). (Syn. by Bright, 1966.)

Geographic distribution and host range.—Although apparently restricted to southern Californian species of *Ceanothus*, it is probable that *S. sulcatus* will attack most species of *Ceanothus*. If so, then its distribution should be throughout southwestern North America.

California records (map 45).—LOS ANGELES CO.: Mt. Wilson, on *Ceanothus divaricatus* (OSU). MARIPOSA CO.: Yosemite Natl. Park, on *C. integerrimus* (USNM). TUOLUMNE CO.: Strawberry, on *C. integerrimus* (PSW).

Biology.—Unknown.

Discussion.—Adults of this species measure about 1.6 to 1.7 mm in length. The characters given in the discussion of the preceding species will readily distinguish *S. sulcatus* from *S. rhois*.

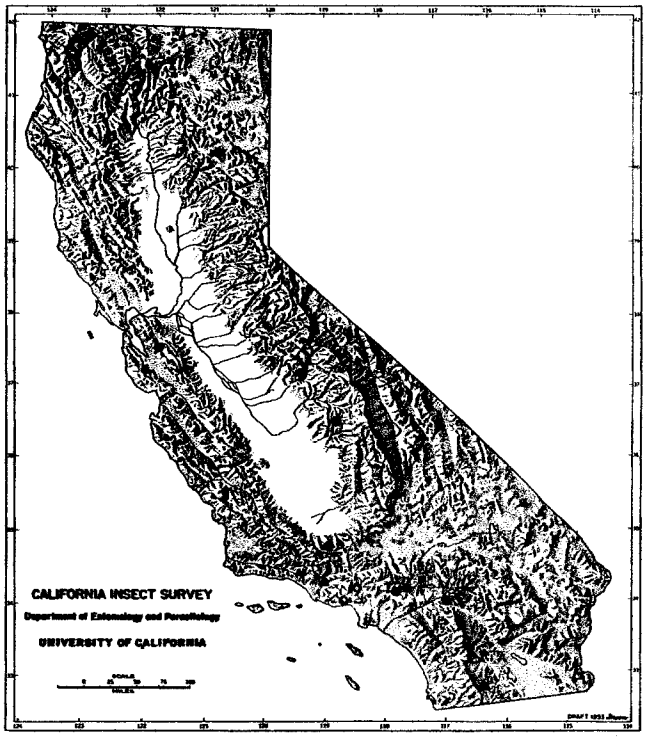
Genus *Pseudothysanoes* Blackman

Pseudothysanoes Blackman, 1920, Miss. Agric. Exp. Stn. Tech. Bull., 9:46. Type-species: *Pseudothysanoes drakei* Blackman, original designation.

This is a genus of very small, black beetles which are found in various broad-leaved trees and shrubs. The genus contains 10 North American species, only 2 of which are found in California.

Pseudothysanoes is closely related to *Thysanoes* LeConte. The two genera are easily distinguished from the other California Micracini by the lack of an acuminate elytral apex (as in *Micracis* and *Hylocurus*), by the erect, broad interstrial setae and by the convex elytral declivity. *Pseudothysanoes* is distinguished from *Thysanoes* by the bifurcate terminal process of the anterior tibiae and by the pronotal proportions.

For a key to all species in the United States, see Bruck (1936*a*).



Map 46. California distribution of *Pseudothysanoes bartoni* Bruck, ○ ; *Pseudothysanoes hopkinsi* Blackman, ● ; *Thysanoes phorodendri* (Blackman), ▲ .

KEY TO THE SPECIES OF PSEUDOTHYSANOES IN CALIFORNIA

1. Elytral striae slightly impressed, interspaces appearing convex; third, fifth and seventh declivital interspaces of male with very small, curved, sharp-pointed teeth . . . . . *bartoni* Bruck
   Elytral striae not, or at most very feebly, impressed, interspaces flatter; declivital interspaces of male devoid of teeth . . . . . *hopkinsi* Blackman

Pseudothysanoes bartoni Bruck
(Map 46)

Pseudothysanoes bartoni Bruck, 1936, Bull. S. Calif. Acad. Sci., 35(1):32. Holotype ♂, Saddle Peak, Santa Monica Mtns., California (OSU).

Geographic distribution and host range. — *Pseudothysanoes bartoni* is probably distributed throughout southern California. Although collected on only one species of chaparral, it probably attacks other species of the genus *Malacothamnus*.

California records (map 46).—LOS ANGELES CO.: Pacoima, on *Malvastrum thurberi* (UCD); Saddle Peak, Santa Monica Mtns., on *M. thurberi* (OSU).

Biology.—Unknown.

Discussion.—This species is easily distinguished by the peculiar declivital armature of the male which is

suggestive of *P. spinatus* Wood. The declivital teeth are much shorter, however. In the adults of *P. bartoni* they are about one-half as long as the erect scales on the declivity. The odd host will also distinguish it from the other species in the genus.

Pseudothysanoes hopkinsi Blackman
(Figs. 19, 48; map 46)

Pseudothysanoes hopkinsi Blackman, 1928, Bull. N. Y. State Coll. For., 1(3-b):200. Holotype ♂, Piru Creek, Ventura Co., California (USNM).

Geographic distribution and host range.—Although known only from southern California, *P. hopkinsi* probably occurs in Arizona and northern Mexico within the range of *Fremontia californica*. Chamberlin (1939) also records the host as willow (*Salix* spp.) but we could find no records to verify this.

California records (map 46).—ALAMEDA Co.: 10 mi W. Livermore (DEB). KERN Co.: Lebec, on *Fremontia californica* (SLW). LOS ANGELES Co.: Big Pines Park, on *F. californica* (SLW); Westwood Hills (CIS). MADERA Co.: Northfork, on *F. californica* (HSC). SAN BERNARDINO Co.: Wrightwood, on *F. californica* (CIS). TULARE Co.: 2 mi E. California Hot Springs, 4,000′, on *F. californica* (CAS); Sequoia Natl. Park, on *F. californica* (CIS).

Biology.—Unknown except the gallery (fig. 19).

Discussion.—*Pseudothysanoes hopkinsi* can be readily separated from *P. bartoni* by the flat, unarmed third declivital interspace of the male, by the feebly impressed elytral striae, and by the flattening of the remaining interspaces.

Genus *Thysanoes* LeConte

Thysanoes LeConte, 1876, Proc. Am. Philos. Soc., 15:369. Type-species: *Thysanoes fimbricornis* LeConte, monotypic.

Eight species of *Thysanoes* have been described from North America and several others have been described from Mexico. Only one species occurs in California and it is rare in collections.

Adults of this genus are distinguished from those in *Pseudothysanoes* by the single, curved, terminal process on the anterior tibiae and by the pronotum being longer than wide.

Thysanoes phorodendri (Blackman)
(Map 46)

Pseudothysanoes phorodendri Blackman, 1928, Bull. N. Y. State Coll. For., 1(3-b):202. Holotype ♂, Victoria, Texas (USNM).
Thysanoes phorodendri: Bright, 1966, Pan-Pac. Entomol., 42(4): 306.

Geographic distribution and host range.—*Thysanoes phorodendri* occurs on the common mistletoe which parasitizes various hardwoods. It should ultimately be found throughout southwestern North America and northern Mexico.

California records (map 46).—SAN DIEGO Co.: Mt. Laguna, *Phorodendrum* on *Quercus kellogii* (CIS). VENTURA Co.: Santa Paula, on black walnut, at base of mistletoe (CDA).

Biology.—Unknown.

Discussion.—*Thysanoes phorodendri* is apparently a common species in Arizona and northern Mexico, but it is not common in California. Its host is the common mistletoe that is prevalent on oaks and other trees so it may be found in many areas of southern California.

The adults of *T. phorodendri* range in size from 1.25 mm to 1.65 mm, the males being smaller than the females.

Genus *Hylocurus* Eichhoff

Hylocurus Eichhoff, 1871, Berl. Entomol. Z. 15:133. Type-species: *Hylocurus elegans* Eichhoff, monotypic.
Micracisoides Blackman, 1920, Miss. Agric. Exp. Stn. Tech. Bull., 9:19. No type species designated. (Syn. by Blackman, 1922.)

Blackman (1920) revised the Micracinae of North America and designated the species now in *Hylocurus* as a subgenus of *Micracis* with the name *Micracisoides*, apparently overlooking Eichhoff's earlier name. In 1922 Blackman corrected this error and later (1928*a*) gave a revised key to the *Micracinae* and a key to the species of *Hylocurus*.

This genus is closely related to *Micracis* LeConte but differs by the fact that the antennal scape is club-shaped, not triangular. Other characters can be found by consulting Blackman's generic key (1928*a*).

Thirteen species are known from America north of Mexico. Two of these have been found in California.

KEY TO THE SPECIES OF HYLOCURUS IN CALIFORNIA

1. Size 2.0 to 2.3 mm; male declivity flattened, very steep, abrupt; pubescence of elytra sparse and short, about equal in length to the width of an interspace; pronotum without special areas of pubescence behind summit..... *parkinsoniae* Blackman

   Size 2.4 to 3.0 mm; declivity convex in both sexes; pubescence of elytra more abundant and longer, more than twice as long as width of interspace; pronotum with two circular areas of denser and longer pubescence on each side of median line behind summit (fig. 77)..... *hirtellus* (LeConte)

Hylocurus parkinsoniae Blackman

Hylocurus parkinsoniae Blackman, 1922, Bull. N. Y. State Coll. For. 22(5), Tech. Publ., 16:142. Holotype ♂, Ray, Arizona (USNM).

Geographic distribution and host range.—Hylocurus parkinsoniae has been collected in Arizona, California, and Texas. The known hosts include species of *Parkinsonia* and *Cercidium*.

California record.—RIVERSIDE CO.: Mecca (CNC).

Biology.—Unknown.

Discussion.—The characters given in the key will easily distinguish the adults of this species from the adults of *H. hirtellus*.

Hylocurus hirtellus (LeConte)
(Fig. 77; map 47)

Micracis hirtellus LeConte, 1876, Proc. Am. Philos. Soc., 15:369. Holotype ♀, Southern California (MCZ).
Hylocurus hirtellus: Wood, 1966, Great Basin Nat. 26(1-2):241.
Hylocurus crinitus Blackman, 1943, Proc. U.S. Natl. Mus., 93(3165):347. Holotype ♀, Orange Co. California (USNM). (Syn. by Bright, 1966.)

Geographic distribution and host range.—Although *Hylocurus hirtellus* has been collected from a wide variety of broad-leaved trees and shrubs, it is apparently restricted to the coastal areas of the western United States. Since its hosts include species of *Alnus, Arbutus, Ceanothus, Myrica, Quercus, Rhamnus, Rhus, Salix,* and *Umbellularia*. It will probably also be found in Baja California.

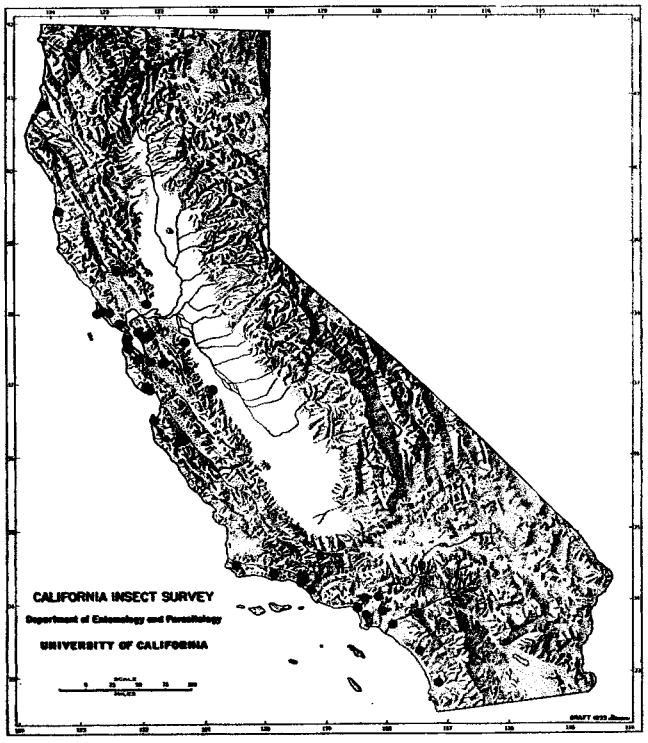
California records (map 47).—Numerous localities in the following counties: Alameda, Contra Costa, Humboldt, Lake, Los Angeles, Marin, Mendocino, Merced, Monterey, Orange, Riverside, San Diego, San Francisco, San Joaquin, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, and Ventura.

Biology. (Struble and Hall, 1954)

No detailed biological studies have been made. It is known that adults attack the stems or twigs of host plants and bore into the wood. Distinct vertical egg galleries are excavated and packed with dry powderlike frass. Egg niches are widely spaced. The larvae mine outward from the egg niche at first but soon turn and mine with the grain. They do not pack the frass behind them as tightly as many other scolytids. There is apparently only one generation per year and more than one generation may develop in the same stem, that is, brood adults may remain within the host in which they developed.

Discussion.—Hylocurus hirtellus is a very common species throughout the western areas of the state. It is of little importance except that, on occasion, it has attacked the lead or polyethylene plastic covering of telephone cables, causing short circuits.

The adults are easily distinguished from those of *Hylocurus parkinsoniae* by the larger size, by the longer pubescence, and by the declivital characters given in the key.



Map 47. California distribution of *Hylocurus hirtellus* (LeConte).

Genus *Micracis* LeConte

Micracis LeConte, 1868, Trans. Am. Entomol. Soc., 2:164. Type-species: *Micracis suturalis* LeConte, (Hopkins, 1914).

Micracis is represented in America north of Mexico by six species, only one of which occurs in California. About 21 species are known from Mexico and the Neotropical region. The genus has been thrice reviewed by Blackman (1920, 1928*a*, and 1943).

Micracis swainei Blackman
(Fig. 49)

Micracis swainei Blackman, 1920, Miss. Agric. Exp. Stn. Tech. Bull., 9:32. Syntypes ♀ ♀ and ♂ ♂, Iuka, Mississippi (USNM).
Micracis populi Swaine, 1920, *in* Blackman, Miss. Agric. Exp. Stn. Tech. Bull., 9:31. Holotype ♀, Ithaca, New York (CNC). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—M. swainei is distributed from eastern Canada south to the southern states, west through Texas and Arizona into southern California and probably northern Mexico. Its hosts include various species of willow (*Salix*).

California records.—LOS ANGELES CO.: Los Angeles (USNM). SAN DIEGO CO.: Spring Valley, on *Salix* (CIS).

Biology.—Unknown. Specimens were collected from galleries situated in the wood just beneath the bark of a broken limb. However, larvae are believed to feed in the wood.

Discussion.—Although ***Micracis swainei*** has apparently been collected only twice in California, it should be found in many areas in the southern part of the state. In general shape and size, the adults of *M. swainei* resemble those of ***Hylocurus hirtellus*** but may be distinguished most easily by the triangular-shaped antennal scape.

Tribe Cryphalini

Genus *Cryphalus* Erichson

Cryphalus Erichson, 1836, Arch. Naturgesch., 1:61. Type-species: *Bostrichus asperatus* Gyllenhal (Thomson, 1865).

Trypophloeus Fairmaire, 1868, Faune Entomol. Fr., 4:105. Type-species: ***Bostrichus binodulus*** Ratzeburg, monotypic. (Syn. by Eichhoff, 1881.)

Glyptoderus Eichhoff, 1878. Ratio, descriptio, emendatio, eorum tomicinorum, p. 137. Type-species: ***Bostrichus binodulus*** Ratzeburg (Hopkins, 1914). (Syn. by Eichhoff, 1881.)

Cryphalus is closely related to *Taenioglyptes* but can be distinguished by the absence of a lateral line on the pronotum, by the 5-segmented antennal funicle, by the slender, pointed antennal club with three straight sutures and by the cylindrical third tarsal segment.

Two of the four North American species occur in California.

Species of *Cryphalus* are believed to bore in the bark of the main bole and larger limbs, seldom reaching the cambium. The parent galleries are small and cavelike, with short galleries extending out in which eggs are deposited. No detailed biologies are known.

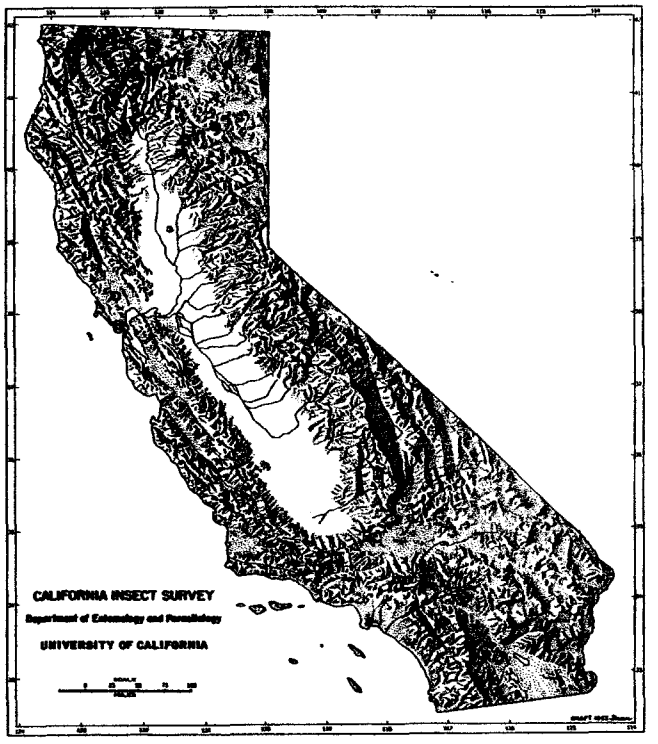
For an extensive revision of this tribe, see Wood (1954*b*).

KEY TO THE SPECIES OF CRYPHALUS IN CALIFORNIA

1. Anterior margin of pronotum with 4 close-set asperities, the medium 2 longer; posterior end of fourth elytral interspace with from 1 to 5 small teeth; strial punctures not impressed, obscure..... ***thatcheri*** Wood
   Anterior margin of pronotum with more than 4 asperities, extending laterally much farther on margin; fourth elytral interspace devoid of granules or teeth on posterior portion; strial punctures distinctly impressed.. *salicis* (Hopkins)

Cryphalus thatcheri Wood
(Map 48)

Cryphalus thatcheri Wood, 1954*b*, Univ. Kans. Sci. Bull., 36(2), No. 15:994. Holotype ♀, 2 mi northwest of Blue Lake, Lassen Co., California (UK).



Map 48. California distribution of *Cryphalus thatcheri* Wood, ●; *Cryphalus salicis* (Hopkins), ○.

Geographic distribution and host range.—Although collected only in California, the distribution of *C. thatcheri* should be more extensive since its host, quaking aspen, is widely distributed throughout North America.

California records (map 48).—ALPINE CO.: Sonora Pass (OSU). LASSEN CO.: 2 mi N. W. Blue Lake, on *Populus* (CIS). MODOC CO.: County record only, on *P. tremuloides* (PSW); Warner Mtns., on *P. tremuloides* (CAS).

Biology.—Unknown.

Discussion.—***Cryphalus thatcheri*** is closely related to *C. populi* and Wood (1954*b*) states that it may prove to be only a subspecies. It probably occurs throughout the state wherever its host is found. Adults of *C. thatcheri* are between 1.5 and 1.9 mm in length, black in color, and bear numerous scalelike setae and bristles.

Cryphalus salicis (Hopkins)
(Map 48)

Trypophloeus salicis Hopkins, 1915, U.S. Dep. Agric. Rep. 99, p. 36. Holotype ♀, Del Monte, California (USNM).

Cryphalus salicis: Wood, 1954, Univ. Kans. Sci. Bull. 36(2), No. 15:991.

Trypophloeus concentralis Hopkins, 1915, U.S. Dep. Agric. Rep. 99, p. 36. Holotype ♂, Easton, Washington (USNM). (Syn. by Wood, 1954*b*.)

Geographic distribution and host range.—The distribution of *C. salicis* is currently described as from Washington to central California. However, its host, *Alnus* spp. and *Salix* species are distributed throughout western North America and we expect the distribution of *C. salicis* to reflect more that of its host.

California records (map 48).—MARIN Co.: 2 mi W. Muir Woods Natl. Mon., on *Salix lasiolepis* (CWOB); Redwood Creek S. of Muir Woods, on *S. lasiolepis* (CAS). SHASTA Co.: 3 mi E. Mt. Lassen, on *Salix* (CIS). SONOMA Co.: Cotati (CAS).

Biology.—Unknown.

Discussion.—*Cryphalus salicis* is about the same size as *C. thatcheri*, the adults measure from 1.4 to 1.7 mm in length. It may be distinguished by the much less evident elytral striae and by the lack of prominent granules on the declivous portion of the fourth interspace. The range and host are also quite different.

Genus *Procryphalus* Hopkins

Procryphalus Hopkins, 1915, U. S. Dep. Agric., Rep., 99:33. Type-species: *Procryphalus populi* Hopkins, original designation.

Procryphalus closely resembles *Cryphalus* in general facies but the 4-segmented antennal funicle, the broadly rounded antennal club, the scalelike setae on the pronotum and the evenly convex declivity will readily distinguish adults of the former.

Of the three species occurring in the United States, all in the west, only one is known from California.

Galleries of *Procryphalus* are similar to those of *Cryphalus* except that they apparently penetrate more often to the living cambial tissue. A black-staining fungus is usually found in the galleries. Eggs are deposited in clusters in the parent galleries and the larval mines are irregular, short (4 to 5 mm), and in the bark. No details of species biologies are available.

Procryphalus utahensis Hopkins

Procryphalus utahensis Hopkins, 1915, U. S. Dep. Agric., Rep., 99:33. Holotype ♀, Alta, Utah (USNM).

Procryphalus salicis Hopkins, 1915, U. S. Dep. Agric., Rep., 99: 33. Holotype ♀, Black Hills, South Dakota (USNM). (Syn. by Wood, 1954*b*.)

Geographic distribution and host range.—This species is known from throughout the western United States and western Canada in various species of *Salix*.

California records.—MADERA Co.: Madera (USNM). MODOC Co.: Fort Bidwell, on *Salix* (CIS).

Biology.—Unknown.

Discussion.—*Procryphalus utahensis* is somewhat rare in California, probably due to lack of collecting. It should be found throughout the range of its host trees.

Adults are 1.5 to 1.7 mm in length. There are normally eight teeth on the anterior margin of the pronotum and the anterior one-sixth of the elytral interspaces are much more coarsely granulate-punctate than in the posterior one-third of the disk.

Genus *Taenioglyptes* Bedel

Taenioglyptes Bedel, 1888, Ann. Soc. Entomol. Fr., 6:398. Type-species: *Bostrichus piceae* Ratzeburg (Hopkins, 1914).

Species of *Taenioglyptes* are readily distinguished by the 4-segmented antennal funicle, by the large antennal club with 3 sutures (fig. 50), and by the pronotal summit being located on the posterior one-third. Among the California Cryphalini the genus is most closely related to *Cryphalus*.

This genus contains species formally placed in *Cryphalus* by various authors, e.g., Chamberlin (1939). For a complete discussion of the nomenclatural changes and a revision of the genus, see Wood (1954*b*).

Four species occur in North America, only two of which are present in California.

KEY TO THE SPECIES OF TAENIOGLYPTES IN CALIFORNIA

1. Elytral interspaces each with a row of long, hairlike, setae, these longer than width of interspace (fig. 78) ..... *pubescens* (Hopkins)
   Elytral interspaces with inconspicuous flat bristles, no long setae present ..... *ruficollis amabilis* (Chamberlin)

Taenioglyptes pubescens (Hopkins)
(Figs. 50, 78; map 49)

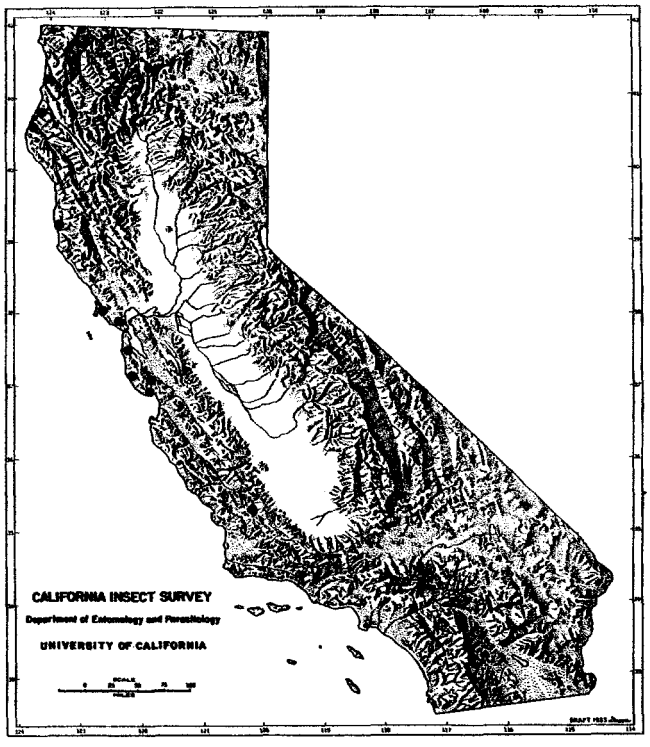
Cryphalus pubescens Hopkins, 1915, U.S. Dep. Agric. Rep. 99: 40. Holotype ♀, Port Williams (USNM).

Taenioglyptes pubescens: Wood, 1954, Univ. Kans. Sci. Bull., 36(2), No. 15:1003.

Cryphalus subconcentralis Hopkins, 1915, U.S. Dep. Agric. Rep. 99:40. Holotype ♀, Astoria, Oregon (USNM). (Syn. by Wood, 1954*b*.)

Geographic distribution and host range. — *T. pubescens* is known to occur along the coast from British Columbia south to central California. It is most common in Douglas fir but has also been collected from grand fir, redwood, and Sitka spruce.

California records (map 49).—HUMBOLDT Co.: Eureka, on *Abies grandis* (HSC); Ferndale, on *Picea sitchensis* (CIS); Freshwater, on *Pseudotsuga menziesii* (HSC); 11 mi S. E. Orick, on *P. menziesii* (CIS). MARIN Co.: 2 mi S. E. Inverness, ex branch Douglas fir (CWOB); Mt. Tamalpais (CAS); Muir Woods (CAS). MENDOCINO Co.: Mendocino (CWOB). SAN LUIS OBISPO Co.: La Panza Campground (CIS). SAN MATEO Co.: La Honda, on redwood (HSC); Lake Pilarcitos (CWOB);



Map 49. California distribution of *Taenioglyptes pubescens* (Hopkins), ● ; *Taenioglyptes ruficollis amabilis* (Chamberlin), ○ .

Pescadero (UCD). SANTA CRUZ CO.: Santa Cruz (CIS); 18 mi N. Santa Cruz, on *P. menziesii* (CIS).

Biology.—This species usually attacks young, weakened trees 10–20 cm in diameter, broken limbs, and seedlings. Parent galleries are simply oval, circular, or elongate cavities in the cambial region. Eggs are laid in clusters along the edge of the cavity and the larvae mine in any direction in the phloem-cambial region. The life history and number of generations per season are unknown.

Discussion.—*Taenioglyptes pubescens* is a very common species throughout the north coastal region of California. Its adults are readily recognized by the generally brown to black color and by the very long interstrial setae; they are 1.6 to 1.9 mm long, about 2.4 times as long as wide.

Taenioglyptes ruficollis amabilis (Chamberlin) (Map 49)

Cryphalus ambilis Chamberlin, 1917, Can. Entomol., 49:321. Lectotype ♀, Santiam Natl. Forest, Oregon (CNC).
Taenioglyptes ruficollis amabilis: Wood, 1954, Univ. Kans. Sci. Bull., 36(2), No. 15:1008.

Geographic distribution and host range.—The present known distribution of *T. r. amabilis* is southern Oregon and northern California. However, since it attacks red fir (and probably other firs) and Douglas fir it may be found as far north as British Columbia.

California records (map 49).—MADERA CO.: Devils Post Pile Natl. Mon. (Wood, in litt.). SHASTA CO.: Summit Lake, on *Abies magnifica* (PSW).

Biology.—Attacks are made on small trees and saplings, usually just below a branch connection. The adults bore to the cambium and excavate a small, oval chamber, less than 2 cm in its longest dimension. Up to 25 eggs are deposited, loosely packed in frass.

Larval feeding and pupation occur in the phloem-cambial region. The larvae feed in all directions from the egg chamber and may girdle small stems or limbs.

Attack and oviposition take place in July through August but neither the complete life cycle nor the number of generations are known.

Discussion.—This subspecies intergrades completely with *T. r. ruficollis* but according to Wood (1954*b*), it is sufficiently distinct to warrant subspecific recognition. It is easily distinguished from *T. pubescens* by the characters presented in the key.

Genus *Hypothenemus* Westwood

Hypothenemus Westwood, 1836, Trans. Entomol. Soc. Lond., 1:34. Type-species: *Hypothenemus eruditus* Westwood, monotypic.
Stephanoderes Eichhoff, 1871. Berl. Entomol. Z., 15:132. Type-species: *Crypturgus dissimilis* Zimmerman (Hopkins, 1914). (Syn. by Browne, 1963.)

After examining the characters separating the genera *Hypothenemus* and *Stephanoderes*, Browne (1963) concluded that only one genus was recognizable. This opinion has been voiced by other individuals and no serious objections have arisen since Browne's paper. Nevertheless, Browne's name change has not been applied in some of the recent literature.

Hypothenemus (sensu Browne) contains 81 species in the United States, of which only 2 occur in California. The remainder occur in the eastern and southeastern part of the country.

All the species in the genus are small, ranging from 0.9 to 2.4 mm long. The females tend to be larger than the males. The genus is characterized by the 3- to 5-segmented antennal funicle, by the stocky body shape, by the strongly convex and strongly asperate pronotum, and by the uniserrate rows of erect elytral bristles.

Wood's (1954*b*) revision contains a more complete discussion of the nomenclature and variation within the genus.

KEY TO THE SPECIES OF HYPOTHENEMUS IN CALIFORNIA

1. Posterior lateral areas of pronotum with close, deep punctures extending to lateral margin; pronotum summit in front of middle; mature scale color white..... *californicus californicus* Hopkins

   Posterior lateral areas of pronotum appearing minutely reticulate and sparsely granulate; summit of pronotum at middle; mature scale color yellowish . . *eruditus* Westwood

Hypothenemus californicus californicus Hopkins

Hypothenemus californicus Hopkins, 1915, U.S. Dep. Agric. Rep., 99:19. Holotype ♀, Pomona, California (USNM).

H. c. californicus: Wood, 1954. Univ. Kans. Sci. Bull., 36(2): No. 15:1053.

Geographic distribution and host range.—Although collected only in California, this species may occur throughout the southwestern United States and northern Mexico; its hosts, *Encelia* spp. and *Malacothamnus* (*Malvastrum*) spp. are widespread and more or less contiguous.

California records.—Los Angeles Co.: Hermosa (CAS); Pasadena (Wood, in litt.); Pomona (Wood, in litt.); Redondo (Wood, in litt.); Westwood Hills, on *Encelia californica* (CIS). San Diego Co.: Laguna (Wood, in litt.).

Biology.—Unknown.

Discussion.—In addition to the characters given in the key, the adults of this subspecies can be distinguished from those of *H. eruditus* by their larger size, 1.2 to 1.3 mm, and by the pronotum being slightly longer than wide. Wood (1954*b*) states that this subspecies can be distinguished from *H. californicus triciti* Hopkins only with extreme difficulty, if at all. When specimens from Mexico become available, the two forms probably will be found to intergrade. If so, then no subspecies should be recognized.

Hypothenemus eruditus Westwood

Hypothenemus eruditus Westwood, 1836, Trans. Entomol. Soc. Lond., 1:34. Type ♀, England (BM).

Bostrichus areccae Horning, 1842, Stettiner Entomol. Z., 3:117. Type material unknown.

Bostrichus boieldieui Perroud, 1864, Ann. Soc. Linn. Lyon, p. 188. Type material unknown.

Hypothenemus pruni Hopkins, 1915, U.S. Dep. Agric. Rep. 99: 16. Holotype ♀, Tryon, North Carolina (USNM). (Syn. by Wood, 1954*b*.)

Hypothenemus rumseyi Hopkins, 1915, U.S. Dep. Agric. Rep. 99:16. Holotype ♀, Little Falls, West Virginia (USNM). (Syn. by Wood, 1954*b*.)

Hypothenemus asiminae Hopkins, 1915, U.S. Dep. Agric. Rep., 99:16. Holotype ♀, Plummers Island, Maryland (USNM). (Syn. by Wood, 1954*b*.)

Hypothenemus hamamelidis Hopkins, 1915, U.S. Dep. Agric. Rep. 99:16. Holotype ♀, Morgantown, West Virginia (USNM). (Syn. by Wood, 1954*b*.)

Hypothenemus punctifrons Hopkins, 1915, U.S. Dep. Agric. Rep., 99:18. Holotype ♀, Lakeland, Florida (USNM). (Syn. by Wood, 1954*b*).

Hypothenemus subelongatus Hopkins, 1915, U.S. Dep. Agric. Rep. 99:19. Holotype ♀, Victoria, Texas (USNM). (Syn. by Wood, 1954*b*.)

Hypothenemus nigripennis Hopkins, 1915, U.S. Dep. Agric. Rep., 99:19. Holotype ♀, Tallulah, Louisiana (USNM). (Syn. by Wood, 1954*b*.)

Stephanoderes evonymi Hopkins, 1915, U.S. Dep. Agric. Rep., 99:26. Holotype ♀, Morgantown, W. Va. (USNM). (Syn. by Wood, 1954*b*.)

Stephanoderes germari Eichhoff, 1878, Ratio, descriptio, emendatio, eorum tomicinorum, p. 159. Type ♀, Mexico (location unknown). (Syn. by Wood, 1954*b*.)

Hypothenemus juglandis Blackman, 1922. Miss. Agric. Exp. Stn. Tech. Bull., 11:88. Syntypes ♀ ♀ and ♂ ♂, Port Gibson, Mississippi (USNM). (Syn. by Wood, 1954*b*.)

Hypothenemus citri Ebling, 1935, Pan-Pac. Entomol., 11:21. Holotype ♀, Orange, California (CAS). (Syn. by Wood, 1954*b*.)

Geographic distribution and host range.—*H. eruditus* is found in tropical and subtropical regions throughout the world north into Europe and Japan. In California it is found along the southern Pacific coast. The host range is equally diverse. *Hypothenemus eruditus* has been recorded from a wide variety of plants throughout the world (Wood 1954*b*; Schedl, 1961). Host genera occurring naturally in California include: *Abutilon, Aesculus, Albizzia, Bidens, Celtis, Cornus, Elaeagnus, Helianthus, Hibiscus, Ipomoea, Juglans, Paspalum, Purshia, Phragmites, Prunus, Ricinus, Sambucus, Sarcostemma, Sida, Smilax, Verbesina,* and *Yucca*. Undoubtedly, many other planted exotic hosts occur also.

California records.—Los Angeles Co.: Los Angeles (Wood, in litt.). Orange Co.: Orange, on lemon (PHT). San Diego Co.: Carlsbad (Wood, in litt.); Coronado (Wood, in litt.).

Biology. (Schedl, 1961 and Wood, 1954*b*)

The biology of *H. eruditus* in California is not well known. The following account, taken from studies in other areas, probably holds true in California.

The entrance hole, made by the female, is usually located at leaf or branch attachments or under bark irregularities in dying twigs or branches less than 6 cm in diameter. The gallery system consists of a small central chamber in the cambium region; from this chamber one or more brood galleries are constructed, more-or-less parallel with the grain of the wood. Eggs are deposited individually or in small clusters. The larvae feed in congress or individually, creating different shapes of larval mines. Young adults may feed under the bark for awhile or may immediately emerge. Those that immediately emerge may feed for a short time in twigs.

Several generations a year are probably produced in California so that all stages are present throughout the year. Males are very rare, the sex ratio being about

1:20 to 1:50. It is possible that parthenogenesis occurs.

Discussion.—This is the most widely distributed and most variable species of this genus in North America, as evidenced by the many synonyms.

In addition to the characters used in the key, adults of *H. eruditus* are separated from *H. c. californicus* by the slightly smaller size (1.1 to 1.2 mm) and by the pronotum being wider than long.

Tribe Crypturgini

Genus *Crypturgus* Erickson

Crypturgus Erickson, 1836, Arch. Naturgesch., 2:60. Type-species: *Bostrichus pusillus* Gyllenhall (Thompson, 1856).

Of the three species of *Crypturgus* known from North America, only one has been taken in California. These are among the smallest scolytids known.

Crypturgus borealis Swaine
(Fig. 51)

Crypturgus borealis Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):7. Lectotype ♀, Winnipeg, Manitoba (CNC).

Crypturgus corrugatus Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):8. Lectotype ♀, North Mountain, Pennsylvania (CNC). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—C. borealis probably occurs throughout the coniferous forest regions of the United States and Canada. Its preferred hosts in California appear to be *Abies concolor* and *A. magnifica*, but it probably attacks other fir species and possibly other conifers.

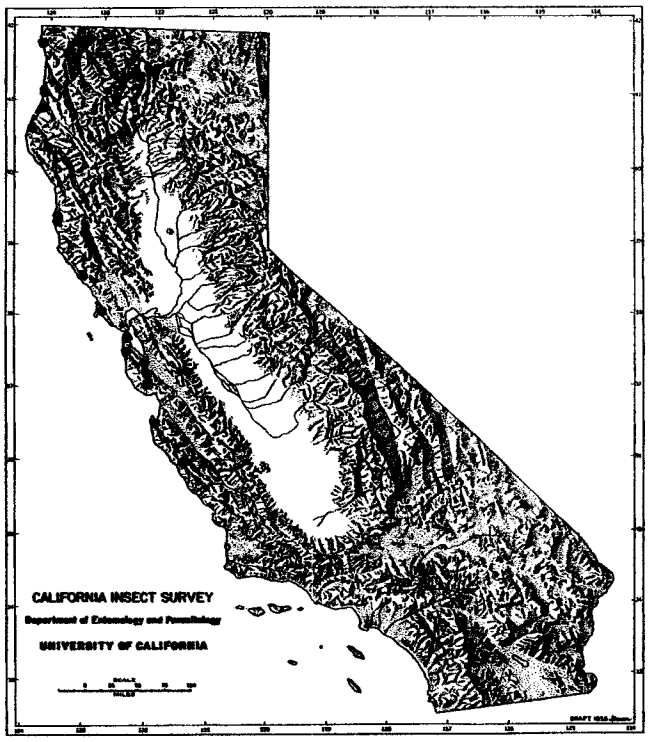
California records.—KERN Co.: Breckenridge Mtn., on *Abies concolor* (CAS). County unknown: Yosemite Natl. Park, on *Abies magnifica* (CIS).

Biology.—The life history and number of generations per year are not known. This species is found in the inner bark of dying or dead hosts. The adults enter the host through the entrance holes of larger bark beetle species or even the "ventilation holes" of cerambycids. The egg and larval galleries of *Cryturgus borealis* are merely extensions of the galleries of the scolytid or wood borer whose entrance hole was used.

Discussion.—The adults of *C. borealis* measure about 1.1 mm in length and are approximately the same size and color as *Dolurgus pumilus* but can be readily distinguished by the antennal characters given in the key.

Genus *Dolurgus* Eichhoff

Dolurgus Eichhoff, 1868, Berl. Entomol. Z., 12:147. Type-species: *Hylastes pumilus* Mannerheim, monotypic.



Map 50. California distribution of *Dolurgus pumilis* Eichhoff.

Specimens of this monotypic genus are found along the coastal regions of western North America. They resemble specimens of *Crypturgus* but may be distinguished by the characters of the antennal club and funicle (fig. 52).

Dolurgus pumilus (Mannerheim)
(Fig. 52; map 50)

Hylurgus pumilus Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:247. Type (sex ?), Sitka, Alaska (University of Helsinki).

Dolurgus pumilus: Eichhoff, 1868, Berl. Entomol. Z., 12:147.

Geographical distribution and host range.—Dolurgus pumilus is apparently a coastal species occurring in coniferous forests from Alaska south to Monterey County, California. Its favored hosts are Sitka spruce, Santa Lucia fir, and several coastal pines. It will probably be found in other members of the Pinaceae.

California records (map 50).—DEL NORTE Co.: Crescent City, on *Picea sitchensis* (CIS). HUMBOLDT Co.: Arcata, on *P. sitchensis* (HSC); Ferndale, on *P. sitchensis* (CIS); Trinidad, on *P. sitchensis* (CIS). MARIN Co.: Inverness, on *P. muricata* (CIS); 1 mi S.E. Inverness, on Bishop pine (CWOB). MENDOCINO Co.: Fort Bragg, on *P. muricata* (CAS). MONTEREY Co.: Carmel (CWOB); Cone Peak, on *Abies bracteata* (HSC); Pacific Grove (UCR). SAN FRANCISCO Co.: San Francisco (CIS). SAN MATEO Co.: Montara (CAS). SANTA CLARA Co.: Palo Alto (UCR). SANTA CRUZ Co.: 14 mi N. Santa Cruz, on *Pinus radiata* (CIS). SONOMA Co.: 4 mi S. Plantation, on *P. tuberculata* (CIS).

Biology.—*Dolurgus* species are similar to *Crypturgus* species in their habit of using the entrance holes of larger bark beetles to gain entry to the host. Galleries are minute, apparently without pattern, and confined to the inner bark. Adults hibernate under moss and lichens on the tree trunks. No further details are known.

Discussion.—This very common species is encountered in the coastal forests of California and is closely related to *Crypturgus borealis*. The adults of *D. pumilus* can be distinguished by the 3-segmented antennal funicle and the 4-segmented antennal club (fig. 52).

Tribe Xyloterini

The tribe was revised by Wood (1957*b*) and of the three genera found in North America, two occur in California.

Genus *Trypodendron* Stephens

Trypodendron Stephens, 1830, Illustrations of British Entomology, Mandibulata, 3:353. Type-species: *Dermestes domesticus* Linnaeus (Westwood, 1840).

Xyloterus Erichson, 1836, Arch. Naturgesch., 2:60. Type-species: *Bostrichus lineatus* Olivier (Thomson, 1865). (Syn. by Wood, 1957*b*.)

Of five species in *Trypodendron* known to occur in North America, three are found in California. All are ambrosia beetles, which bore into the woody tissue of the host and feed on a fungus that is introduced by the beetle and grows in the burrows.

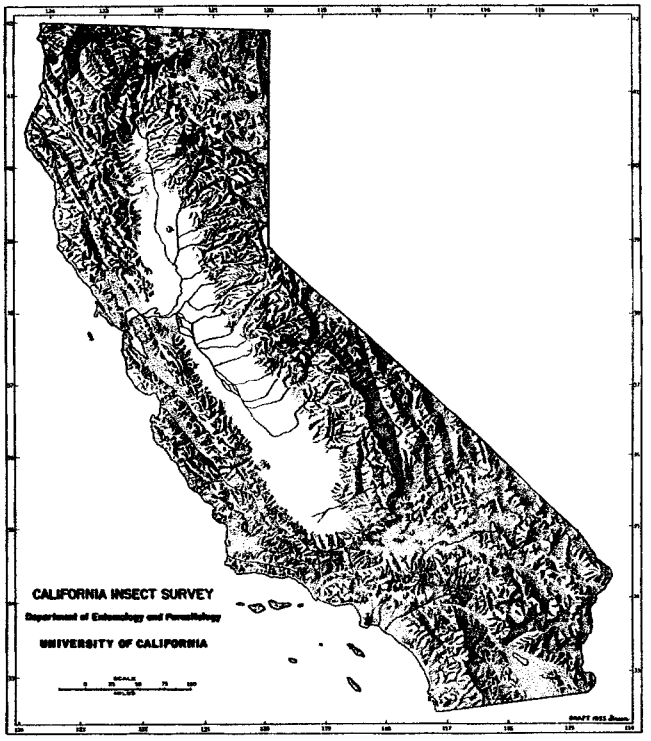
KEY TO THE SPECIES OF TRYPODENDRON IN CALIFORNIA
(From Wood, 1957*b*)

1. Body size larger, males 3.6 to 4.3 mm, females 3.8 to 4.6 mm in length; female pronotum usually not asperate on median area at base; in *Populus* spp. . . . *retusum* (LeConte)
   Body size small, males 2.7 to 3.3 mm, females 3.0 to 3.7 mm in length; median area of pronotum asperate to basal margin on both sexes; in coniferous hosts 2
2. Elytral surface smooth and shining, the interspaces usually minutely and irregularly punctured; elytra broadly rounded behind, the subapical margin appearing rounded from above (fig. 79) . . . . . *lineatum* (Oliver)
   Elytral surface rather dull, minutely reticulate; elytra more narrowly rounded behind, the subapical margin appearing subacuminate from above . . . . . *rufitarsus* (Kirby)

Trypodendron retusum (LeConte)
(Map 51)

Xyloterus retusus LeConte, 1868, Trans. Am. Entomol. Soc., 2:158. Holotype ♂, Canada (MCZ).

Trypodendron retusum: Swaine, 1913, Annu. Rep. Entomol. Soc. Ont., 43:89.



Map 51. California distribution of *Trypodendron retusum* (LeConte, ● ; *Trypodendron rufitarsus* (Kirby), O .

Geographic distribution and host range.—*Trypodendron retusum* probably occurs throughout the boreal forest of North America. It has been recovered as far south as Virginia in the east and the central Sierra Nevada in the west. Various species of poplar are its preferred host but it has been reported in paper birch in the Pacific Northwest. The single record from redwood is believed to be erroneous.

California records (map 51).—Del Norte Co.: Klamath, on *Sequoia sempervirens* (PSW). Lassen Co.: 2 mi N.W. Blue Lake, on aspen (CIS). Mariposa Co.: Yosemite Valley (CAS). Plumas Co.: County record only (CAS); Chester, on aspen (CAS). Shasta Co.: Lassen Natl. Park (CAS). Siskiyou Co.: Bray, on *Populus* sp. (CIS). Modoc Co.: Modoc Ntl. For., on *Populus* sp. (PSW).

Biology.—The biology of this species is not well known. All members of the genus penetrate the bark, boring into the sapwood and frequently the heartwood. The galleries are often very elaborate, with several branches in both the horizontal and vertical planes. The walls are stained with a fungus introduced by the beetle and on which the young feed. The larvae are reared in separate "cradles" or extensions from the parent gallery.

Trypodendron retusum adults are monogamous but form colonies utilizing a single entrance hole. However, each pair has it own one– or two–branched galleries.

These galleries may extend a short distance into the heartwood.

The eggs are laid in "cradles" extended upwards and downwards at right angles to the parent gallery. A yellowish fungus is established in the neighborhood of the larval cradles and the female plugs the mouth of the cradle with the fungus for the feeding larva.

The complete life history or number of generations per year are not known.

Discussion.—Damage inflicted by all *Trypodendron* species is reflected by the reduced value of the products manufactured from infested logs due to fungal stain discoloration and possible structural weakness from heavy attacks. Vigorous growing trees and trees felled during the growing season are usually attacked and damage may be severe.

The larger size, black color, and smooth, shining, elytral surface will distinguish adults of *T. retusum* from those of other species. This is the only species of *Trypodendron* in California found in broad-leaved trees.

Trypodendron lineatum (Oliver)

(Figs. 20, 53, 79; map 52)

Bostrichus lineatus Oliver, 1795, Entomologie, 4(77):18. Types unknown.

Trypodendron lineatum: Eichhoff, 1878, Ratio, descriptio, emendatio, eorum tomicinorum, p. 417.

Apate bivittata Kirby, 1837, Fauna Bor. Am., 4:192. Type ♀ ?, Canada (BM). (Syn. by Chamberlin, 1939 (?).)

Bostrichus cavifrons Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:297. Type ♂, Sitka, Alaska (University of Helsingfors). (Syn. by Wood, 1957*b*.)

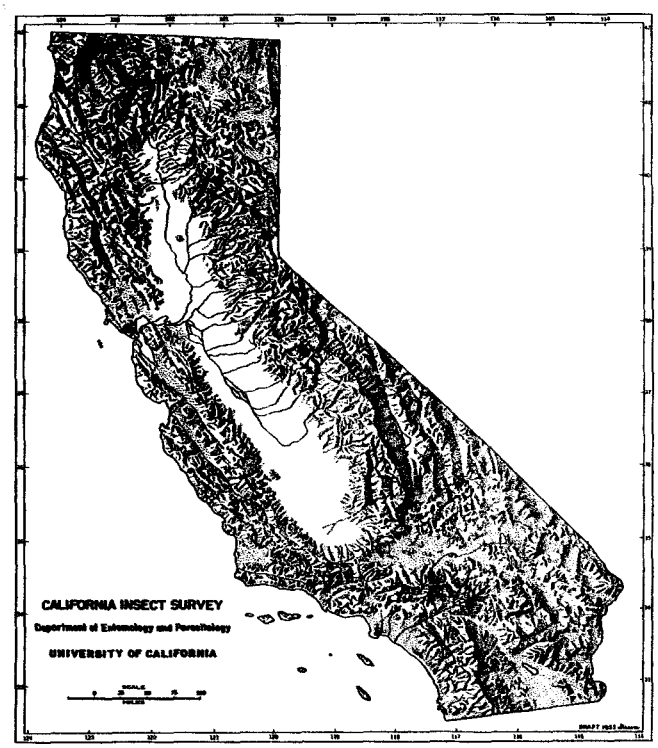
Trypodendron vittiger Eichhoff, 1881, Die Europaischen Borken-Käfer, p. 298. Type ♀ ?, Europe (Location unknown). (Syn. by Chamberlin, 1939 (?).)

Trypodendron borealis Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):21. Lectotype ♀, Athabaska Landing, Alberta (CNC). (Syn. by Wood, 1957*b*.)

Geographic distribution and host range.—Trypodendron lineatum is distributed worldwide in the boreal and temperate zones. It apparently attacks all Pinaceae species.

California records (map 52).—DEL NORTE Co.: Klamath, on *Sequoia sempervirens* (PSW). HUMBOLDT Co.: Greenpoint (CAS); 5 mi E. Orick, on *Pseudotsuga taxifolia* (CIS). MARIN Co.: Lagunitas, on Douglas fir (CAS). MARIPOSA Co.: Yosemite, on *Pinus monticolae* (PSW); Badger Pass, Yosemite Natl. Park, on red fir (CAS). NEVADA Co.: Truckee (PSW). PLACER Co.: County record only (CAS). PLUMAS Co.: Meadow Valley (CIS). SAN BERNARDINO Co.: Big Bear Lake (Wood, in litt.). SISKIYOU Co.: Happy Camp, on *Pseudotsuga taxifolia* (CIS); Happy Camp, on *Picea breweriana* (CIS); 7 mi N.W. Callahan, on *P. engelmanni* (CIS).

Biology.—(Borden, et al., 1968; Chapman, 1966; Dyer, 1962, 1963; Dyer and Chapman, 1965; Dyer and Kinghorn, 1961; Francia and Graham, 1967; Funk, 1965; Kinghorn and Chapman, 1959; Prebble and Graham, 1957; Rudinsky and Daterman, 1964)



Map 52. California distribution of *Trypodendron lineatum* (Oliver).

This account of the biology of *Trypodendron lineatum* is based almost entirely on studies in British Columbia, Canada. Differences in developmental rate and even in the number of broods or generations per year could well exist in California.

Adults are attracted to windthrown, cut and dying trees, stumps, and logging slash. Healthy living trees apparently possess neither attractants nor repellent properties. Once a few beetles have successfully invaded a host, a powerful secondary attractant is produced by the female which results in mass invasion of the log.

The flight period extends from late March through August; the heaviest emergence and attack period is in April and May. Later flights consist principally of reemerging parent adults. The beetles attack logs and larger logging slash in almost any location, including the upper surface of logs in ponds. There is some preference for shaded portions of the host in exposed locations. The time of death of the host material affects the time of attack. Hemlock logs felled up to 20 months were attacked by the spring flight. Logs felled after December were not attacked until the second season

of exposure. The heaviest spring attacks were in logs felled from October to December of the previous year and much lighter attacks were made on logs felled January to May. June to August fallings were free from attack until the following year.

Slash and logging debris from trees felled in the autumn and left untreated is an important breeding place for *T. lineatum*. In one area there was a fourfold increase in the emerging population over the number attacking. Large slash, 2 meters or more in length and larger than 30 cm diameter, produced three-quarters of the brood. Brood size was larger in such material.

Galleries are begun by the female. In Douglas fir these are restricted to the sharply defined sapwood from 1 to 7 cm deep. In *Abies*, *Tsuga*, and probably other hosts, the galleries may penetrate the heartwood to a depth of 10 cm or more. The gallery is usually forked with two, and occasionally three, branches (fig. 20). They usually extend obliquely across the annual rings, but occasionally two branches may follow an annual ring in the sapwood. The entire gallery lies in one plane at right angles to the grain of the wood. The gallery walls become blackened by the ambrosia fungus, *Monilia ferruginea* Mathiesen-Käärik, within a few weeks following attack. The fungus is introduced by the beetle, hence the name, ambrosia beetle.

Oviposition commences in the first 2 weeks of gallery construction. Eggs are laid singly in niches cut into the end grain of the wood on both sides of the gallery. The larvae hatch within 10 days and as they grow they enlarge the niche to form a larval cradle. The larvae feed on the ambrosial fungus as it matures. Pupation occurs within a month in the larval cradle and the pupal stadium lasts approximately 10 days. The young adults emerge from July through September and seek hibernation sites in the duff and in bark fissures of standing trees. The optimum hibernation sites are apparently just inside the edge of a forest stand. The hibernation period lasts 7 to 11 months.

In British Columbia, there is only one generation per year but two or more broods. The second attack, made only by parent adults, usually begins in early July. Upon establishment of the second brood, the parent adults and eventually the progeny of this brood emerge and fly to hibernation sites. Adults apparently live more than one year and may produce additional broods.

Discussion.—*Trypodendron lineatum*, along with other ambrosia beetles, cause extensive economic loss through degrading of the products manufactured from infested logs. The pinholes caused by their galleries and the attendant stain may render unmerchantable the high-value outer section of large logs.

This is apparently the most common species of *Trypodendron* in California. It resembles *T. rufitarsus* but the rounded apical elytral margin and the smooth elytral surface will distinguish its adults.

Trypodendron rufitarsus (Kirby)
(Map 51)

Apate rufitarsus Kirby, 1837, Fauna Bor. Am., 4:193. Type ♀, Canada (BM).

Trypodendron rufitarsus: Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):22.

Trypodendron ponderosa Swaine, 1917, Can. Dep. Agric. Entomol. Branch Bull., 14(1):22. Lectotype ♀, Peachland, British Columbia (CNC). (Syn. by Wood, 1957*b*.)

Geographic distribution and host range.—*T. rufitarsus* is distributed throughout the boreal forest of Canada and the northern states extending south to Tuolumne county in the Sierra Nevada. Although recorded only from spruces and pines, it probably attacks other members of the Pinaceae.

California records (map 51).—Siskiyou Co.: Happy Camp, on *Picea breweriana* (PSW); Medicine Lake, on *Pinus contorta* (PSW); Weed, on *P. contorta* (HSC). Tuolumne Co.: White Wolf, on *P. contorta* (CIS). County unknown: Yosemite Natl. Park, on *P. contorta* (PSW).

Biology.—The biology of *Trypodendron rufitarsus* is unknown but is believed to be similar to that of *T. lineatum*.

Discussion.—This species is very difficult to distinguish from *T. lineatum* but the adults may be separated by the subacuminate apical portion of the elytra when viewed from above, by the unarmed anterior margin of the female pronotum and usually by the different color pattern.

Tribe Dryocoetini

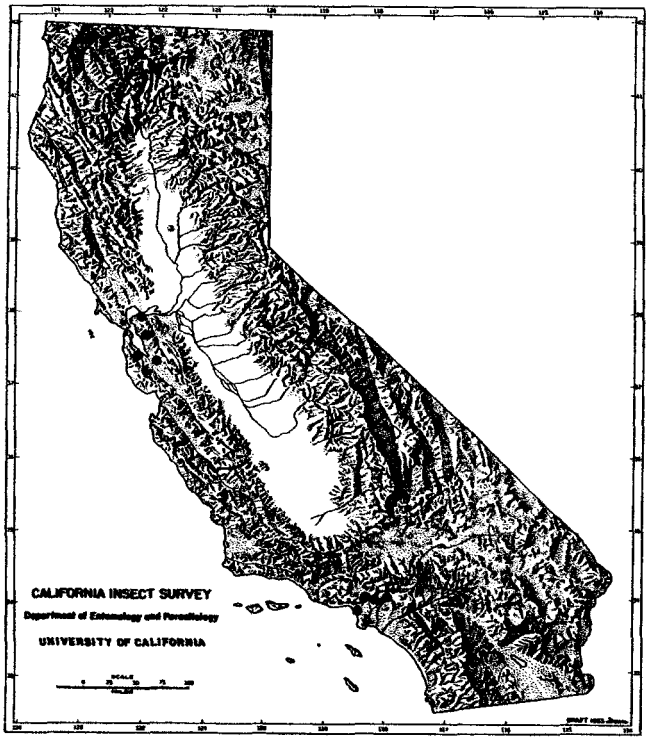
Genus *Dendrocranulus* Schedl

Dendrocranulus Schedl, 1937, Arch. Inst. Veg., 3(2):165. Type species not designated.

Xylocleptes (Of Am. authors, not Ferrari, 1867): Hopkins, 1915, U. S. Dep. Agric. Rep. 99:42.

This little-known genus contains about 14 species in the New World. Only one species occurs in the central and southern regions of California.

The United States species have previously been placed in the genus *Xylocleptes* Ferrari (Hopkins, 1915; Chamberlin, 1939). Schedl (1937) described *Dendrocranulus* for several Central and South American forms. According to Wood (1961) the United States species should be placed in Schedl's genus.



Map 53. California distribution of *Dendrocranulus californicus* (Hopkins).

Dendrocranulus californicus (Hopkins)
(Map 53)

Xylocleptes californicus Hopkins, 1915, U. S. Dep. Agric., Rep., 99:44. Holotype ♀, Pomona, California (USNM).
Dendrocranulus californicus: Wood, 1961, Coleopt. Bull., 15:41.
Xylocleptes venturina Hopkins, 1915, U. S. Dep. Agric., Rep., 99:44. Holotype ♀, Ventura Co., California (USNM). (Syn. by Bright, 1971.)
Dendrocranulus venturina: Wood, 1961, Coleopt. Bull., 15:41.

Geographic distribution and host range.—The distribution is not well known. The host genus *Cucurbita* (gourd, melon, pumpkin) occurs naturally throughout the southwest, into Mexico, and one species grows as far north as Nebraska. Although *Dendrocranulus californicus* has been collected only in southern and central California it probably occurs elsewhere in the southwest and Mexico. The single *Quercus* record is probably erroneous.

California records (map 53).—Alameda Co.: Oakland Hills, on *Quercus agrifolia* (CAS). Contra Costa Co.: Martinez, on wild cucumber (CAS). Los Angeles Co.: Azusa (OSU); Glendale (UCD); Pasadena (CAS); Playa del Rey, on *Cucurbita foetidissima* (OSU). Riverside Co.: Desert Center (SJSC). Santa Clara Co.: Alum Rock Park (CWOB); Stanford University (Palo Alto) (SJSC).

Biology.—Nothing is known about the life history, generation time, and the like of any species in this genus. All that is known about *D. californicus* is that the adults are found in dead and dying stems, rarely in the gourd itself.

Discussion.—Adults of this species are about 1.8 mm in length. The elytral striae are strongly punctured and the declivity is convex to nearly flat. Each elytral interspace bears a row of fairly long whitish setae. The frons of the male is deeply concave, smooth and shining, bearing a flattened tooth on the upper margin; the frons of the female is convex and roughly punctured.

Genus *Dryocoetes* Eichhoff

Dryocoetes Eichhoff, 1864. Berl. Entomol. Z., 8:38. Type-species: *Bostrichus autographus* Ratzeburg (Hopkins, 1914).

Bright (1963) revised this genus and recognized seven species from North America. Only one species has been found in California.

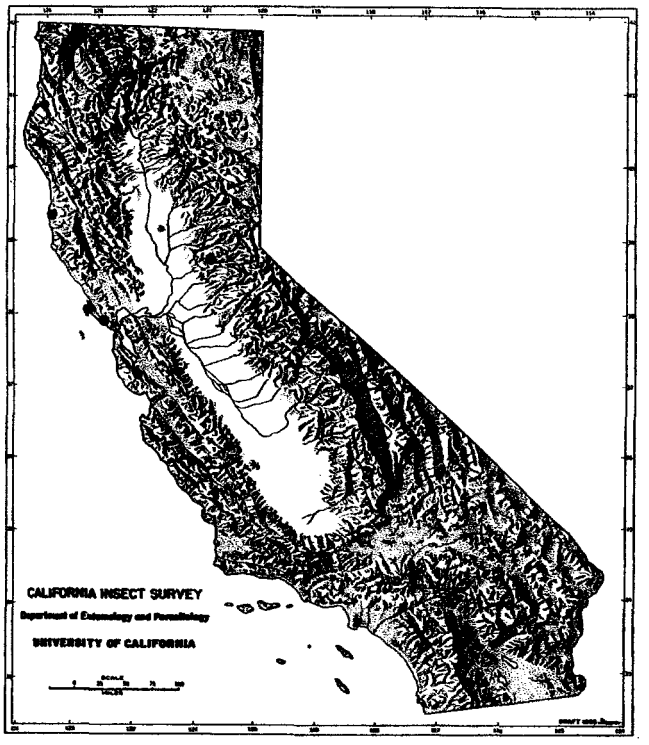
Dryocoetes autographus (Ratzeburg)
(Fig. 54; map 54)

Bostrichus autographus Ratzeburg, 1837, Die Forstinsekt. Mitteleuropas, 1:160. Holotype (sex ?), Europe (location unknown).
Dryocoetes autographus: Eichhoff, 1864, Berl. Entomol. Z., 8:38.
Bostrichus septentrionis Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:298. Type (sex ?), Sitka, Alaska (Univ. of Helsingfors (?)). (Syn. by Bright, 1963.)
Dryocoetes septentrionis: LeConte, 1876, Proc. Am. Philos. Soc., 15:361.
Dryocoetes americanus Hopkins, 1915, U. S. Dep. Agric. Rep., 99:51. Holotype ♀, Randolph Co., West Virginia (USNM). (Syn. by Bright, 1963.)
Dryocoetes pseudotsugae Swaine, 1915, Can. Entomol., 47:360. Lectotype ♀, Stanley Park, Vancouver, British Columbia (CNC). (Syn. by Bright, 1963.)

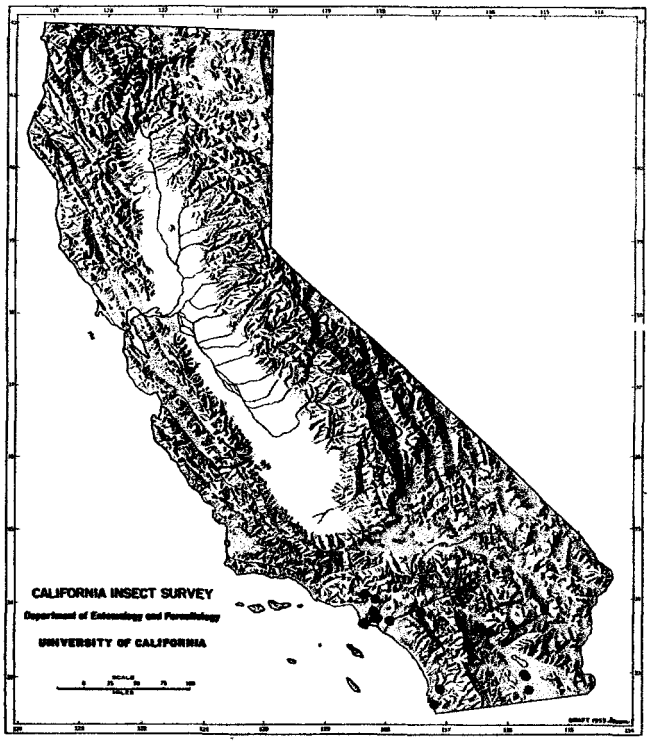
Geographic distribution and host range.—Dryocoetes autographus is distributed throughout the boreal and temperate coniferous forests of the world, except in arid regions. Although most prevalent in pines and Douglas fir it undoubtedly attacks most members of the Pinaceae.

California records (map 54).—El Dorado Co.: Blodgett Research Forest, 10 mi E. Georgetown, on *Pinus ponderosa* (CIS). Humboldt Co.: Green Point (CAS); Korbel, on Douglas fir (HSC). Marin Co.: Lagunitas (CAS); Olema (CIS); Pt. Reyes (CAS). Mendocino Co.: Mendocino (CWOB). Siskiyou Co.: McCloud (CAS). Trinity Co.: Carrville, on *P. ponderosa* (OSU).

Biology. (Bright, 1963; Dyer and Chapman, 1965)
Only a few details are known. *Dryocoetes autographus* is found in the base and roots of dying or injured standing trees and in felled or windthrown trees. Attacking adults demonstrate the same preference for aged material as do species of *Trypodendron*. Heaviest attacks are in logs felled from October to December the season before.



Map 54. California distribution of *Dryocoetes autographus* (Ratzeburg).



Map 55. California distribution of *Coccotrypes dactyliperda* (Fabricius).

The larval galleries are short, irregular, and often clustered so close together that it is impossible to trace individual galleries. The parent galleries are often confined to the bark; the wood is seldom scored and never penetrated.

Hibernation galleries are confined to the bark and are considerably larger than brood galleries. As many as 20 adults have been found in a single hibernation gallery. The life cycle, number of generations per year, and number of broods are not known.

Discussion. — In California, this species is rather common along the coast but is rare inland. Only one small series from the Sierra region was seen and these specimens were smaller than usual and seemed to reflect the adverse conditions in that region. It causes no economic damage.

Adults of *D. autographus* are from 3.4 to 5.0 mm in length. The declivity is evenly convex and has a row of fine granules in each interspace. The pronotum appears circular when viewed from above.

Genus *Coccotrypes* Eichhoff

Coccotrypes Eichhoff, 1878, Ratio, descriptio, emandatio, eorum tomicinorum, p. 308. Type-species: *Bostrichus dactyliperda* Fabricius (Hopkins, 1914).

This is an extremely large genus, being found in all tropical areas of the world. Apparently two species occur in the United States, one of which is found in California.

Coccotrypes dactyliperda (Fabricius)
(Map 55)

Bostrichus dactyliperda Fabricius, 1801, Systema Eleuth., 2:387. Syntypes ♀ ♀, Europe (Kiel Museum).
Coccotrypes dactyliperda: Eichhoff, 1878, Ratio, descriptio, emandatio, eorum tomicinorum, p. 309.

Geographic distribution and host range.—C. dactyliperda is found throughout the tropical regions of the world in a wide variety of plants. In southern California it is found in date palm seeds.

California records (map 55).—Imperial Co.: Brawley, on *Phoenix dactylifera* (CDA); El Centro (CIS); Westmorland, on date palm (CDA). Los Angeles Co.: N. Huntington Park (CDA); Los Angeles, on *P. canariensis* (USNM); Norwalk, on date palm seed (CDA); San Marino (UCR); San Pedro, on ornamental date (CDA). Orange Co.: Santa Ana (CDA). Riverside Co.: Cathedral City (UCD); Riverside (UCD). San Diego Co.: Coronado (CDA); La Mesa, on date (CDA). San Francisco Co.: San Francisco, in date stone from Indio (CAS).

Biology.—Unknown in North America. Notes on its

tropical biology may be found in Schedl (1961).

Discussion.—*C. dactyliperda* is a common species in the date-growing regions of southern California but may be found in almost any city in imported seeds or nuts. Adults measure from 1.5 to 2.5 mm in length and may easily be distinguished by the characters presented in the key to genera.

Tribe Xyleborini

Schedl (1957) considered this entire tribe (except *Eccoptopterus*) under the generic name *Xyleborus* Eichhoff. Wood (1961) preferred to retain tentative generic recognition for the North American genera. Bright (1968) reviewed the tribe for the United States and Canada and, for the most part, followed Schedl's concept. Two genera were recognized in North America, *Xyleborus* Eichhoff and *Xylosandrus* Reitter. Only *Xyleborus* occurs in California.

Genus *Xyleborus* Eichhoff

Xyleborus Eichhoff, 1864, Berl. Entomol. Z., 8:37. Type-species: *Bostrichus monographus* Eichhoff (Lacordaire, 1866).
Anisandrus Ferrari, 1867, Borkenkäfer, p. 24. Type-species: *Apate dispar* Fabricius, monotypic. (Syn. by Eichhoff, 1878.)
Premnobius Eichhoff, 1878, Ratio, descriptio, emandatio, eorum tomicinorum, p. 404. Type-species: *Premnobius cavipennis* Eichhoff, monotypic. (Syn. by Schedl, 1957.)
Xyleborinus Reitter, 1913, Wien. Entomol. Z., Beih., 32:83. Type-species: *Bostrichus saxeseni* Reitter (Chamberlin, 1939?). (Syn. by Schedl, 1957.)
Ambrosiodmus Hopkins, 1915, U.S. Dep. Agric., Rep., 99:55. Type-species: *Xyleborus tachygraphus* Zimmerman, original designation. (Syn. by Bright, 1968.)
(Only North American generic synonyms are listed here. For a complete list, see Schedl, 1962.)

This is the largest genus of Scolytidae in the world. Over 1,500 names have been proposed in the genus. Seventeen species occur in North America, north of Mexico; only three occur in California.

KEY TO THE SPECIES OF XYLEBORUS IN CALIFORNIA*

1. Pronotum wider than long, rather coarsely asperate in front; body stout, 2.0 times longer than wide..... *dispar* (Fabricius)
   Pronotum longer than wide, rather finely asperate in front; body elongate, more than 2.5 times longer than wide... 2
2. Scutellum conical; lower margin of declivity, beginning about interspace 7, bearing a series of pointed tubercles, the 2 at the end of interspace 2 the longest..... *saxeseni* (Ratzeburg)
   Scutellum flat; lower margin of declivity rounded and smooth ..... *scopulorum* Hopkins

* This key is based on females only. Almost all specimens collected are females. Males are much smaller, wingless, and never leave the gallery system; and are therefore rarely collected.

Xyleborus dispar (Fabricius)

Apate dispar Fabricius, 1792, Systema. Ent., p. 363. Syntypes ♂ and ♀, Germany (Zoological Museum, Kiel, Germany).
Bostrichus dispar: Herbst, 1793, Natur. Insecten., 5:113.
Tomicus dispar: Thomson, 1865, Skand. Col., 7:369.
Xyleborus dispar: Eichhoff, 1864, Berl. Entomol. Z., 8:38.
Anisandrus dispar: Ferrari, 1867, Forst. und Baum. Borkenkäfer, p. 26.
Scolytus pyri Peck, 1817, Mass. Agric. Rep., 4:205. Type ♀, Massachusetts (destroyed?). (Syn. by Riley and Howard, 1890.)
Anisandrus pyri: Hopkins, 1915, U. S. Dep. Agric. Rep., 99:69.
Anisandrus swainei Drake, 1921, Ohio J. Sci., 21(6):203. Holotype ♀, Wanakena Lake, New York (USNM). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—*X. dispar* is distributed throughout boreal and temperate zones in the world. Although collected only from nectarine (*Prunus*) in northern California, it will probably occur elsewhere in the state on other hosts.

California record. — Siskiyou Co.: Hamburg, on nectarine branches (UCD).

Biology.—Attack is usually on weak or sickly trees, especially newly set, frost injured, or sunscalded trees, and in locations where there is a high water table or poor soil. However, perfectly healthy young trees may be attacked and killed over a 2- to 3-month period. Smaller branches and tips of healthy trees are often killed; this damage resembles that caused by pear blight and other diseases.

The egg gallery is variable; it is apparently adjusted to host conditions. In small trees or branches it may spiral around the tree upward from the point of entry. The adults introduce an ambrosial fungus which stains the sapwood in the vicinity of the larval galleries. Larval galleries are in the same plane as those of the adults. No further details are known.

Discussion.—*Xyleborus dispar* has been known by the name *Anisandrus pyri* by various authors (Chamberlin, 1939, 1958; Swaine, 1918). Bright (1968), after examining several hundred specimens of *A. dispar* (Europe) and *A. pyri* (North America) decided that there was no basis for continuing to recognize two species.

This beetle occasionally causes concern in new orchards and in areas of excessive or insufficient water or nutrients. It seems to be rare in California but more common in the Pacific Northwest.

Adults of *X. dispar* are easily recognized by the very stout body shape, by the serrate anterior margin of the

pronotum and by the convex, faintly granulate elytral declivity.

Xyleborus saxeseni (Ratzeburg)
(Fig. 55; map 56)

Bostrichus saxeseni Ratzeburg, 1837, Die Forstinsekt. Mittle Europos Vol. 1:167. Type ♀, Europe (destroyed).
Xyleborus saxeseni: Ferrari, 1867, Forst-und Baum. Borkenkäfer, p. 21.
Xyleborinus saxeseni: Reitter, 1913. Wien. Entomol. Z., 32:83.
Xyleborus xylographus of authors (nec Say): Swaine, 1909. N. Y. State Mus. Bull., 134:157.
Xyleborus quercus Hopkins, 1915, U. S. Dep. Agric. Rep., 99:63. Holotype ♀, Baxterville, Mississippi (USNM). (Syn. by Wood, 1962.)
Xyleborus floridensis Hopkins, 1915, U. S. Dep. Agric. Rep., 99:63. Holotype ♀, Enterprise, Florida (USNM). (Syn. by Wood, 1962.)
Xyleborus pecanis Hopkins, 1915, U. S. Dep. Agric. Rep., 99:63. Holotype ♀, Waynesboro, Mississippi (USNM). (Syn. by Wood, 1962.)
Xyleborus arbuti Hopkins, 1915, U. S. Dep. Agric. Rep., 99:64. Holotype ♀, Walker, California (USNM). (Syn. by Wood, 1957*a*.)
Xyleborinus tsugae Swaine, 1934, Can. Entomol., 66:204. Holotype ♀, Mission, British Columbia (CNC). (Syn. by Wood, 1957*a*.)
Xyleborinus librocedri Swaine, 1934, Can. Entomol., 66:205. Holotype ♀, Oak Ridge, Oregon (CNC). (Syn. by Wood, 1957*a*.)

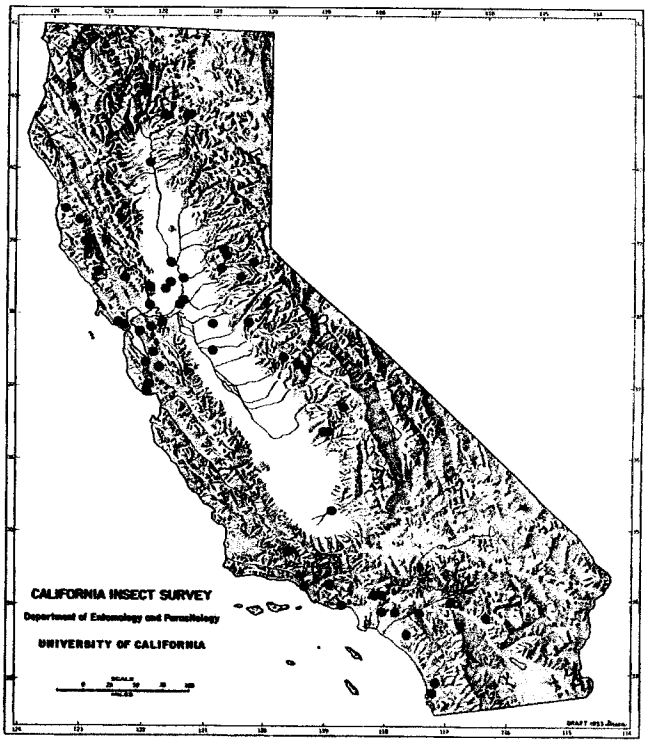
Geographic distribution and host range.—*X. saxeseni* is found throughout the southern forests of Canada and continental United States. It attacks a wide variety of broad-leaved and coniferous trees and possibly no species is exempt from invasion.

California records (map 56).—Numerous localities in the following counties: Alameda, Contra Costa, El Dorado, Fresno, Humboldt, Kern, Lake, Los Angeles, Madera, Marin, Mariposa, Mendocino, Napa, Orange, Placer, Riverside, Sacramento, San Bernardino, San Diego, San Joaquin, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Siskiyou, Solano, Sonoma, Stanislaus, Tehama, Tuolumne, Tulare, Ventura, Yolo, and Yuba.

Biology. (Prebble and Graham, 1957)

Although *X. saxeseni* is widely distributed in various hosts its biology is not well known. It is an ambrosia beetle whose galleries penetrate deep into the sapwood like those of *Trypodendron* spp. It attacks dying trees, usually of large size. The adults mine more-or-less straight in toward the pith and then turn in a radial direction and form a large cave. The parent adults occasionally enter a gallery of *Gnathotricus* and construct their own as an offshoot.

Up to 48 eggs are deposited freely in the radial galleries and in the cave and the larvae and young adults wander about freely. The walls of the chambers are coated with ambrosia fungus upon which the larvae feed. The larvae also aid in extending the chamber. Larvae, pupae, and adults overwinter in the logs.



Map 56. California distribution of *Xyleborus saxeseni* (Ratzeburg).

Discussion.—This species has been recorded on numerous occasions under the name *Xyleborus xylographus* Say and for a long time the two species were confused by many authors. Wood (1960), Schedl (1962/63) and Bright (1968) showed that the two species were completely different.

The peculiar conical scutellum and the declivital characters will immediately distinguish the adults of this species.

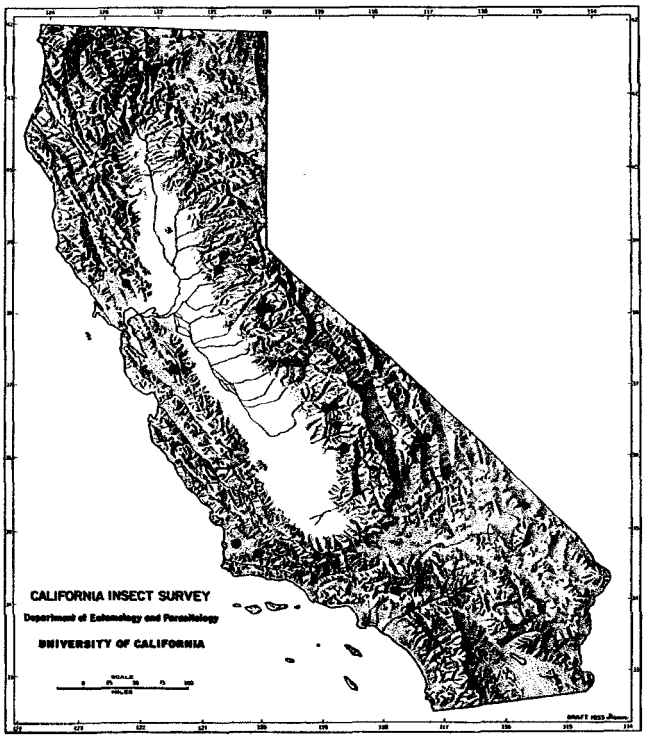
Xyleborus scopulorum Hopkins
(Map 57)

Now is *Intrusus* Blandford (synonymy in Wood, 1982)

Xyleborus scopulorum Hopkins, 1915, U. S. Dep. Agric. Rep., 99:66. Holotype ♀, Black Hills, South Dakota (USNM).

Geographical distribution and host range.—*X. scopulorum* attacks a wide variety of coniferous trees. It has been collected from fir and pine in California. It is widely distributed in western North America.

California records (map 57).—Various localities in the following counties: El Dorado, Fresno, Inyo, Lake, Los Angeles, Madera, Mariposa, Napa, San Diego, Santa Barbara, Santa Clara, Tulare, and Tuolumne.



Map 57. California distribution of *Xyleborus scopulorum* Hopkins.

Biology.—Unknown.

Discussion.—This species is easily recognized by the extremely convex elytral declivity with granules on the first and third interspaces, by the flat scutellum, and by the host. Males are quite rare and may be recognized by the concave depression on the anterior portion of the pronotum.

(Now known as *X. intrusus* Blandford, see Wood, 1972, Great Basin Nat. 32 (4): 198.)

Tribe Ipini

Schedl (1964) grouped all the genera in the tribe Ipini (except *Pityogenes*) into one genus, *Ips* DeGeer. There may be merit to this grouping and Wood (1966) felt that this action was the result of considerable study. However, before this is accepted a very thorough review of all aspects of the problem should be undertaken. We join with Wood (1966) in preferring, for the present, to retain the generic names *Pityokteines* Fuchs, *Orthotomicus* Ferrari, and *Ips* DeGeer.

Genus *Pityogenes* Bedel

Pityogenes Bedel, 1888, Faun. Coleop. du Bassin de la Seine, p. 397. Type-species: *Dermestes chalcographus* Linnaeus, original designation.

Six species of this Holarctic genus occur in North America and three of these are found in California.

Species of this genus may be easily recognized by the peculiar frontal pit on the female frons and by the declivital characters of the male. All are found in various species of *Pinus* and occasionally in other conifers where they make a star-shaped gallery system which deeply engraves the wood (fig. 21). They are usually of secondary importance attacking the tops, limbs, and twigs of weakened, dying, or recently killed trees. Occasionally, however, they may develop in sufficiently large numbers to attack and kill small trees near their breeding place.

KEY TO THE SPECIES OF PITYOGENES IN CALIFORNIA

1. Declivity convex with 3 teeth on each side, much larger in the male; pronotum narrowly rounded anteriorly..... *fossifrons* (LeConte)
   Declivity steep with 3 small teeth on each side in the female, and a larger, hook-shaped tooth on each side in the male; pronotum broadly rounded anteriorly..... 2
2. Frontal cavity of female large, undivided; in *Pinus ponderosa* and related pines (fig. 80).... *carinulatus* (LeConte)
   Frontal cavity of female smaller, divided into two equal pits; in *Pinus contorta* ..... *knechteli* (Swaine)

Pityogenes fossifrons (LeConte)

(Fig. 21; Map 58)

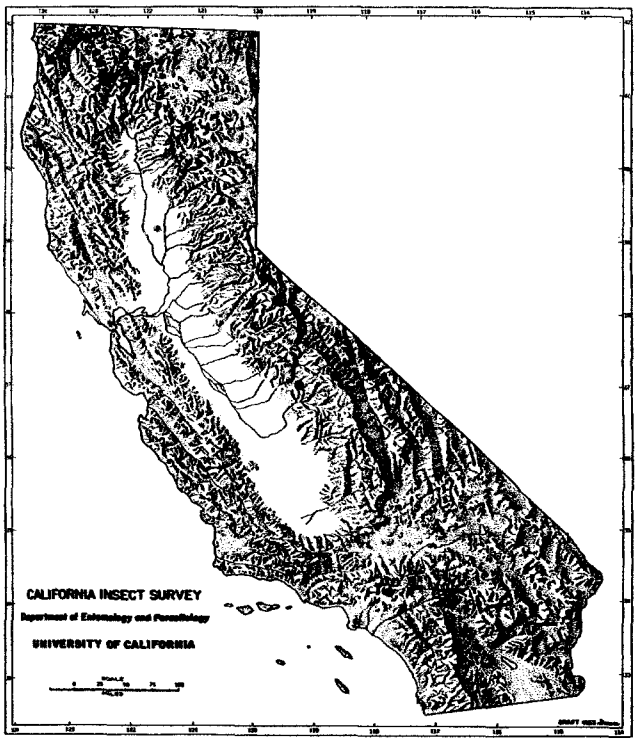
Pityophthorus fossifrons LeConte, 1876, Proc. Am. Philos. Soc., 15:353. Syntypes ♂ ♂, Vancouver Island, British Columbia (MCZ).

Pityogenes fossifrons: Schwarz, 1896, Proc. U. S. Natl. Mus., 18:609.

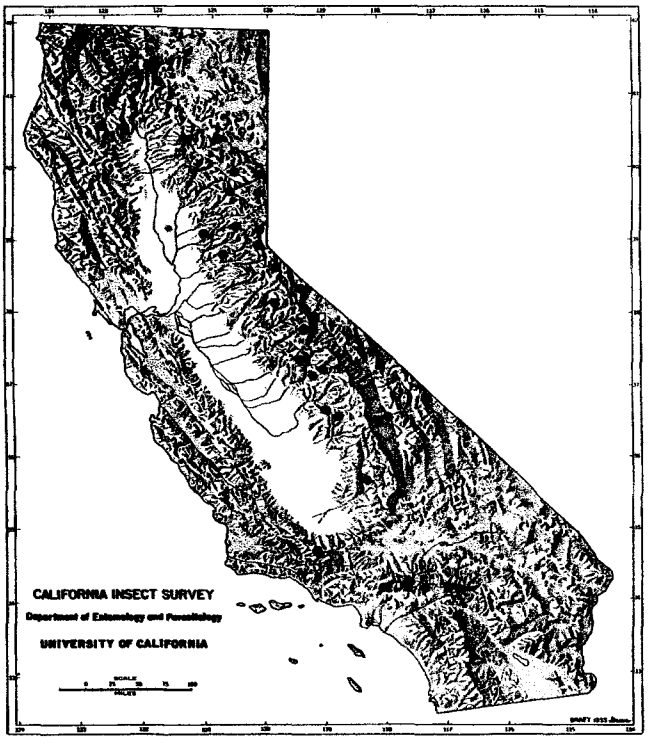
Geographic distribution and host range.—Pityogenes fossifrons is distributed throughout northwestern North America east to the Rocky Mountains. It attacks spruces and pines and may be found in other Pinaceae.

California records (map 58).—ALPINE Co.: Ebbets Pass, on *Pinus contorta* (CIS). DEL NORTE Co.: Red Mtn., on *P. monticola* (PSW). FRESNO Co.: Kaiser Pass, Huntington Lake, on pine (UCD). INYO Co.: Lake Sabrina, Inyo Natl. Forest, on *P. balfouriana* (CIS); 1 mi S. Onion Valley, on *P. balfouriana* and *P. flexilis* (CNC); Mt. Whitney, 11,000' (PSW). LASSEN Co.: Grassy Lake, on *P. monticola* (CAS). LOS ANGELES Co.: Big Pines Park, on *P. jeffreyi* (OSU). MONO Co.: Blanco's Corral, White Mtns. (UCD); Crooked Creek, White Mtns., on *P. aristata* (CIS). SHASTA Co.: Mt. Shasta, on *P. albicaulis* (CIS). SISKIYOU Co.: 7 mi N.W. Callahan, on *Picea engelmanni* (CIS); Callahan, on *P. breweriana* (HSC); 18 mi N. Happy Camp, on *Pinus monticola* (CIS); Gin Alpine (CAS). County unknown: Sonora Pass, on *P. monticola* (HSC).

Biology.—Essentially unknown. The gallery pattern is typically star-shaped with four or five egg galleries 2.5 to 4.0 cm long radiating from a central nuptial chamber (fig. 21).



Map 58. California distribution of *Pityogenes fossifrons* (LeConte).



Map 59. California distribution of *Pityogenes carinulatus* (LeConte).

Discussion.—Pityogenes fossifrons is characterized by the rounded elytral declivity with three laterally flattened teeth in the second interspace, which are much larger in the male. Its principal host is western white pine.

Pityogenes carinulatus (LeConte)
(Fig. 80; map 59)

Cryphalus carinulatus LeConte, 1874, Trans. Am. Entomol. Soc., 5:70. Syntypes (sex ?) Lake Tahoe, Calaveras and Mojave Region, California (MCZ).
Pityogenes carinulatus: Schwarz, 1894, Insect Life 7:255.
Xyleborus hamatus LeConte, 1874, Trans. Am. Entomol. Soc., 5:72. Types ♂ ♂, Mojave Desert, California (MCZ). (Syn. by LeConte, 1878.)

Geographic distribution and host range.—Pityogenes carinulatus is distributed throughout western North America. Its preferred host, at least in California, appears to be ponderosa pine but it probably attacks all species of pine within its range.

California records (map 59).—Numerous localities in the following counties: Alpine, El Dorado, Fresno, Humboldt, Inyo, Kern, Lassen, Los Angeles, Madera, Mariposa, Mono, Nevada, Placer, Plumas, Riverside, San Bernardino, Shasta, Siskiyou, Tuolumne, Tulare, Trinity, and Ventura.

Biology.—Pityogenes carinulatus is a secondary insect attacking twigs of weakened trees or felled trees and slash on the ground. First attacks occur in early June.

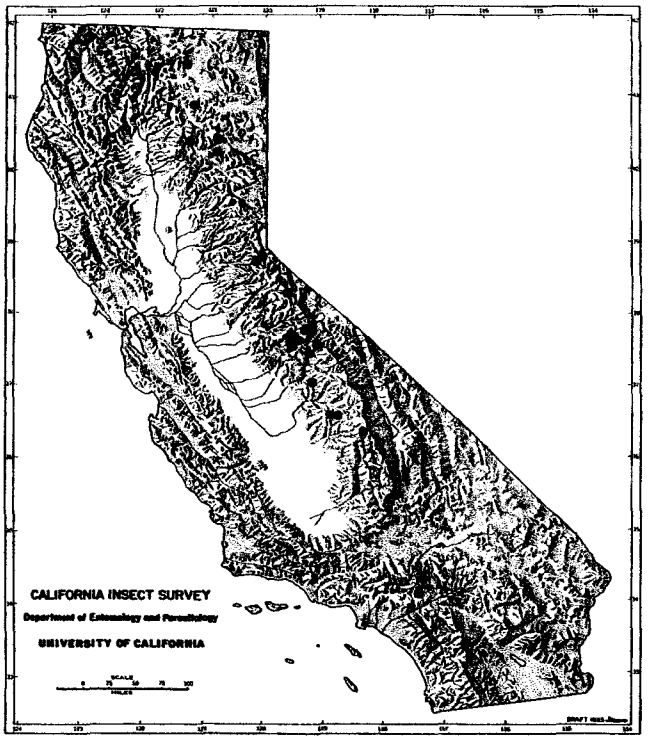
The adult male initiates attack, forming a roughly circular central nuptial chamber. It is joined by up to 10 females, each of which constructs its own egg gallery up to 5 cm long. Eggs are laid on each side of the egg gallery and the larval galleries radiate out in all directions from the egg gallery.

There are probably two generations per year, one established in the spring and developing to adults by midsummer to late fall, the second established by the progeny of the first generation. The second generation overwinters.

Discussion.—This is a very common species in California pines. It is closely related to *P. knechteli* Swaine but the characters of the female frons will always distinguish it. It occurs rarely in *P. murrayana*, the principal host of *P. knechteli*, so this also may generally be used to separate them.

Pityogenes knechteli Swaine
(Map 60)

Pityogenes knechteli Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):106. Holotype ♀, Jasper Natl. Park, Alberta (CNC).



Map 60. California distribution of *Pityogenes knechteli* (Swaine).

Geographical distribution and host range. — *P. knechteli* is distributed in pine forests throughout western North America. Its principal host appears to be lodgepole pine but it has been collected from pinyon, ponderosa, and western white pine so it may attack most pines.

California records (map 60).—Various localities in the following counties: El Dorado, Fresno, Lassen, Madera, Mariposa, Mono, San Bernardino, Shasta, Siskiyou, Tulare, and Tuolumne.

Biology. (Reid, 1955)

The biology reported here is taken from notes on the species in Alberta. The biology of the species in California is not known but is probably similar to that reported here.

First attacks were observed during the latter part of May. The original attacking adults frequently reemerge in early July and establish second broods. Teneral adults from the first brood appear in mid-July and feed extensively under the bark until fall. By September, the second brood was mainly in the larval and pupal stage, with a small number of teneral adults. There is thus one generation a year with two broods.

The gallery pattern, characteristic of species in this genus, consists of a central nuptial chamber from which radiate four to six egg galleries. The nuptial chamber and egg galleries are constructed in the inner bark, engraving the sapwood only slightly. Eggs are laid singly in niches, covered with frass and hatch in 9 to 13 days. Larval mines are confined to the inner bark until the larvae reach maturity. Pupation takes place in small pits in the sapwood, or in the inner bark.

Head capsule measurements indicate four and possibly five larval instars.

Discussion.—This species breeds mainly in lodgepole pine and is extremely common. The divided pit on the female frons and the (usually) different host will easily distinguish the adults from those of *P. carinulatus.*

Genus *Pityokteines* Fuchs

Pityokteines Fuchs, 1911, Habilitschr. Tech. Hochschule Karlsruhe, p. 33. Type-species: *Ips curvidens* Germar (Hopkins, 1914).

Four species of the genus are known from North America, three of which occur in California. They are generally small, about 1.5 mm in length and easy to recognize by the dense brush of hair on the female frons and pronotum (except *P. ornatus*) and by the declivital characters.

KEY TO THE SPECIES OF PITYOKTEINES IN CALIFORNIA

1. Female frons and anterior margin of pronotum densely pubescent; in *Abies* or *Pseudotsugae* 2
   Female frons and anterior margin of pronotum sparsely pubescent; in *Pinus* ..... *ornatus* (Swaine)
2. Declivital teeth of female minute; those of males shorter than width of discal interspace; elytral interspaces rather closely punctured on disk ..... *minutus* (Swaine)
   Declivital teeth of female moderate in size, those of male distinctly longer than width of discal interspace; elytral interspaces rather sparsely punctured on disk ..... *elegans* Swaine

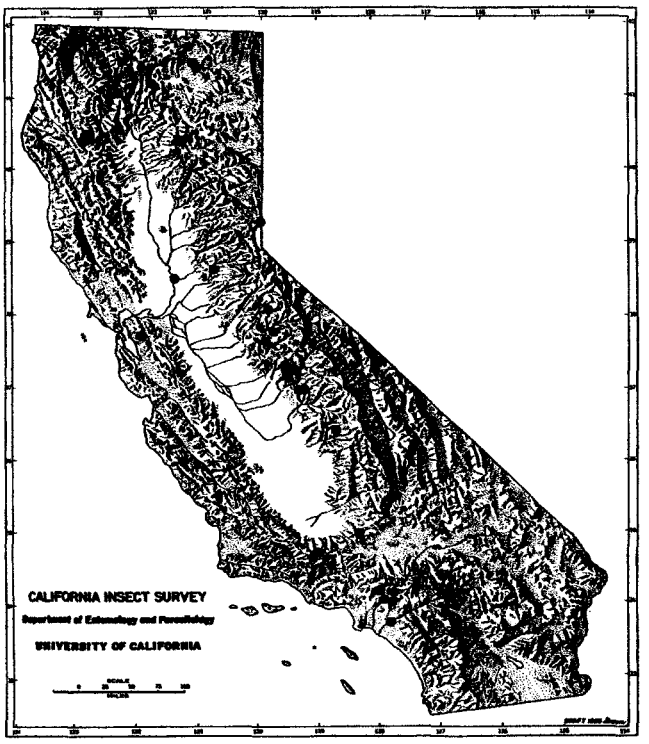
Pityokteines ornatus (Swaine)
(Map 61)

Orthotomicus ornatus Swaine, 1916, Can. Entomol., 48:185. Lectotype ♀, Williams, Arizona (CNC).
Pityokteines ornatus: Wood, 1966, Great Basin Nat. 26(1-2):27.

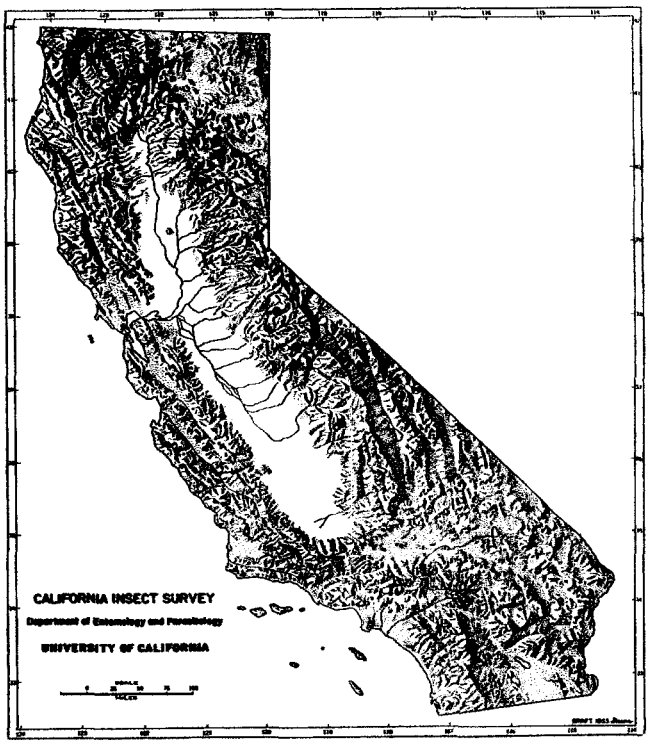
Geographic distribution and host range.—Pityokteines ornatus occurs throughout western North America as far east as Arizona and the western Rockies. It apparently attacks most pine species.

California records (map 61).—Numerous localities in the following counties: Butte, Contra Costa, El Dorado, Fresno, Kern, Los Angeles, Madera, Mariposa, Modoc, Monterey, Nevada, Orange, Riverside, Sacramento, San Bernardino, San Diego, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology.—Only the collecting sites and the galleries, which are usually placed near the base of the host tree



Map 61. California distribution of *Pityokteines ornatus* (Swaine).



Map 62. California distribution of *Pityokteines elegans* Swaine.

in the thick bark, are known. The galleries are sinuous, in no particular pattern, and almost entirely in the bark.

Discussion.—The adults of this species differ from those of all other species of *Pityokteines* by the lack of dense pubescence on the frons and on the anterior margin of the pronotum of the females and it is the only species in this genus in North America known to occur in pines. Also, the vestiture of the declivity of both sexes is generally denser than in the other species. The declivital armature resembles *P. elegans.*

Pityokteines minutus (Swaine)

Dryocoetes minutus Swaine, 1912, Can. Entomol., 44:352. Lectotype ♀, Colorado, Cornell Univ.

Pityokteines minutus: Swaine, 1918. Can. Dep. Agric. Entomol. Branch Bull., 14(2):124.

Pityokteines jasperi Swaine, 1916, Can. Entomol., 48:181. Lectotype ♀, Jasper Park, Alberta (CNC). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—P. minutus is found throughout western North America west of the Rocky Mountains. Hosts include species of true fir and Douglas fir.

California record.—Los Angeles Co.: Big Pines Park, on *Abies concolor* (OSU).

Biology.—Practically unknown. Adults of *P. minutus* have been found killing small Douglas fir saplings in Oregon. Mature broods were found in mid-June. The galleries are similar to those of *P. elegans.*

Discussion.—The nearly complete lack of granules on the female declivity and the very small teeth on the male declivity will distinguish the adults of *P. minutus* from those of other members of the genus. The adults are also slightly smaller in size than those of the other species, measuring about 2.3 mm in length.

Pityokteines elegans Swaine
(Map 62)

Pityokteines elegans Swaine, 1916, Can. Entomol., 48:182. Lectotype ♀, Hood River, Oregon (CNC).

Geographical distribution and host range.—P. elegans occurs from British Columbia south to the central Sierra Nevada. Most collections have been made on red and white fir but it probably attacks all species of fir. If so, the distribution probably extends inland to the Rocky Mountains.

California records (map 62).—Various localities in the following counties: El Dorado, Humboldt, Lassen, Madera, Mariposa, Modoc, Placer, Plumas, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology.—Practically unknown. The adults attack the

tops and limbs of dying or cut trees and construct a radiate gallery consisting of a central nuptial chamber with two to five egg galleries.

Discussion.—Adults of *Pityokteines elegans* closely resemble those of *P. ornatus*. They may be distinguished by the dense pubescence on the frons and pronotum of the female and by the host. The declivital characters given in the key should serve to separate the adults of this species from those of *P. minutus*.

Genus *Orthotomicus* Ferraire

Orthotomicus Ferraire, 1867, Forst-und Baum. Borkenkäfer, p. 44. Type-species: *Bostrichus laricis* Fabricius (Hopkins, 1914).

Neotomicus Fuchs, 1911, Habilitschr. Techn. Hochschule Karlsruhe, p. 38. Type-species: *Ips laricis* (Fabricius) (Hopkins, 1914). (Syn. by Reitter, 1913.)

There is considerable confusion about this generic concept. The characters presented in the key to genera hold fairly well for the Holarctic species but generic limits and characters are not clear in the tropical areas.

Originally, in North America, the genus contained five species. One species (*vicinus*) was placed in synonymy by LeConte (1876), one (*lasiocarpi*) was moved to *Orthotomides* by Wood (1951), and one (*ornatus*) was placed in *Pityokteines* by Wood (1966). Hopping (1963*a*) placed *Ips latidens* and a related new species (*sabinianae*) in the genus but Wood (1966, 1968) reassigned them to *Ips*. They do not appear to belong in *Ips* or *Orthotomicus* but in order to avoid further confusion, Wood's concept is accepted here.

As the genus now stands, two species are known from North America, one of which occurs in California.

Orthotomicus caelatus (Eichhoff)

Tomicus caelatus Eichhoff, 1867, Berl. Entomol. Z., p. 402. Type (sex ?), America Borealis (destroyed?).

Xyleborus caelatus: Zimmermann, 1868, Trans. Am. Entomol. Soc., 2:146.

Ips caelatus: Smith, 1900, Cat. Ins. N. J., p. 303.

Orthotomicus caelatus: Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):121.

Xyleborus vicinus LeConte, 1874, Trans. Am. Entomol. Soc., 5:72. Holotype (sex ?), British Columbia (MCZ). (Syn. by LeConte, 1876.)

Orthotomicus vicinus: Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):122.

Geographic distribution and host range.—Orthotomicus caelatus is distributed throughout the northern coniferous forests of North America. It breeds in all species of pine, spruce and larch. Its preferred western host is lodgepole pine.

California record.—Lassen Co.: Norval Flats, on *Pinus murrayana* (CAS).

Biology.—Orthotomicus caelatus breeds mainly in the thicker bark at the base of the trunk in standing trees and the thicker-barked portions of felled trees.

Adults are polygamous and construct a radiate gallery similar to various species of *Ips*. However, the egg galleries are usually short and from two to six eggs are deposited in each egg niche rather than singly.

The life cycle and number of generations per year are unknown.

Discussion.—This species is very common throughout Canada and most of the United States but not in California. The western form has been known under the name *O. vicinus* (Swaine, 1918; Chamberlin, 1939, 1958) but there is no basis for continuing to recognize a separate western species. LeConte (1876) placed *Xyleborus vicinus* in synonymy under *X. caelatus* and we follow his usage.

Adults of *O. caelatus* may be easily recognized by the characters given in the key to genera.

Genus *Ips* DeGeer

Ips DeGeer, 1775, Mem. pour servir a l'hist. des insectes 5, p. 190. Type-species: *Dermestes typographus* Linnaeus (Hopkins, 1914).

Most of the species of *Ips* were described in other genera. Much of the older literature treated them under *Tomicus* Latreille, but this name is now applied to an entirely different group of bark beetles.

There are 27 currently recognized species in North America. Nine were recorded from California by Hopping (1963–1965) in his revision of the genus. Thirteen species and two subspecies are listed herein. This net increase is a result of changing taxonomic status of some entities previously known to occur in California, of the discovery of *I. concinnus* near the borders of the state, and of the deletion of *I. utahensis*. The latter species, normally found in the Intermountain states in *Picea engelmannii*, is represented by a series in the CNC labeled "Big Bear Lake, Cal., 6,800′, Aug. 8–13, 1921"—far from the natural range of spruce. Also in the CNC is a series of *utahensis*, taken by the same collectors (Knaus, Nininger, and Hoover) labeled "The Mammoth Mt., Utah, 7–13–1921, *Picea*" and a series of *pini* bearing labels identical to the Big Bear *utahensis*. It seems probable that *utahensis* from the Mammoth Mt. were inadvertently mixed with *pini* from Big Bear Lake when the specimens were pinned.

Complementing the taxonomic investigations (Hopping op. cit.; Lanier, 1966, 1970*a*, *b*, 1972) of the beetles themselves, mites (Lindquist and Bedard, 1961; Kinn, 1967*a*, *b*, 1968; Lindquist, 1969), and nematodes (Massey, 1957, 1960, 1962; Nickle, 1963*a*, *b*, *c*) parasiting *Ips* have been intensively studied taxonomically and biologically. Many of the phenomena of mass colonization were worked out with *Ips* (Anderson, 1948; Wood and Bushing, 1963; Wood and Vité, 1961; Wood, 1963; Borden, 1967) and the sex pheromone of *I. paraconfusus* (*"confusus"*) has been synthesized (Silverstein et al., 1966). In addition, *Ips* species have been the subjects of studies of emergence (Reid, 1955; Cameron and Borden, 1967), development (Berryman and Stark, 1961), muscle generation (Borden and Slater, 1968, 1969), toxicology (Moore, 1957; Lyon, 1959; Lyon and Shea, 1967), and sound production (Wilkinson et al., 1967; Barr, 1969).

Members of this genus are easily recognized by the concave elytral declivity armed on the lateral margins with three to six spines and by the antennal characters. Included in this genus are some of the most common and destructive forest pests in California.

KEY TO THE SPECIES OF IPS IN CALIFORNIA

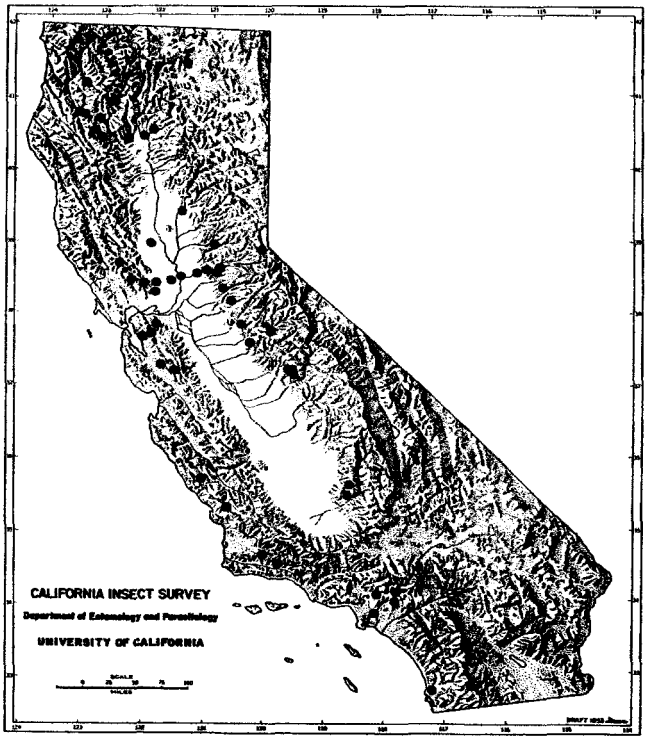
1. Declivity of elytra with 3 spines on each lateral margin 2
   Declivity of elytra with more than 3 spines on each lateral margin 5
2(1). Sutures of antennal club broadly bisinuate or nearly straight (Group 0) 3
   Sutures of antennal club strongly arcuate (Group I) (fig. 56) 4
3(2). Frons with 2 prominent tubercles just above epistomal margin; principally in *Pinus sabiniana*..... *sabinianae* (G. Hopping)
   Frons devoid of prominent tubercles; in *Pinus ponderosa* and other pines..... *latidens* (LeConte)
4(2). Caudal half of pronotum finely, densely punctured, diameter of each puncture 0.03 mm or less, caudal margin of each puncture raised giving the surface a granulate appearance; in *Picea sitchensis* ..... *concinnus* (Mannerheim)
   Caudal half of pronotum sparsely punctured, diameter of each puncture 0.04 mm or more; surface not granulate, at least on caudal fourth of disk; in *Pinus* ..... *mexicanus* (Hopkins)
5(1). Elytral declivity with 4 spines on each lateral margin 6
   Elytral declivity with more than 4 spines on each lateral margin 11
6(5). Third declivital spine broad, compressed, emarginate at the tip; body size large, about 6 mm in length (Group II) ..... *emarginatus* (LeConte)
   Third declivital spine not appreciably broadened or compressed, not emarginate at the tip; body size smaller, usually less than 6 mm in length..... 7
7(6). Elytral interspaces impunctate on the disk; third spine of male subcapitate, subacute at the tip, often bent ventrad; third spine of females similar to second with an emarginate ridge joining the 2.. 8
   Elytra with 1 or more interspaces on the disk punctate-setose; third declivital spine strongly capitate and acute at the tip or subcapitate and rounded at the tip; declivital armature of male and female similar ..... *tridens* (Mannerheim)
8(7). Sutures of antennal club strongly, acutely angled at the middle (Group III) 9
   Sutures of antennal club bisinuate, not strongly or acutely angled at the middle (Group IV) (fig. 57) ..... *pini* (Say)
9(8). Carina between frontal tubercle and epistomal margin well developed; body size larger, 5.0 to 6.2 mm; usual host: *Pinus ponderosa*.. *integer* (Eichhoff)
   Carina between frontal tubercle and epistomal margin weakly developed or absent; body size smaller, 4.0 to 5.5 mm; rarely in *Pinus ponderosa*.....10
10(9). Frontal carina and epistomal tubercle weakly present or absent; struts of male genitalia approximately 1.1 times longer than lobe; high mountains in *Pinus murrayana* ..... *plastographus plastographus* (LeConte)
   Frontal carina and tubercle on epistomal margin rarely apparent; struts of male genitalia approximately 1.4 times longer than lobe; coastal regions in *Pinus radiata, muricata* and *contorta*..... *plastographus maritimus* Lanier
11(5). Declivity of elytra with 5 spines on each lateral margin (Group IX) 12
   Declivity of elytra with 6 spines on each lateral margin (Group X)..... *calligraphus* (Germar)
12(11). Length usually less than 4.8 mm; median fovea on frons distinctly impressed 13
   Length more than 5.0 mm; median fovea on frons shallowly impressed or obsolete..... *montanus* (Eichhoff)
13(12). Declivity of male densely punctuate; struts of male genitalia equal to, or shorter than lobe; striations on pars stridens .6μ or wider; in pinyon pines..... *confusus* (LeConte)
   Declivity of male sparsely or moderately densely punctate; struts of male genitalia slightly longer than lobe; striations on pars stridens of female less than .6μ in width; in other pines (fig. 81)..... *paraconfusus* Lanier

Ips sabinianae (G. Hopping)

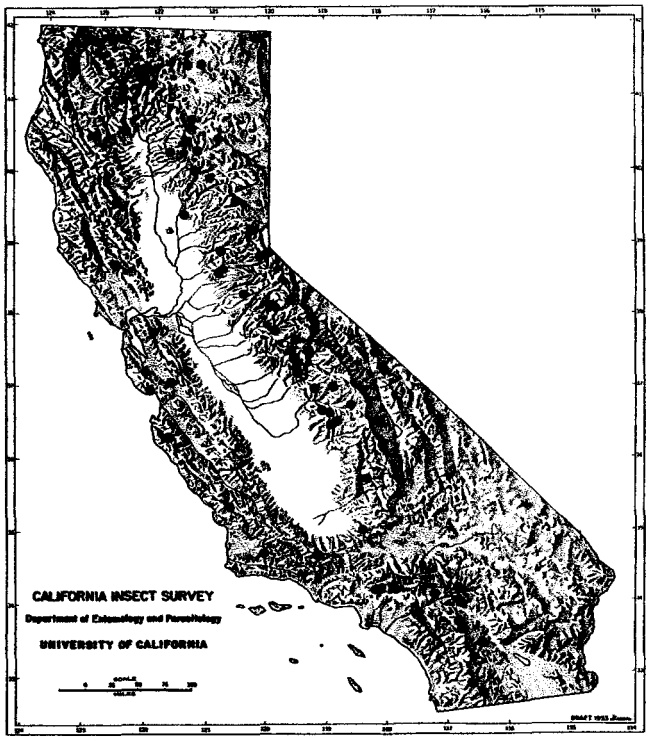
(Map 63)

Orthotomicus sabinianae Hopping, 1963, Can. Entomol., 95:64. Holotype ♂, Middletown, California (CAS).
Ips sabinianae: Wood, S.L., 1968, Great Basin Nat., 28(1):15.

Geographic distribution and host range.—Ips sabinianae is ap-



Map 63. California distribution of *Ips sabinianae* (Hopping).



Map 64. California distribution of *Ips latidens* (LeConte).

parently restricted to the range of its principal host, Digger pine, which includes the dry ridges and slopes of the inner Coast Ranges and the foothills of the Sierra Nevada south to the Sierra San Pedro Martir of Baja California in Mexico. Other known hosts are ***P. attenuata, jeffreyi,*** and ***ponderosa.***

California records (map 63).—Numerous localities in the following counties: Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Kern, Lake, Los Angeles, Madera, Mariposa, Monterey, Napa, Nevada, Riverside, Sacramento, San Diego, San Luis Obispo, Santa Barbara, Santa Clara, Shasta, Siskiyou, Solano, Trinity, Tuolumne, and Yolo.

Biology.—I. sabinianae is occasionally a primary killer of *Pinus sabiniana* (Keen, 1952—under *I. latidens*). These small scolytids may attack a large tree in great numbers, utilizing the entire bole and all branches over 5 cm in diameter. One to five egg galleries extend from each nuptial chamber. These are often sinuate whereas those of most *Ips* are straight along the grain of the wood. The number of generations per year is not known.

Discussion.—Some literature on *Ips latidens* in California actually refers to *Ips sabinianae.*

Adults of these closely related species can be distinguished by the presence of two tubercles on the frons of *I. sabinianae.*

Ips latidens (LeConte)

(Fig. 23; map 64)

Tomicus latidens LeConte, 1874, Trans. Am. Entomol. Soc., 5:72. Type (sex ?) Lake Tahoe, California (MCZ).
Ips latidens: Swaine, 1908, N. Y. State Mus. Bull., 135, p. 119.
Orthotomicus latidens: Hopping, 1963, Can. Entomol., 95:64.
Ips latidens: Wood, 1966, Great Basin Nat., 26(1-2):24.
Tomicus spinifer Eichhoff, 1878, Ratio, descriptio, emandatio, eorum tomicinorum, p. 499. Type (sex ?) California (destroyed ?). (Syn. by Swaine, 1918.)
Ips longidens Swaine, 1911, Can. Entomol., 43:214. Lectotype ♂, Ithaca, New York (CNC). (Syn. by Hopping, 1963*a*.)
Ips guildi Blackman, 1922, Bull. N. Y. State Coll. For. 22(5) Tech. Publ., 16:142. Holotype ♀, Grand Lake, Colorado (USNM). (Syn. by Hopping, 1963*a*.)

Geographic distribution and host range.—I. latidens breeds in most pine species throughout western and eastern Canada and as far south as Virginia in the east and probably to northern Baja California in the west. However, it apparently does not occur in the forests of the Pacific maritime zone or the southeastern Carolina zone.

California records (map 64).—Numerous localities in the following counties: Butte, Calaveras, El Dorado, Fresno, Glenn, Humboldt, Inyo, Kern, Lake, Lassen, Los Angeles, Madera, Mariposa, Modoc, Mono, Monterey, Placer, Plumas, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Clara, Santa Cruz, Shasta, Siskiyou, Trinity, Tulare, Tuolumne, and Ventura.

Biology.—Ips latidens adults usually attack slash on the tops and limbs of dead, dying, or suppressed trees. However, they do attack and kill trees weakened by disease, drought, or other factors and occasionally attack and kill large numbers of apparently healthy sapling or pole-size pines.

The gallery consists of a rather large central chamber from which two to five short (2 to 5 cm), usually curved egg galleries radiate (fig. 23). A single female may construct two or more egg galleries from the same nuptial chamber—most other *Ips* construct one egg gallery per female. Eggs are laid singly in contiguous niches. The life history and number of generations per year are not known.

Discussion.—The characters given in the key will easily distinguish the adults of this species from those of *I. sabinianae*. *Ips latidens* and *Ips sabinianae* form a distinct group (Group 0 of Lanier, 1967) within the genus, recognizable by the unique declivital characters.

Ips concinnus (Mannerheim)
(Map 65)

Bostrichus concinnus Mannerheim, 1852, Bull. Soc. Imp. Nat. Moscou, 25:358. Type ♀, Sitka, Alaska (University of Helsinki).

Ips concinnus: Swaine, 1909, Bull. N. Y. State Mus., 134:121.

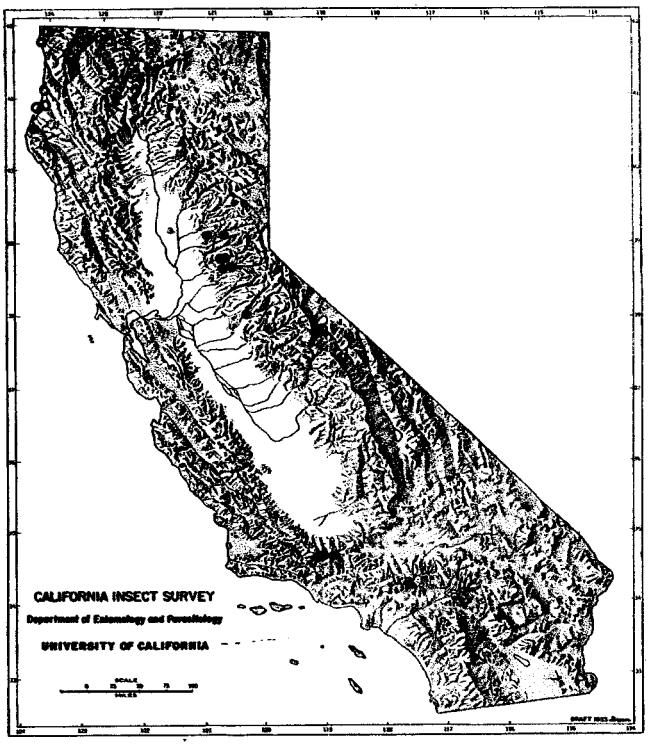
Tomicus hirsutus Eichhoff, 1867, Berl. Entomol. Z., 11:402. Type (sex ?), Sitka, Alaska (destroyed in the bombing of Hamburg during WW II, according to Schedl (1956). (Syn. by Swaine, 1918.)

Ips chamberlini Swaine, 1925, Can. Entomol., 57:196. Holotype ♀, Astoria, Oregon (CNC). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—I. concinnus is apparently restricted to Pacific coastal forests from Alaska to northern California where it breeds in Sitka spruce. Douglas fir is a recorded, but very infrequent, host.

California records (map 65).—Del Norte Co.: Crescent City, on *Picea sitchensis* (CIS); Smith River, on *P. sitchensis* (HSC). Humboldt Co.: Arcata, on *P. sitchensis* (HSC); Ferndale, on *P. sitchensis* (CIS); Samoa, on *P. sitchensis* (HSC); Trinidad, on *P. sitchensis* (CIS).

Biology.—Little is known of the life history or habits. The adults attack living, dying, or felled Sitka spruce but apparently cause little mortality. The parent galleries are in the phloem-cambial region engraving both bark and wood. From the irregular, central nuptial chamber one to five (usually two) females excavate short, crescent-shaped egg galleries. A pair of egg galleries often forms an "S." This species and the succeeding one comprise Group I of Hopping (1963*b*) whose adults are unique among *Ips* in placing two to five eggs in pockets about 2 mm in diameter constructed on the outer curve of the egg gallery.



Map 65. California distribution of *Ips concinnus* (Mannerheim), ○ ; *Ips calligraphus* (Germar), ● ; *Ips confusus* (LeConte), ▲ .

Discussion.—Ips concinnus is closely related to and has been considered a synonym (Schedl, 1956, 1960) of *I. mexicanus*. However, Lanier (1966) documented reproductive isolation between these species and they are distinguished by the pronotal punctation and by the primary host.

Ips mexicanus (Hopkins)
(Fig. 22, 56; map 66)

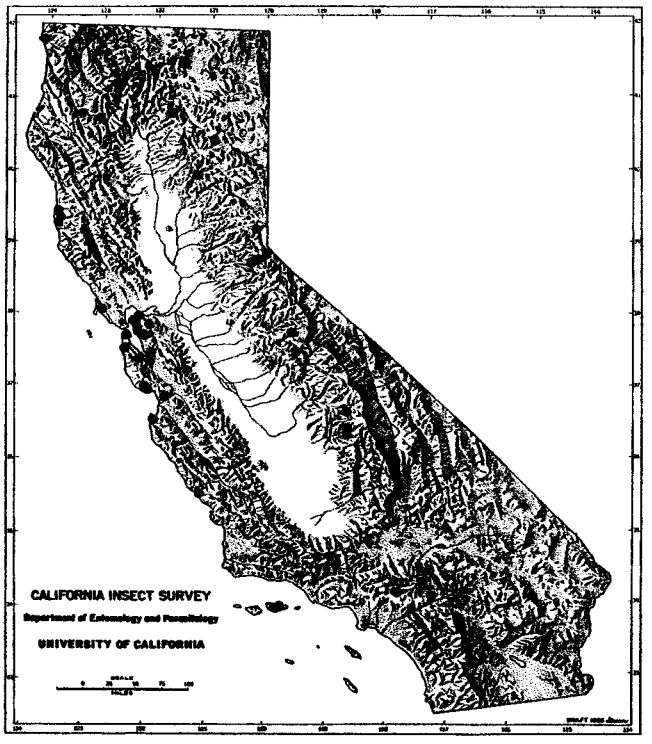
Tomicus mexicanus Hopkins, 1905, Proc. Entomol. Soc. Wash., 7:75. Syntypes ♂ ♂ and ♀ ♀, Mexico City (USNM).

Ips mexicanus: Hopkins, 1915, Proc. Entomol. Soc. Wash., 17:54.

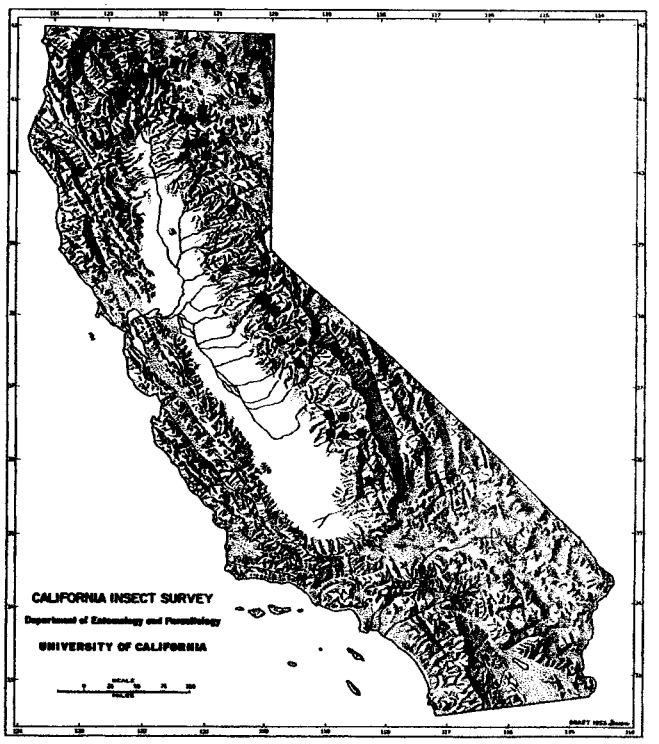
Ips radiatae Hopkins, 1915, Proc. Entomol. Soc. Wash., 17:54. Holotype (sex ?), Berkeley, California (USNM). (Syn. by Hopping, 1963*b*.)

Geographic distribution and host range.—I. mexicanus is found from Alaska to central Mexico. In California this species occurs in pine stands along the coast and in the high mountains, but appears to be absent in the intermediate regions. It apparently attacks all species of pines.

California records (map 66). — Numerous localities in the following counties: Alameda, Contra Costa, Del Norte, El Dorado, Lassen, Los Angeles, Madera, Marin, Mariposa, Mendocino, Monterey, Placer, Plumas, San Bernardino, San Diego, San Luis Obispo, San Mateo, San Francisco, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Siskiyou, Trinity, and Tulare.



Map 66. California distribution of *Ips mexicanus* (Hopkins).



Map 67. California distribution of *Ips emarginatus* (LeConte).

Biology. (Trimble, 1924; Struble, 1961)

I. mexicanus usually attacks weakened or prostrate trees although it has been regarded as a primary killer of young *Pinus radiata* in plantations. However, attacks on healthy trees are almost always in association with more aggressive species; *Dendroctonus valens, I. paraconfusus,* and *I. plastographus* on the coast and *Dendroctonus ponderosae* in the high mountains.

The beetles are usually monogamous; the female excavates a characteristic U-shaped gallery (fig. 22). Occasionally two females join a male and each female excavates a U-shaped gallery from the common nuptial chamber resulting in a characteristic S-shape. Egg pockets, in which three to four eggs are placed, are cut usually in the outside bend of the gallery. The egg pockets are 2 to 2.5 mm deep, 1 to 2 mm wide, and about 0.5 mm apart. An average of 90 eggs per female is laid. The larval mines radiate out from these common starting points.

Along the coast there are usually two summer generations (occasionally only one) and an overwintering generation. The overwintering brood consists of mature larvae, some pupae, and callow adults. In the high mountains there is apparently a single generation per year.

Discussion.—This species and *I. concinnus* were considered conspecific by Schedl (1956, 1960), but their reproductive isolation was demonstrated by Lanier (1966). They may be distinguished by the punctation of the adult pronotum and by the host.

Ips emarginatus (LeConte)
(Map 67)

Tomicus emarginatus LeConte, 1876, Proc. Am. Philos. Soc., 15: 364. Syntypes (sex?) Oregon (MCZ).
Ips emarginatus: Swaine, 1909, Bull. N. Y. State Mus., 134:122.

Geographic distribution and host range.—I. emarginatus is distributed throughout pine forests of western North America and probably extends into Mexico. It has been collected from at least four species of pine in California and probably attacks most species of pine within its range.

California records (map 67).—Numerous localities in the following counties: Calaveras, El Dorado, Glenn, Humboldt, Kern, Lassen, Los Angeles, Madera, Mariposa, Modoc, Mono, Nevada, Placer, Plumas, San Bernardino, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology.—Attacks of *Ips emarginatus* are frequently found in association with the mountain pine beetle (*D. ponderosae*) and the Jeffrey pine beetle (*D. jeffreyi*). It has been reported to attack and kill trees by itself.

Females of this polygamous species construct long (60 cm or more), vertical, parallel galleries connected at various points by horizontal commissures to give a ladder-like appearance. Their work is often confused

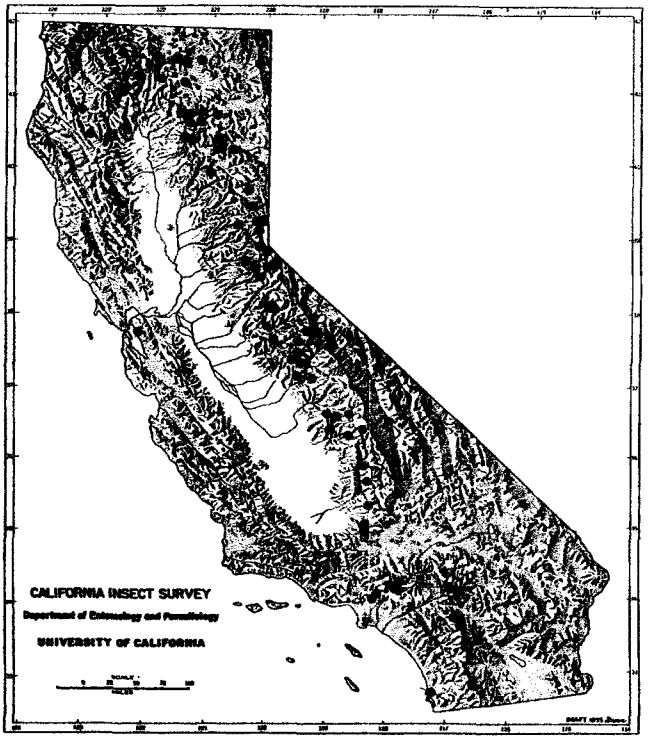
with that of the two *Dendroctonus* species mentioned above but may be distinguished by the presence of the large nuptial chamber and by the absence of boring dust in the *Ips* galleries.

Eggs are laid singly in niches along the parent gallery and the larvae develop in close proximity to the egg gallery. The large pupal cells are also close, often touching it. About 10 weeks are required for development in the summer.

In the north and alpine areas there are two relatively discrete generations per year but in the south and at lower elevations there may be several summer generations with overlapping broods.

Discussion.—Because of the similarity in gallery pattern of *Ips emarginatus* and the two *Dendroctonus* species it has often been credited with extreme destructive capabilities. However, it has usually been of secondary importance.

This species is the largest in North America in the genus, measuring from 4.5 to 6.5 mm in length. The adults are further distinguished by the large, emarginate, third declivital tooth which appears to arise from the fourth interspace.



Map 68. California distribution of *Ips pini* (Eichhoff).

Ips pini (Say)
(Fig. 57; map 68)

Bostrichus pini Say, 1826, J. Acad. Nat. Sci. Phila., 5:257. Type (sex?) Canada (destroyed).
Ips pini: Smith, 1904, Cat. Insects N. J., p. 363.
Tomicus dentatus Sturm, 1826, Cat. Mein. Ins. Samm., p. 76. (Syn. by Hagedorn, 1910?.) Type material unknown.
Tomicus pallipes Sturm, 1826, Cat. Mein. Ins. Samm., p. 76. (Syn. by Hagedorn, 1910?.) Type material unknown.
Tomicus praefrictus Eichhoff, 1867, Berl. Entomol. Z., 11:401. Type (sex?) American borealis (destroyed?).
Tomicus oregonis Eichhoff, 1868, Berl. Entomol. Z., 12:274. Type (sex?) Oregon (destroyed?). (Syn. by Hopping, 1964.)
Ips oregoni: Swaine, 1909, Bull. N. Y. State Mus., 134:125.
Tomicus rectus LeConte, 1876, Proc. Am. Philos. Soc., 15:365. Syntypes (sex?) Oregon and New Mexico (MCZ). (Syn. by Swaine, 1918.)
Ips laticollis Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):116. Lectotype ♂, Ottawa, Ontario (CNC). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—*Ips pini* is distributed throughout the boreal forests of North America, south in the Appalachian mountains to South Carolina in the east and Baja California in the west. In California it attacks lodgepole, Jeffrey, and ponderosa pines primarily, but will likely be found on most pines within its range.

California records (map 68).—Numerous localities in the following counties: Alpine, Amador, El Dorado, Fresno, Glenn, Inyo, Kern, Lassen, Los Angeles, Madera, Mariposa, Modoc, Mono, Nevada, Placer, Plumas, Riverside, San Bernardino, San Diego, Shasta, Sierra, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology. (Anderson, 1948; Ciesla and Bell, 1968; Reid, 1955; Schenk and Benjamin, 1969; Thomas, 1961)

Adults of *Ips pini* usually attack the thick-barked portions of slash and dead or dying trees. They have been observed invading trees infected with annosus root rot, *Fomes annosus*. Frequently, however, they breed in such large numbers that they will attack and kill trees up to 20 cm in diameter and the tops of larger trees. The males attack first, bore to the phloem-cambial region, and construct a nuptial chamber. This boring activity results in the production of a powerful attraction which causes mass invasion of the host material by additional males and particularly females. From one to eight females (usually three to five) join the male in the nuptial chamber, copulation ensues, and each female then excavates a short (12 to 25 cm) egg gallery running obliquely or nearly parallel to the grain of the wood. Often an "X" or a "Y" pattern is formed. These are mostly in the phloem, scoring the sapwood lightly and may take up to 3 weeks to complete.

Eggs are laid singly in niches cut on both sides of the gallery and hatch in about 10 days. The larvae mine at right angles to the parent gallery for a distance of about 3 cm. They construct a small pupal cell at the end of the mine, partly in the phloem and partly in the wood. Pupation lasts about 10 days. In spite of the

polygamous habit the sex ratio of the broods is 1:1.

In the northern and eastern parts of its range there are usually two generations per year, the first or summer generation having two or three broods, the second overwintering generation only one. In California there are three to four generations per year.

The first attack begins in April-May and this brood develops by early June. The parent adults of this brood re-emerge and establish a second brood and later even a third. The second summer generation may repeat this process resulting in great overlap of broods and generations. Parent adults of the third and fourth generation (first and second in the north) emerge before winter and hibernate in the duff or under the bark. A small proportion of the brood adults of the overwintering generation may complete development and emerge for hibernation but the majority of this generation overwinter as larvae and pupae. It is not unusual for brood adults of the summer generations to remain in the host material throughout the summer, feeding under the bark until fall when they emerge for hibernation.

Discussion.—Like many species of *Ips*, *I. pini* is occasionally a serious pest of plantations and in young forests where thinning is practiced. Outbreaks can be severe and destructive but seldom last more than a single season.

The adults of this four-spined species of *Ips* are distinguished by the sinuate to nearly straight sutures on the antennal club and by the impunctate, convex elytral interspaces.

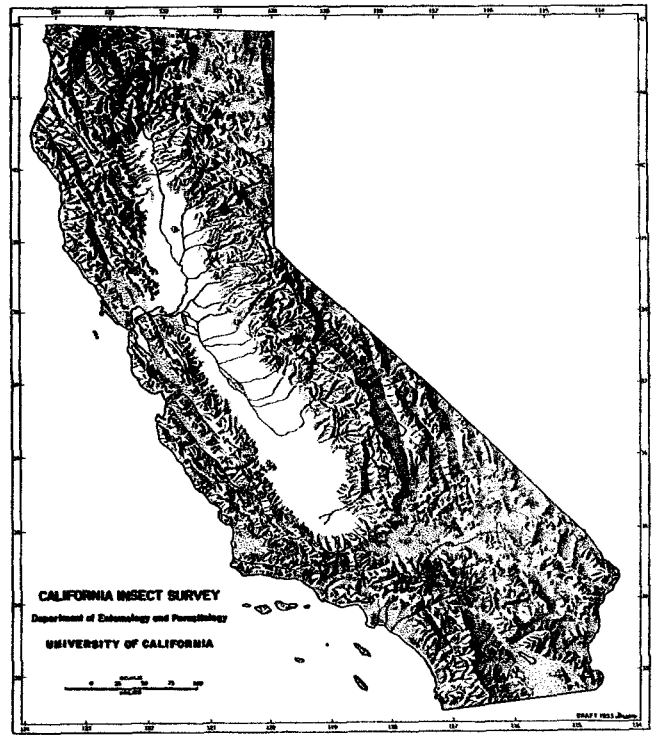
Ips integer (Eichhoff)
(Map 69)

Tomicus integer Eichhoff, 1868, Berl. Entomol. Z., 12:273. Type (sex?) Mexico (destroyed?).
Ips integer Swaine, 1909, N. Y. State Mus. Bull., 134:123.

Geographic distribution and host range. – "This species is known from the pine forests of Guatemala north through Mexico into the southern parts of Utah and Colorado. It is common in the arid ponderosa pine stands of southern interior British Columbia, western Idaho and Montana, and the Great Basin-facing slopes in eastern Washington, Oregon, and northern California" (Lanier, 1970*b*). It probably attacks several species of pine although ponderosa pine is preferred. The single record on *Abies* is believed to be erroneous.

California records (map 69).—ALPINE Co.: County record only (CAS). LASSEN Co.: Norval Flats, 5500′, on *Pinus ponderosa* (CAS); Poison Lake, on *P. ponderosa* (SLW). PLUMAS Co.: Cilo, on yellow pine (CAS). SIERRA Co.: Downieville, on *Abies concolor* (CAS). SISKIYOU Co.: Antelope Creek, on *Pinus ponderosa* (CAS). PLUMAS Co.: County record only (CAS). SISKIYOU Co. County record only (CAS).

Biology.—This species generally breeds in the large diameter portion of weakened or felled trees but occasionally attacks living, healthy trees. Often *I. pini* occurs in the smaller diameter portion of trees infested by *I. integer*.

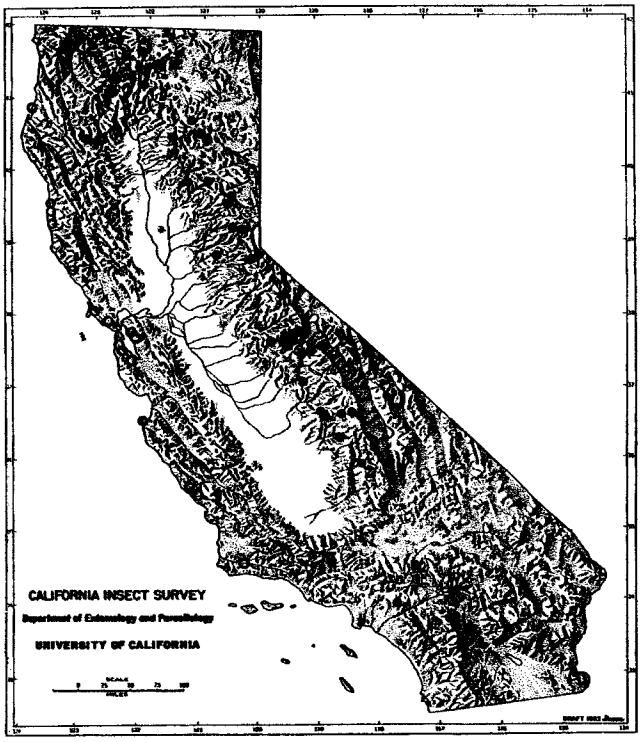


Map 69. California distribution of *Ips integer* (Eichhoff).

The male is joined in its attack by three or four females, each of which construct straight, longitudinal galleries from the central nuptial chamber. The egg niches are so plentiful and close together that gallery walls present a sawtoothed appearance, a distinctive feature of this species' work.

Discussion.—This species was considered to be conspecific with *I. plastographus* by various authors from Blandford (1898) to Hopping (1963). Hopkins (1905) was one of the few authorities to argue for the validity of *integer* until Lanier (1970*b*) established its status. Much of the confusion between these species can be attributed to the fact that several taxonomists consistently misidentified *plastographus plastographus* as *integer* and then compared these "*integer*" to *I. p. maritimus* from coastal California.

The adults of *I. integer* are distinguished from those of *I. plastographus* by their larger size, by the well-developed frontal carina, by the gallery systems, and by the host preference. Lanier (1970*b*) described differences in the pars stridens, male genitalia, and chromosomes.



Map 70. California distribution of *Ips plastographus plastographus* (LeConte), ● ; *Ips plastographus maritimus* Lanier, ○ .

Ips plastographus plastographus (LeConte)
(Map 70)

Tomicus plastographus LeConte, 1868, Trans. Am. Entomol. Soc., 2:163. Holotype ♂, California (MCZ).
Ips plastographus: Swaine, 1909, Bull. N. Y. State Mus., 134:125.
Ips plastographus plastographus: Lanier, 1970, Can. Entomol., 102:1415.

Geographic distribution and host range.—This subspecies follows the distribution of lodgepole pine, its sole host, in the high mountains from southern California (and possibly Baja California) to southern British Columbia and south in the Rocky Mountains to Yellowstone Natl. Park, Wyoming.

California records (map 70).—Numerous localities in the following counties: El Dorado, Fresno, Lassen, Madera, Mariposa, Mono, Nevada, Placer, Plumas, Riverside, San Bernardino, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology. (Johnson, 1954; Lanier, 1970*b*)

This subspecies breeds principally in the exposed side of the lower bole of prostrate lodgepole pine. From each nuptial chamber two or three egg galleries extend 10 to 30 cm along the grain. If there are three galleries, a narrow "tuning fork" pattern is formed. Egg niches may be closely situated but are not as contiguous as are those of *I. integer*. Larvae mine perpendicularly outward in the phloem and pupate. Teneral adults form irregular feeding galleries which score the sapwood. At one edge of the feeding galleries they frequently bore unique (for *Ips*) tunnels 6 to 12 mm into the xylem which apparently provide refuge from predators and lethal high and/or low temperatures.

In California, egg gallery construction commences in late May or early June and extends through August. Parent adults may construct two or three successive galleries in a different host individual. The first new adults appear in late July or August, but it is doubtful that they participate in late summer breeding. Teneral adults overwinter under the bark of the brood logs or fly to previously uninfested material to bore overwintering tunnels in the sapwood (Johnson, 1954). Lanier (1967*b*) found these insects overwintering both within and outside of their tunnels.

Ips pini and *Pityogenes knechteli* Swaine frequently occupy the sides of logs infested with *I. p. plastographus*. Rarely, this species may coexist and hybridize with the closely related *I. integer*. However, species specific sex pheromones help maintain segregation, and laboratory-produced hybrids are nearly always infertile (Lanier, 1970*b*).

Discussion. — Some of the literature on "*I. plastographus*" pertains to *I. integer* which has often been confused with this species and until recently has been considered a synonym. Lanier (1970*b*) separated *I. plastographus* into *I. p. plastographus* and *I. p. maritimus*, based upon the discreteness of their ranges, hosts, and habits and upon differences in morphology and karyology. In controlled breeding experiments, the two subspecies were interfertile but fertility of the F_1 was reduced.

The adults of *I. p. plastographus* are smaller than those of *I. integer* although dimensions of individual specimens overlap. There is no tubercle at the midpoint of the epistoma, and the carina between the epistoma and median frontal tubercle is slightly developed or absent, as opposed to *I. integer* in which the epistomal tubercle, median frontal tubercle, and connecting carina are usually well developed. Strial and declivital punctures are smaller and more lightly impressed than those of *I. integer*. Punctures or interstrial spaces 2 to 4 are located at regular intervals on the caudal third of the elytra rather than being absent or sporadically positioned as in *I. integer*. *I. p. plastographus* can be differentiated from *I. p. maritimus* by range and hosts. In addition, the frontal tubercle of the former is more prominent and the male genitalia, female pars stridens, and the chromosomes differ (Lanier, 1970*b*). The struts: lobe ratio of the *I. p. plastographus* genitalia is typically less than 1.25 while that of *I. p.*

maritimus usually exceeds 1.30.

Adults of *I. plastographus, sensu lato,* and *I. integer* differ from the adults of the other four-spined *Ips* by the strongly angulate sutures of the antennal club.

Ips plastographus maritimus Lanier
(Map 70)

Ips plastographus maritimus Lanier, 1970, Can. Entomol., 102: 1417.

Geographic distribution and host range.—"Although there is no apparent barrier to its distribution northward in *P. contorta* var. *contorta* or inland in *P. attenuata*, collection records for this subspecies are limited to those areas of coastal California where *P. radiata* and *P. muricata* grow. It probably occurs on related pines on the islands off the coast of southern California and Mexico" (Lanier, 1970*b*). Since *I. p. maritimus* attacks four species of pines within its range, it is probable that other species of pine will be attacked.

California records (map 70).—Various localities in the following counties: Alameda, Humboldt, Marin, Mendocino, Monterey, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, and Sonoma.

Biology. (Trimble, 1924)

I. p. maritimus often attacks trees in association with *Dendroctonus valens* LeConte. However, this subspecies is capable of initiating attack on, and killing of, mature trees. Frequently, it is found in prostrate material in conjunction with *I. mexicanus* (Hopkins) or *I. paraconfusus* Lanier.

The male attacks first and is joined by two or three females, typically three. The females excavate egg galleries, 12 to 35 cm long, usually one up and two down the bole. As with most *Ips* species the galleries are kept clear of frass.

The females deposit eggs in well-separated niches. The average is about 60 per female but up to 104 have been recorded. When two egg galleries are parallel, very few eggs are deposited on the inner margin. Larval mines are about 5 cm long.

A "swarming flight" which may be adults emerging to seek hibernation sites has been reported from September to November.

Chamberlin (1958) states that the complete life cycle requires 7 to 8 weeks and that there are only two generations per year in central California but Keen (1952) states that there are three to five generations per year. The former reference may be based upon observation of *I. p. plastographus* and the latter upon *I. p. maritimus.*

Discussion.—The adults of this subspecies are differentiated from those of *I. p. plastographus* by the host, by the range, and by the morphological characters as described in the preceding discussion.

Ips calligraphus calligraphus (Germar)
(Map 65)

Bostrichus calligraphus Germar, 1824, Ins. Spec. Nov., p. 461. Type (sex?), Kentucky (location unknown).
Ips calligraphus: Smith, 1910, Cat. Insects N.J., p. 363.
Ips calligraphus calligraphus: Lanier, 1972, Can. Entomol., 104: 374.
Bostrichus exesus Say, 1826, J. Acad. Nat. Sci. Phila., 5:255. Type material destroyed. (Syn. by Eichhoff, 1878.)
Bostrichus chloroticus DeJean, 1837, DeJean Cat., p. 232. Type material unknown. (Syn. by Eichhoff, 1878.)
Bostrichus conformis DeJean, 1837, DeJean Cat., p. 232. Type material unknown. (Syn. by Eichhoff, 1878.)
Tomicus praemorsus Eichhoff, 1867, Berl. Entomol. Z., 11:401. Type (sex?) America borealis (destroyed). (Syn. by Eichhoff, 1878.)
Tomicus interstitialis Eichhoff, 1868, Berl. Entomol. Z. 12:273. Type (sex?) Jamaica (destroyed?). (Syn. by Hopping, 1965*d*.) (Removed from synonymy by Lanier, 1972.)
Ips ponderosae Swaine, 1925, Can. Entomol., 57:197. Holotype ♂, Coconino Natl. Forest, Arizona (CNC). (Syn. by Hopping, 1965*d*.)
Ips calligraphus ponderosae: Lanier, 1972, Can. Entomol. 104: 374.

Geographic distribution and host range.—*I. c. calligraphus* is found at lower elevations of the ponderosa pine belt in the Sierra Nevada of California, and throughout most of the U.S. east of the Continental Divide; and in southeastern Canada and Mexico south to Honduras. It apparently has been introduced into the Philippine Islands and its occurrence in California may be a result of its introduction from the southeastern states (Lindquist, 1969). It breeds in various species of pine in the east and south but is largely restricted to ponderosa pine in the west.

California records (map 65).—CALAVERAS CO.: Avery, on *Pinus ponderosa* (CIS). EL DORADO CO.: Georgetown, on *P. ponderosa* (CIS); Greenwood, on *P. ponderosa* (CIS); Placerville, on *P. ponderosa* (CIS); Snowline Camp (CIS). NEVADA CO.: Grass Valley, on *P. ponderosa* (CIS). PLACER CO.: Gold Run, on *P. attenuata* (HSC).

Biology. (Wilkinson, 1963; Wood, D. L. and Stark, 1968)

Ips calligraphus breeds predominantly in logging debris and recently felled trees but also in the lower bole and tops of apparently healthy trees. In California it is often replaced by *I. paraconfusus* and *I. latidens* in smaller material (less than 15 cm diameter) but may be mixed with *I. paraconfusus* on the lower bole. It is commonly associated with the western pine beetle (*D. brevicomis*) and the California flat-headed borer (*Melanophila californica* LeConte).

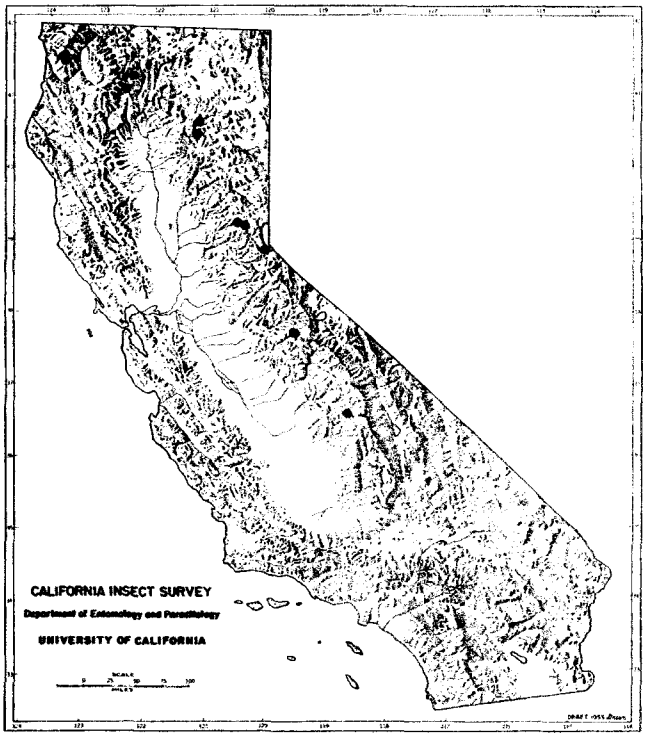
The gallery system is easily distinguished from those of all other species of *Ips* by its pattern, by the coarsely cut egg niches, and by the length. Four to six egg galleries radiate from a large central nuptial chamber excavated by the male. The male initiates gallery construction but usually the females arrive before the

nuptial chamber is completed. The brood galleries range in length from 25 to 38 cm and deeply score the sapwood, particularly in thin-barked trees.

Eggs are laid singly in coarse niches cut in both sides of the gallery wall, except in the wall adjacent to a parallel gallery. Females lay an average of 74 eggs. There are three larval stages as in other species of *Ips*.

The time required to complete development varies considerably within the range and in various exposures. In the areas where *I. calligraphus* was found in California, about 40 days were required for the summer brood to develop. There are four generations per year but extensive overlap of generations results in the almost continuous presence of attacking adults during the summer. Definite peak attack periods were observed in April, late May, late July, and early September. At lower elevations or in particularly mild years there is the possibility of a partial fifth generation. All stages except the egg overwinter.

Discussion.—This relatively rare species in California is not considered of economic importance. Adults are easily distinguished by the six spines on the lateral margins of the declivity.



Map 71. California distribution of *Ips montanus* (Eichhoff).

Ips montanus (Eichhoff)
(Map 71)

Tomicus montanus Eichhoff, 1881, Die Europaischen Borkenkäfer, p. 219. Syntypes (sex?) Cisco, California (destroyed?).
Ips montanus: Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):113.
Ips vancouveri Swaine, 1916, Can. Entomol., 48:188. Holotype ♂, Quathiaski Cove, Vancouver Is., British Columbia (CNC). (Syn. by Wood, 1957*a*.)

Geographic distribution and host range.—I. montanus occurs at higher elevations in the pine forests of western North America from the interior mountain ranges in British Columbia, south to the Sierra Nevada, and east to the Rocky Mountains. Its usual host is western white pine but it is also recorded from lodgepole and whitebark pine.

California records (map 71).—Del Norte Co.: 18 mi E. Klamath, on *Pinus monticola* (CIS); Red Mtn., on *P. monticola* (PSW). El Dorado Co.: Fallen Leaf Lake, on *P. contorta* (CAS). Lassen Co.: Badger Flat, on *P. contorta* (CAS); Grassy Lake, on *P. monticola* (CAS). Mariposa Co.: Yosemite, on *P. monticola* (PSW). Nevada Co.: Kingvale, on *P. monticola* (GNL). Placer Co.: Old Soda Springs, on *P. monticola* (GNL). Siskiyou Co.: Deadfall Lakes, Weed, on *P. monticola* (HSC). Trinity Co.: Trinity Center, on *P. monticola* (HSC). Tulare Co.: Avalanche Meadow, on *P. contorta* (CAS).

Biology.—Ips montanus is typically associated with *Dendroctonus ponderosae* but may attack slash and diseased or weakened trees in the absence of *Dendroctonus*. Usually there are two or three egg galleries associated with each nuptial chamber and a "tuning fork" pattern similar to that constructed by *I. paraconfusus* is formed.

There are probably two generations per year. Some adults overwinter in irregular feeding aggregations among the developing broods of *D. ponderosae* in the bases of large western white pines (*P. monticola*).

Discussion.—This is a common species of *Ips* in the western white pine regions of northern and central California. It is a five-spined *Ips*, and the adults closely resemble and are often confused with those of *I. paraconfusus* and *I. confusus*. The adult is distinguished by its larger size, by the smaller median fovea on the frons, by the longer and denser pubescence, and by the coarser sculpture of both sexes.

Ips confusus (LeConte)
(Map 65)

Tomicus confusus LeConte, 1876, Proc. Am. Philos. Soc., 15:364. Holotype ♀, southern California (MCZ).
Ips confusus: Swaine, 1909, Bull. N. Y. State Mus., 134:122.

Geographic distribution and host range.—This species occurs throughout the pinyon pine regions of Arizona, California, Colorado, Idaho, Nevada, New Mexico, Utah, and Baja California in Mexico (Lanier 1970*a*). Its sole host in California is the pinyon pine, *P. monophylla*, but it occurs in other nut pines in other parts of its range.

California records (map 65).—KERN Co.: Frazier Park, on *Pinus monophylla* (CIS). LOS ANGELES Co.: Gorman, on *P. monophylla* (CIS); Valyermo, on *P. monophylla* (GNL). MONO Co.: County record only, on *P. monophylla* (CAS); Coleville, on pinyon pine (CAS). RIVERSIDE Co.: Joshua Tree Natl. Mon., on *P. monophylla* (PSW); Pinyon Flat, 16 mi S.W. Palm Desert, on *P. monophylla* (CIS). SAN BERNARDINO Co.: Wrightwood, on *P. monophylla* (CIS). VENTURA Co.: Chuchupate Ranger Station, on *P. monophylla* (GNL); Mt. Pinos, on *P. monophylla* (PSW).

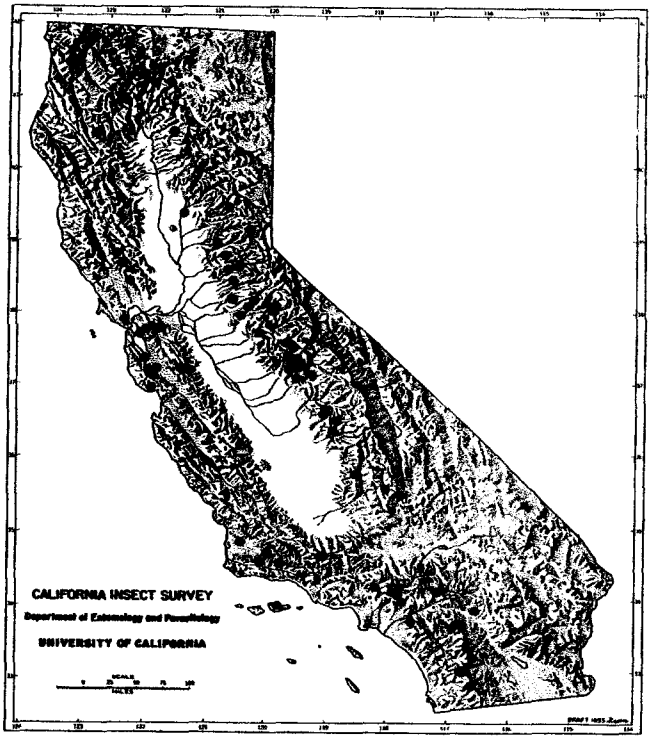
Biology.—This species normally exists endemically in pinyon pine stands, and breeds in diseased or decadent trees. If slash from clearing becomes available, *I. confusus* may increase sufficiently in number and vigor to infest and kill nearby healthy pinyon pines. The bole and branches over 5 cm in diameter may be attacked. This species shows unique tolerance (for *Ips*) to resin. Often pitch tubes up to 2 cm long are formed at the points of infestation. A successful attack is indicated by the presence of boring dust or by a red-brown pitch tube; a failure is indicated by a white or yellowish pitch tube.

Usually one to five females join the male and extend egg galleries from the central nuptial chamber. These parallel the grain, but they are generally shorter and more irregular than those of the closely related *I. paraconfusus*. Eggs are deposited singly in niches and larvae move perpendicularly away from the egg gallery.

Little is known of the life cycle of this insect but it is suspected that there may be as many as five generations per year, owing to the long hot summers which characterize its habitat. Many adults overwinter under the bark in dense feeding aggregations (Chansler, 1964), in uninfested portions of the brood material, or in previously unattacked trees.

Discussion.—*Ips paraconfusus* Lanier and *I. hoppingi* Lanier, were recently described from material previously considered to be *I. confusus* (Lanier, 1970*a*). Most of the literature referring to *I. confusus* actually pertains to *I. paraconfusus*. However, the majority of such articles have been sorted out by Lanier (1970*a*).

Adults of *I. confusus* differ from those of *I. montanus* by their smaller size, by their host preference, and by their habitat. In addition, the male *I. confusus* has a tubercle on the midpoint of the epistomal margin and the female has a median fovea slightly above the epistomal margin, whereas the male *I. montanus* has a tubercle slightly above the epistomal margin and the female has a small carina rather than a fovea. Host and habitat also provide reliable differentiation of *I. confusus* from its sibling species *I. paraconfusus* and *I. hoppingi* but externally morphological characters are of value to experts only. Lanier (1970*a*) diagnoses their differences as follows: "Females of this species differ from those of *I. hoppingi* and *I. paraconfusus* by having a narrower pars stridens with wider striations. In males of *I. confusus*, the median struts of the genitalia are shorter than the median lobe, whereas in *I. hoppingi* and *I. paraconfusus* they are equal to, or larger than, the median lobe. The declivities of both sexes are more densely punctate than those of *I. paraconfusus*."



Map 72. California distribution of *Ips paraconfusus* Lanier.

Ips paraconfusus Lanier
(Fig. 81; map 72)

Ips paraconfusus Lanier, 1970, Can. Entomol., 102(9):1146. Holotype ♀, Avery, California (CNC).

Geographic distribution and host range.—*I. paraconfusus* is distributed throughout California and Oregon, west of the crests of the Sierra Nevada and Cascade ranges. It probably attacks all species of pine within its range.

California records (map 72).—Numerous localities in the following counties: Alameda, Butte, Calaveras, Contra Costa, Del Norte, El Dorado, Fresno, Glenn, Kern, Lake, Los Angeles, Madera, Marin, Mariposa, Napa, Placer, Plumas, Riverside, San Bernardino, San Diego, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Sierra, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology. Cameron and Borden, 1967; Chansler, 1964; Gara, 1963; Silverstein et al., 1966; Struble and Hall,

1955; Wood, D. L., 1963; Wood, D. L. and Bushing, 1963; Wood, D. L. and Vité, 1961)

Ips paraconfusus attacks standing, apparently healthy, trees, from sapling to small sawlog size (less than 60 cm), the tops of larger trees of all ages, fresh slash, and trees infected with annosus root rot, *Fomes annosus*, and probably other root diseases. The attack on live standing trees is primarily by beetles emerging in spring and early summer from fresh slash cut in late winter, spring, and early summer. Green slash that escapes attack for three months after late fall felling may be attacked but brood development is poor.

In standing trees, initial attacks are made at the junction of branch and stem. Later attack may occur anywhere on the bole on smaller trees. In slash, the first attacks are in the top part of the main stem followed by indiscriminate entries in all shaded parts of the stem and on branches more than 8 cm in diameter.

The initial entry is made by the male, which bores into the phloem-cambial layer and constructs a roughly triangular nuptial chamber two or three times its own size. The "pioneer" beetles are able to distinguish between host (pine) and non-host (e.g., Douglas fir). Upon successful establishment, a powerful attractant is produced, present in the extruded frass, which causes a mass aggregation of both sexes. This attractant is produced within a few hours of attack and persists for several days, apparently until all males have been joined by their complement of females. The response of emerging beetles and beetles in flight to the attractant is immediate and effective up to 1,000 meters at least. However, there is great variation in response between sexes and within populations. Significant numbers do not respond to one source but may seek another.

The male is joined by two to five females, usually three, each of which bores an individual egg gallery with the grain. The resultant pattern resembles a tuning fork. The galleries are 10 to 15 cm long, lightly engraved in the sapwood, and are kept clean of frass. Once copulation has been completed or oviposition commences the secondary attraction to that gallery ceases. Attacks are often dense, from 400 to 1,000 cm of gallery per square meter.

From 50 to 60 percent of parent adults re-emerge to establish a second attack. This re-emergence occurs some 20 days after initial attack and apparently is related to overcrowding and deterioration of the host.

Eggs are laid in individual niches on both sides of the gallery, about 4 per cm. They hatch in 5 to 14 days in the summer and the larvae mine at right angles to the egg gallery, destroying the cambial layer. The average development period of larvae is 3 weeks (from 2 to 5). At maturity they construct a pupal cell. The pupae develop in 7 to 14 days at temperatures above 15°C.

Before emergence, adults tend to congregate under the bark and their activity frequently obliterates the gallery pattern. Several (one to four) may use the same emergence hole. Females emerge first but within a week the sex ratio is equal. The sex ratio of brood adults is approximately 1:1 whereas that of attacking adults is about 1:3 indicating a 50 to 60 percent loss of males. Emerging brood densities are often high, from 100 to 1,200 per square meter.

Mass attacks of adults for feeding alone are common in dense stands of saplings and small poles, in midsummer and fall particularly. Trees so attacked are usually abandoned within 2 to 3 weeks and no broods are produced. When such feeding attacks occur in late fall the adults may overwinter in the tree. From 1,200 to 2,000 adults per square meter may congregate on the main stem from the root crown to the tip. The greater densities are found near the base of the tree.

The number of generations per year varies from two in the north and in colder alpine areas to five per year in the south; the average is three or four. Seasonal variations in climate can result in one less or one more in any particular year. Because of different development times and re-emergence, attacks may occur throughout the season from mid-March to mid-December. However, the first generation from the overwintering brood typically attacks in mid-April, develops in about 60 days, and provides brood for the second generation in mid-June. This brood develops in about 50 days, emerging in late July and August. The third generation begins about July 25, develops in about 45 days, emerging in early September. The fourth generation begins in September and does not complete development until the following spring. The overwintering stages consist primarily of mature larvae, pupae, and callow adults.

Discussion.—Almost all of the literature referring to *Ips confusus* actually deals with this important and destructive species (Lanier, 1970*a*); see the preceding discussion under *I. confusus*.

I. paraconfusus is the most common and most destructive species of *Ips* in California. Severe sporadic outbreaks occur frequently and the increase in top-killed trees is believed to lead to subsequent outbreaks of the western pine beetle, *Dendroctonus brevicomis*. Although of short duration, outbreaks of *I. paraconfusus* may kill hundreds of trees and can cause severe economic loss.

I. paraconfusus is difficult to distinguish by external morphological features from its sibling species in California, *I. confusus*. Lanier (1970*a*) states "Females of

this species differ from *confusus* in having wider pars stridens with narrower striations. Males of *paraconfusus* have genitalia with median struts longer than the median lobe while struts are equal to or shorter than the lobe on the *confusus* genitalia." "The declivities of both sexes are more sparsely punctured than those of *hoppingi*."

Ips tridens (Mannerheim)

Bostrichus tridens Mannerheim, 1852, Bull. Soc. Imp. Nat. Moscou, p. 357. Type ♀, Sitka, Alaska (Univ. of Helsinki).
Ips tridens: Swaine, 1909, Bull. N. Y. State Mus., 134:126.
Bostrichus interruptus Mannerheim, 1852, Bull. Soc. Imp. Nat. Moscou, p. 357. Type ♂, Sitka, Alaska (Univ. of Helsinki). (Syn. by S. L. Wood, 1969*b*.)
Ips interruptus: Swaine, 1909, Bull. N. Y. State Mus., 134:119.
Ips engelmanni Swaine, 1917, Can. Dep. Agric., Entomol. Branch Bull., 14:30. Lectotype ♀, Rogers Pass, British Columbia (CNC). (Syn. by Lanier, 1973, in press.)
Ips yohoensis Swaine, 1917, Can. Dep. Agric., Entomol. Branch Bull., 14:31. Lectotype ♀, Yoho Valley, British Columbia (CNC). (Syn. by Lanier, 1973, in press.)
Ips dubius Swaine, 1918, Can. Dep. Agric., Entomol. Branch Bull., 14(2):119. Holotype ♂, Rogers Pass, British Columbia (CNC). (Syn. by Wood, 1957*a*, under *engelmanni*.)
Ips semirostris Hopping, 1963, Can. Entomol. 95:213. Holotype ♀, Kenai Pen., Alaska (CNC). (Syn. by Lanier, 1973, in press.)
Ips amiskiwiensis Hopping, 1963, Can. Entomol. 95:216. Holotype ♀, Amiskwi River, British Columbia (CNC). (Syn. by Lanier, 1973, in press.)

Geographic distribution and host range.—*I. tridens* is distributed throughout the western spruce forests from Alaska to northern California and east to the Rocky Mountains where it attacks Sitka, white, and Engelmann spruce.

California records.—DEL NORTE CO.: Crescent City, on *Picea sitchensis* (CIS). SISKIYOU CO.: 7 mi N. Callahan, on *P. engelmannii* (CIS).

Biology.—*Ips tridens* is not economically important as its attacks are limited to weakened or windthrown trees. Flight begins in May in coastal areas and mid-June in the mountains. Attacks by re-emerging parent adults continue through July. As in other species of *Ips*, males locate suitable host material, initiate the attack, construct a nuptial chamber, and release a powerful sex pheromone which attracts both males and females to the breeding site. One to 10 (typically four to six) females enter each nuptial chamber to construct egg galleries which approximately parallel the grain. Usually these appear in contiguous pairs, with only a thin septum of phloem between them (Hopping, 1965*c*). When host material is thin-barked or low in moisture, egg niches are cut about 1 mm apart adjacent to the xylem. However, in "good" host material egg niches are constructed contiguously in the top of the gallery in a zipper-like pattern. Larvae mine for about 3 mm entirely in the phloem, often crossing over an adjacent egg gallery. They then continue the mine against the xylem, and pupate about 5 cm from the egg gallery. Teneral adults feed in the brood material through the summer, often reducing the inner bark to a powder. If the host material becomes very dry, beetles will emerge to overwinter in the forest litter (mountain and coastal populations) or possibly to initiate new attacks (coastal only). Otherwise the beetles will overwinter *in situ*.

In the mountains two or three successive broods may be produced by the overwintering generation, but it is doubtful that new adults participate in attacks. On the coast there are probably two or more complete generations annually.

The sex-ratio in coastal populations is apparently 1:1, but in mountain populations there are typically three to five females per male. This anomaly results from the existence of bisexual brood-producing and female-producing (gynogenetic) individuals in the mountain populations (Hopping, 1962; Lanier and Oliver, 1966).

Discussion.—All of the species listed in synonymy are based entirely upon frontal characteristics which are polymorphic in females. Lanier (1973, in press) discusses this phenomenon in detail. Mountain populations are invariably polymorphic but females from the California coast are uniformly the "*interruptus*" form.

Adults of *Ips tridens* are distinguished by the convex to strongly protuberant female frons (which is often adorned by a thick setal brush), by the characters of the elytral declivity, and by the host.

Tribe Corthylini

Genus *Monarthrum* Kirsch

Monarthrum Kirsch, 1866, Berl. Entomol. Z., 10:213. Type-species: *Monarthrum chapuisi* Kirsch, monotypic.
Pterocyclon Eichhoff, 1868. Berl. Entomol. Z., 12:277. Type-species: *Pterocyclon laterale* Eichhoff (Hopkins, 1914). (Syn. by Wood, 1966.)

Five species of this genus are known from the United States, two of which occur in California.

KEY TO THE SPECIES OF MONARTHRUM IN CALIFORNIA

1. Body length 3.5 to 4.1 mm; epistomal process well developed, narrow and trifid in the female, broad in the male; elytral decivity flattened, pubescent in the female, deeply concave in the male..... *scutellare* (LeConte)
   Body length 1.9 to 2.4 mm; well-developed epistomal process lacking; elytral declivity of both sexes, vertical, margin swollen and bearing 2 small teeth, with a single tooth on the declivital face..... *dentiger* (LeConte)

Map 73. California distribution of *Monarthrum scutellare* (LeConte).

Monarthrum scutellare (LeConte)
(Figs. 27, 58; map 73)

Corthylus scutellare LeConte, 1860, Pac. R. R. Explor., 1:59. Type ♂ (?), California (MCZ).
Monarthrum scutellare LeConte, 1876, Proc. Am. Philos. Soc., 15:348.
Cryphalus cavus LeConte, 1868, Trans. Am. Entomol. Soc., 2: 153. Holotype ♀, California (MCZ). (Syn. by LeConte, 1876.)
Pterocyclon obliquecaudatum Schedl, 1935, Rev. Entomol., 5: 351. Types ♂ ♂, California (K. Schedl coll'n). (Syn. by Wood, 1966.)

Geographical distribution and host range.—Monarthrum scutellare is reportedly distributed throughout Oregon to southern California. However, because its principal hosts are the true oaks and tanbark oak, we believe it is probably distributed more widely in western North America. Single records have been obtained from sequoia and "*Abies.*" Until further records are obtainable, these are considered accidental or erroneous.

California records (map 73).—Numerous localities in the following counties: Alameda, El Dorado, Humboldt, Los Angeles, Marin, Mariposa, Mendocino, Monterey, Napa, Orange, Plumas, Riverside, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Siskiyou, and Tulare.

Biology. (Farris, 1965; Funk, 1965)
Monarthrum scutellare, like most ambrosia beetles, attacks dying, weakened, diseased, or recently dead trees or parts of trees. Attack is initiated by the male, which penetrates the sapwood to a depth of about 60 mm and excavates a nuptial chamber. The female joins the male there and introduces the symbiotic fungus, *Monilia brunnea*, which it transports in an enlargement of the forecoxal cavities (mycangia).

Following copulation, the female, assisted by the male, excavates two to four diverging galleries deep into the sapwood, each from 5 to 15 cm long (fig. 27). The female excavates egg niches in the sidewalls of the gallery which are later extended into "larval cradles" by the larvae. The fungus becomes established in the vicinity of the egg niches and serves as a food source. Gallery extension and oviposition extends over 2 to 4 months, larval development lasts 6 to 8 weeks, and pupation requires 2 to 3 weeks.

There are two generations per year in California, the main egg-laying periods are in March and October but there are usually adults present in the field throughout the year.

Discussion.—The damage done by ambrosia beetles consists of degrading of lumber and wood products by the "pin-holes" they cause, but primarily by the wood-staining caused by the fungus. Conversely, this has been turned to advantage by some manufacturers in producing modern "antiques."

M. scutellare is the more common species of the two found in California. The adult is easily recognized by the characters given in the key.

Monarthrum dentiger (LeConte)
(Fig. 83; map 74)

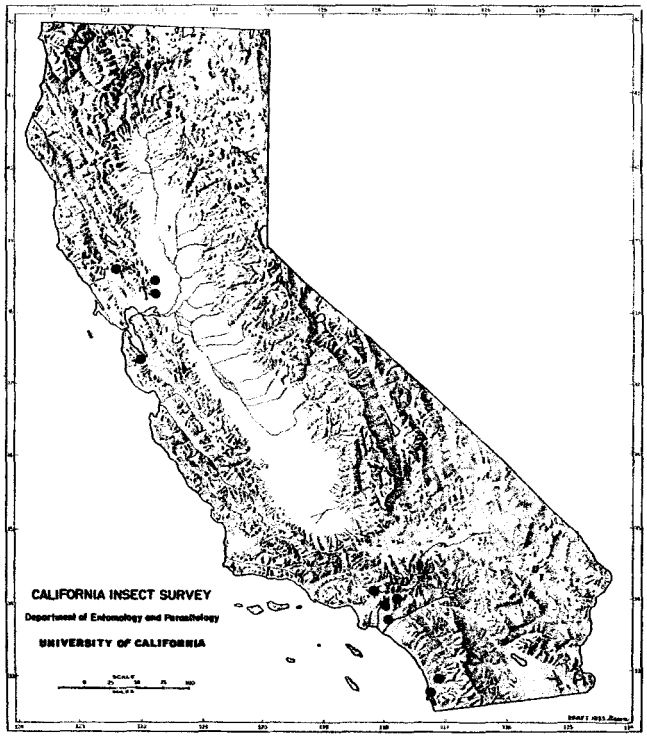
Cryphalus dentiger LeConte, 1868, Trans. Am. Entomol. Soc., 2:154. Holotype ♂ (?), California (MCZ).
Monarthrum dentiger: LeConte, 1876, Proc. Am. Philos. Soc., 15:349.

Geographical distribution and host range.—Monarthrum dentiger is restricted to California and Arizona but since its main hosts are the true oaks and it has been recorded from avocado and walnut we suspect that both the distribution and host range are more extensive.

California records (map 74).—Lake Co.: St. Helena, on black walnut (CAS). Los Angeles Co.: Pasadena (USNM); Pomona, on live oak (USNM); San Marino (UCR); N. Whittier Heights, on avocado (CDA). Orange Co.: Anaheim, on live oak (CDA). San Diego Co.: Poway (UCD); San Diego, house (CDA). Santa Clara Co.: Palo Alto, on *Quercus agrifolia* (USNM). Solano Co.: Vacaville (UCD). Yolo Co.: Winters (UCD).

Biology.—Unknown but probably similar to *M. scutellare.*

Discussion.—This is a much smaller species than *M. scutellare.* The declivital characters plus its small size will easily distinguish it.



Map 74. California distribution of *Monarthrum dentiger* (LeConte).

Tribe Pityophthorini

Genus *Dendroterus* Blandford

Dendroterus Blandford, 1904, Biol. Cent.-Amer., 4(6):233. Type-species: *Dendroterus mexicanus* Blandford (Hopkins, 1914).

Pleisophthorus Schedl, 1939, An. Esc. Nac. Cienc. Biol. Mex., 1: 343. Type-species: *Pleisophthorus perspectus* Schedl, monotypic. (Syn. by Wood, 1959.)

Dendroterus contains about 10 described species, principally distributed in Mexico, extending north into California and Texas. One species is found in California and it is quite rare in collections.

Dendroterus striatus (LeConte)
(Fig. 24)

Cryphalus striatus LeConte, 1868, Trans. Am. Entomol. Soc., 2:156. Type (sex?), Baja California (MCZ).

Dendroterus striatus: Wood, 1959, Great Basin Nat., 19(1):2.

Geographic distribution and host range.—The known distribution of *D. striatus* is southern California and Baja California, Mexico. Since the range of its host, the elephant tree (*Bursera microphylla*) also occurs from the western edge of the Colorado desert to Arizona we expect the distribution of this scolytid will be extended.

California records.—San Diego Co.: 5 mi S. Ocotillo, on *Bursera microphylla* (CIS); 7 mi S. of Ocotillo Wells, on *B. microphylla* (CIS).

Biology.—Only the gallery pattern (fig. 24) is known.

Discussion.—*Dendroterus striatus* was taken in association with *Cactopinus desertus*. The 3-segmented antennal funicle, the strongly punctured elytral striae, and the unarmed, slightly flattened declivity should distinguish the adults of this rare species. Adults are 1.7 to 2.2 mm in length.

Genus *Myeloborus* Blackman

Myeloborus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3–b) Tech. Publ., 25:16. Type-species: *Pityophthorus ramiperda* Swaine, original designation.

Myeloborus is closely related to *Conophthorus* Hopkins and *Pityophthorus* Eichhoff, and these genera are sometimes difficult to separate. The anterior margin of the pronotum is serrate in adults of *Myeloborus* and smooth in those of *Conophthorus*. Also, species of *Conophthorus* are most commonly found in cones (only occasionally in twigs) and those of *Myeloborus* are always found in twigs.

Distinguishing *Myeloborus* from *Pityophthorus* (particularly Group I) is considerably more difficult. The only character separating the two is the presence of chitin in the sutures of the antennal club of adults of *Pityophthorus* species (figs. 62–65) and the lack of chitin in the antennal club of adults of *Myeloborus* species (fig. 59). Even this character is not totally reliable since intergrades have been discovered. A thorough study of *Myeloborus* and *Pityophthorus* is needed before definite conclusions can be reached.

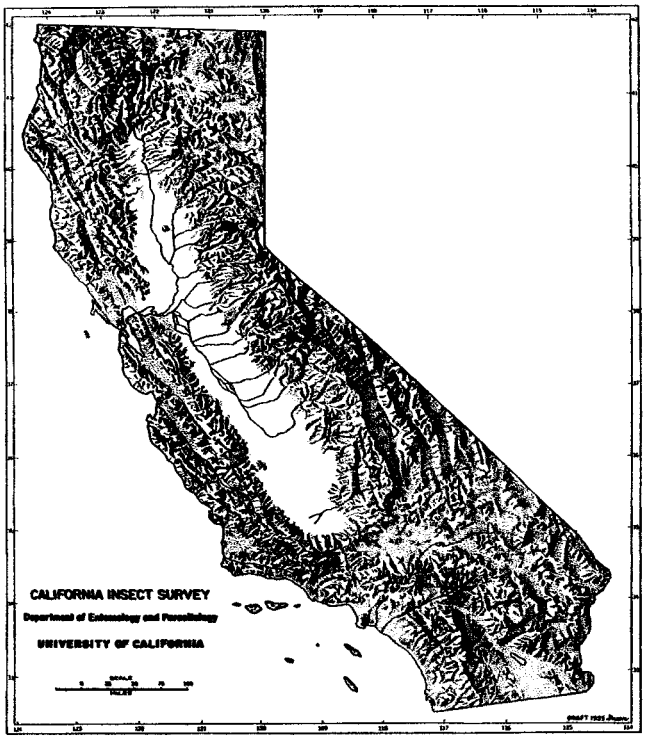
Myeloborus consists of eight species in the United States, two of which occur in California. Blackman (1928*b*) revised the genus. *Myeloborus confusus* Bright (1966), from California is a synonym of *Pityophthorus toralis* Wood.

KEY TO THE SPECIES OF MYELOBORUS IN CALIFORNIA

1. Frons without an indication of a carina in either sex; body length 2.0 to 2.2 mm; in *Pinus monophylla*, southern California ..... *keeni* Blackman
   Frons of the male with a definite carina extending from epistoma to above eyes; body length 2.5 to 3.0 mm; in other pines, northern and central California..... *boycei* (Swaine)

Myeloborus keeni Blackman

Myeloborus keeni Blackman, 1928, N. Y. State Coll. For. Bull. 1(3–b) Tech. Publ., 25:19. Holotype (sex?), Jacumba, California (USNM).



Map 75. California distribution of *Myeloborus boycei* (Swaine).

Geographic distribution and host range.—M. keeni is reported only from southern California in pinyon pine. However, it probably extends throughout the range of its host, at least further north in California, east to Arizona and south into Baja California.

California records.—San Bernardino Co.: Lake Baldwin, on *Pinus monophylla* (PSW). San Diego Co.: Jacumba, on *P. monophylla* (USNM).

Biology.—Unknown.

Discussion.—Myeloborus keeni is apparently very rare in southern California. Only one specimen other than the type series was examined during this study.

Myeloborus boycei (Swaine)
(Fig. 59; map 75)

Pityophthorus boycei Swaine, 1925, Can. Entomol., 57:192. Holotype ♂, Cisco, California (CNC).
Myeloborus boycei: Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Pub., 25:26.

Geographic distribution and host range.—M. boycei is known to occur throughout the Sierra Nevada in California and southeastern Oregon. However, since its hosts are lodgepole and ponderosa pine, we expect a wider distribution will be found.

California records (map 75).—El Dorado Co.: Meyers, on *Pinus murrayana* (CIS). Mariposa Co.: Bridal Veil Mdws., on *P. contorta* (PSW). Nevada Co.: 5 mi W. Donner Pass, ex *P. contorta* twig tips (CWOB); Kingvale, on *P. contorta* (CIS). Placer Co.: Cisco, on *P. contorta* var. *murrayana* (CAS). Tuolumne Co.: Tuolumne Mdws., on *P. contorta* (CIS).

Biology.—Unknown.

Discussion.—Myeloborus boycei is common in the central Sierra, although recorded from only a few localities. It is most easily distinguished by the distinct longitudinal carina on the frons of the male.

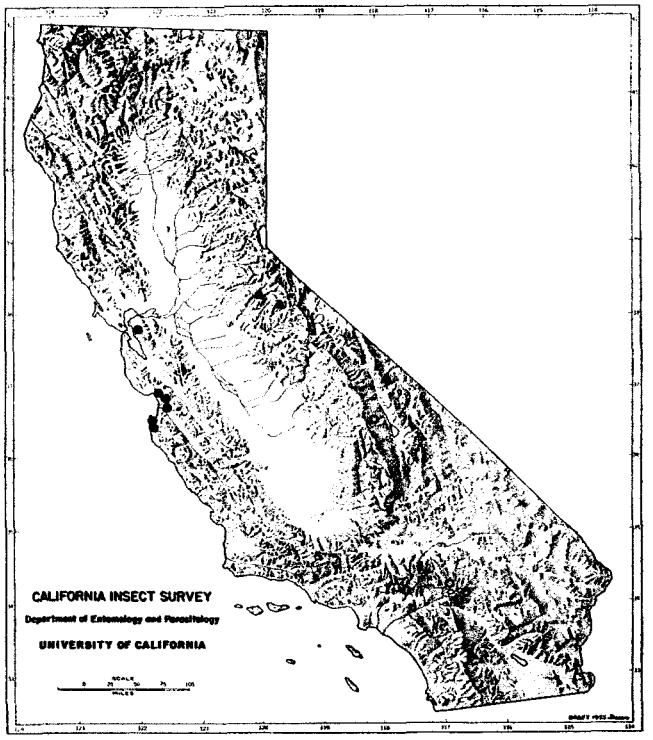
Genus *Conophthorus* Hopkins

Conophthorus Hopkins, 1915, J. Wash. Acad. Sci., 5:430. Type-species: *Pityophthorus coniperda* Schwarz, original designation.

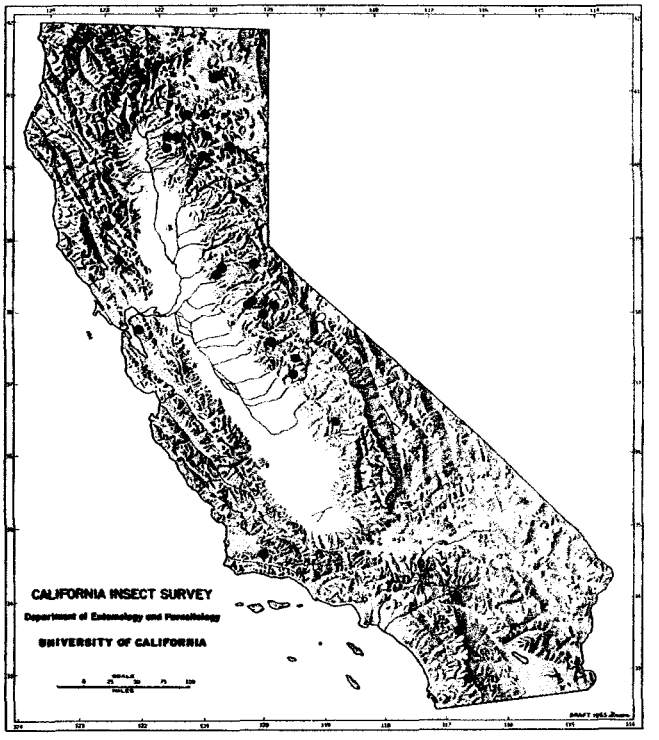
The members of this genus attack the cones of various species of *Pinus* in North America. Sixteen species have been described in the United States and Canada although probably no more than 10 actually exist; 7 occur in California. This genus needs to be revised utilizing biological as well as morphological data. Ruckes (1963) treated the species in California but recognized no synonyms or host races. His key, with modifications and the addition of *C. flexilis*, is used here.

KEY TO THE SPECIES OF CONOPHTHORUS IN CALIFORNIA
(After Ruckes, 1963)

1. Elytral declivity with striae 1, 2, and 3 punctured and parallel; declivity slightly impressed, interspace 1 feebly granulate, interspace 3 punctate with each puncture surrounded by a raised annulus..... *monophyllae* Hopkins
   Elytral decivity with stria 1 not punctured or feebly so, striae 2 and 3 punctured, with 2 converging on 3 at apex of declivity and forming the lateral margins of the declivity; declivity more strongly impressed, interspace 1 smooth, interspace 3 annulate-punctate. 2
2(1). Elytra with punctures of striae 1 and 2 and interspace 2 equal in size and nearly equal in density; declivity slightly impressed ..... *ponderosae* Hopkins
   Elytra with punctures of interspace 2 smaller and much less numerous than punctures of striae 1 and 2..... 3
3(2). Elytra with distinct and parallel rows of strial punctures on lateral area; declivity strongly impressed, punctures of stria 2 in declivity numerous and close together, granules of interspace 1 lacking or very faint ..... *lambertianae* Hopkins
   Elytra with strial punctures in obscure rows or confused on lateral area; declivity not strongly impressed 4
4(3). Declivity more strongly impressed; granules of interspace 1 lacking or very faint..... 5
   Declivity slightly or not at all impressed; granules of interspace 1 present and obvious 6
5(4). In cones of *Pinus flexilis*..... *flexilis* Hopkins
   In cones of *Pinus monticola*..... *monticolae* Hopkins



Map 76. California distribution of *Conophthorus monophyllae* Hopkins, ○ ; *Conophthorus contorta* Hopkins, ▲ ; *Conophthorus radiatae* Hopkins, ● .



Map 77. California distribution of *Conophthorus ponderosae* Hopkins.

6(4). Interspace 1 of declivity granulate at apex only..... *contortae* Hopkins

Interspace 1 of decivity obviously granulate for entire length ..... *radiatae* Hopkins

Conophthorus monophyllae Hopkins
(Map 76)

Conophthorus monophyllae Hopkins, 1915, J. Wash. Acad. Sci., 5:433. Holotype ♀, Ventura Co., California (USNM).

Geographic distribution and host tree.—*C. monophyllae* is distributed throughout the southwestern United States and into northern Mexico. Its host is pinyon pine.

California records (map 76).—Inyo Co.: Whitney Portal, on *P. monophylla* ex cones (CIS). San Bernardino Co.: Baldwin Lake, on *P. monophylla* ex cones (PSW); 10 mi N. Big Bear Lake, on *P. monophylla* ex cones (CWOB); Sugar Loaf Mtn., on pinyon pine (OSU); Wrightwood, on *P. monophylla* ex cones (CIS).

Biology. (Keen, 1958; Ruckes, 1963)

Very little is known about the biology of *Conophthorus monophyllae*. Adults and fresh attacks have been found in the early spring and in late fall leading to the conclusion that there are two overlapping generations per year. Both larvae and adults have been found overwintering in cones.

Discussion.—Adults of this species are about 3.0 to 3.5 mm long. They may be distinguished from those of other California species of *Conophthorus* by stria 2 passing through the declivity and not forming the lateral margin of the declivity as it does in the adults of the other species.

Conophthorus ponderosae Hopkins
(Map 77)

Conophthorus ponderosae Hopkins, 1915, J. Wash. Acad. Sci., 5:431. Holotype ♀, Ashland, Oregon (USNM).

Geographic distribution and host range.—*C. ponderosae* is distributed throughout California and Oregon within the range of its principal host, ponderosa pine. Adults occasionally attack Jeffrey pine. We expect that this species will be found farther north and east.

California records (map 77).—Numerous localities in the following counties: Alameda, Calaveras, El Dorado, Lake, Lassen, Madera, Mariposa, Modoc, Plumas, Riverside, San Bernardino, San Diego, Santa Barbara, Shasta, Siskiyou, Tehama, Tulare, and Tuolumne.

Biology. (Keen, 1958; Ruckes, 1963)

The adults of *C. ponderosae* commonly attack cones of ponderosa pine in their second year of growth when

the cones are 2 to 4 cm long. They rarely attack first-year cones, but such attacks do not produce brood. Entrance is made through the scales near the base of the cone. Pitch tubes and frass at the opening are visible symptoms of attack. The adults tunnel in a spiral around the axis of the cone which causes cone death; they then excavate the egg gallery through the central axis of the cone, usually adjacent to the pith. Unlike attacked sugar pine cones, cones of ponderosa pine remain on the tree after attack. Eggs are laid on each side of the gallery and the larvae feed on the seeds and bases of the scales.

There is some confusion over the number of generations per year. Keen (1958) states that the first attack occurs in May, the brood matures by mid-July and a second generation begins soon after. The adults of this generation overwinter. Ruckes (1963) states that attacks begin in May and extend through June. After oviposition the females leave the cone, plugging the holes with frass when they emerge. Their subsequent behavior is unknown. The brood matures by late July but the brood adults remain in the cone throughout the remainder of the season and overwinter there. According to Ruckes there is only one generation per year and occasionally a portion of the population remains in the cones for 2 years. Possibly both authors are correct.

Discussion. – Adults of *Conophthorus ponderosae* measure 3.5 to 4.2 mm in length. They are characterized by the similarity in size of the punctures in striae 1 and 2 and those of interspace 2.

Conophthorus lambertianae Hopkins
(Fig. 60; map 78)

Conophthorus lambertianae Hopkins, 1915, J. Wash. Acad. Sci., 5:433. Holotype ♀, Hilt, California (USNM).

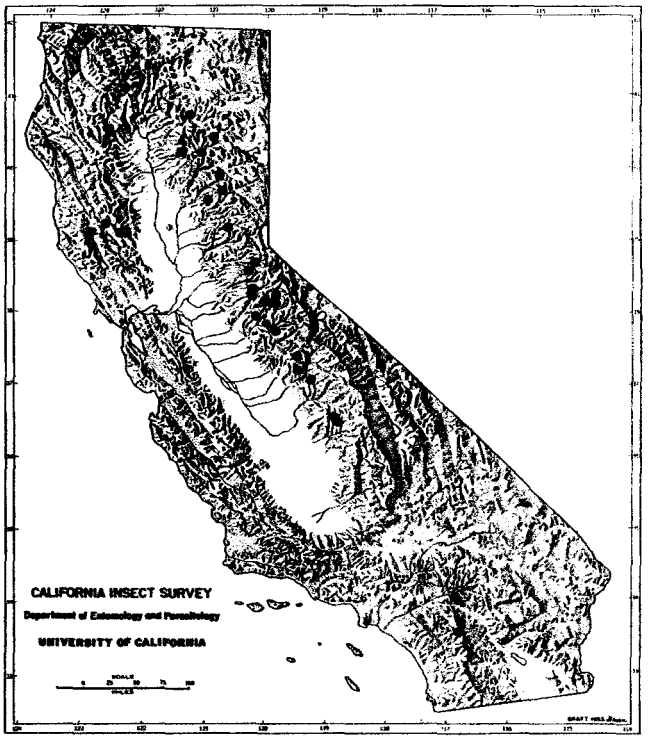
Geographic distribution and host range.—The distribution of *Conophthorus lambertianae* corresponds to that of its host, sugar pine; that is, from southern California to Oregon.

California records (map 78).—Numerous localities in the following counties: Calaveras, El Dorado, Fresno, Lake, Lassen, Madera, Mendocino, Placer, Plumas, Riverside, San Bernardino, Shasta, Siskiyou, Tehama, Trinity, Tulare, and Tuolumne.

Biology. (Bedard, 1966, 1968*a*, *b*; *Keen*, 1958; Ruckes, 1957; Struble, 1947)

The sugar pine cone beetle attacks maturing cones in the second year of development when the cones are from 5 to 40 cm long. Attacks begin in late May, and peak attack is in June, decreasing in intensity until late July when it ceases.

The female attacks the stem and severs the woody water-conducting tissue, causing cone abortion. A



Map 78. California distribution of *Conophthorus lambertianae* Hopkins.

characteristic pitch tube forms at the entrance hole. The female mines down the pendent cone on one side of the central axis. One or more males and even other females may join the first female. Mating takes place in the cone.

Eggs are laid in niches cut into seeds adjacent to the parent gallery, usually one per seed. In small cones the females may not lay eggs. Approximately one-third of attacked cones do not contain broods. The larvae feed within the dying cone and pupate in late June and July. Brood adults appear in July and August and feed for about a month before emerging. The infested cones fall from the tree about this time. There is high mortality of broods in cones which fall in exposed locations, apparently due to lethal temperatures.

Emerging brood adults overwinter in twig tips of sugar pine. They enter at the base of the vegetative bud and mine the current year's growth, remaining at the end of the burrow facing away from the distal or bud end of the tip. Each adult may mine more than one tip before remaining for the winter. Widespread "flagging" of tips in the fall is indicative of large populations.

There is only one generation per year but several overlapping broods. The parent adults emerge after oviposition from the first cone attacked (usually within 10 days) and establish a second brood and possibly even a third.

Discussion.—Conophthorus lambertianae frequently kills 90 percent or more of the sugar pine cone crop thus creating critical problems in regeneration and a shortage of stored seed for nursery and plantation purposes. Twig killing is seldom severe enough to be of concern.

The sugar pine cone beetle is 3.0 to 4.5 mm long and may be most easily recognized by the well-defined parallel rows of strial punctures on the lateral areas of the elytra.

Conophthorus flexilis Hopkins

Conophthorus flexilis Hopkins, 1915, J. Wash. Acad. Sci., 5:433. Holotype ♀, Mount Manitou, Colorado (USNM).

Geographic distribution and host range.—Conophthorus flexilis is found in subalpine locations in the Rocky Mountains and probably occurs in western California wherever its host, limber pine, grows.

California records.—Mono Co.: Crooked Creek, White Mtns., 10,150′, on cones of *Pinus flexilis* (CIS).

Biology. (Keen, 1958)

Parent adults attack small second-year cones in May or June and extend the egg gallery into the axis of the cone, killing the cone before it matures. Re-emergence and attack of additional cones is common.

Larvae develop during July and August, pupate in August, and brood adults appear in late August and September. The adults overwinter in the cones on the tree, feed on dead scales and seeds when conditions permit, and emerge the following spring. There is one generation per year with slightly overlapping broods.

Discussion.—Conophthorus flexilis was only recently recorded from California (Bright, 1964). The characters presented in the key should distinguish the adults.

Conophthorus monticolae Hopkins

Conophthorus monticolae Hopkins, 1915, J. Wash. Acad. Sci., 5:432. Holotype ♀, Priest River, Boundary Co., Idaho (USNM).

Geographic distribution and host range.—Conophthorus monticolae is distributed throughout the Pacific Northwest and south to California wherever its host tree, western white pine, is found.

California record.—Shasta Co.: Lassen Natl. Park, ex cones *Pinus monticola* (CIS).

Biology. (Williamson et al., 1966)

The biology of this insect in California is not known. The description given is based on studies in northern Idaho.

The attack period of *C. monticolae* commences in mid-May, reaches a peak in June, and may continue into July. First attack usually coincides with the time when cones are from 3.5 to 6.5 cm long and turn from the erect to the pendent position. Late emerging adults may attack cones 10 to 15 cms long.

The females initiate the attack, normally through the scales at the base of the cone rather than the stem. A distinctive pitch tube forms at the point of entry. The female tunnels to the center of the cone, turns and bores distally along the axis. The insects are monogamous but occasionally more than one pair will inhabit the same cone and attacks by lone females occur rarely. Such females lay viable eggs indicating that mating occurs outside the cone. Egg galleries may or may not extend the length of the cone.

Eggs are laid singly in niches about 60 mm apart from late May to early July. An average of 7 eggs per female, with a maximum of 8 per 3 cm of gallery are laid; after oviposition, the female may leave the cone and presumably attack another cone. Eggs hatch in 5 to 10 days and the larvae feed indiscriminately on seeds and cone tissues. Cones begin to wither and die during larval feeding but remain on the tree. The larval period lasts about 4 weeks; larvae are found from late May to mid-July. Pupation occurs from June through August, individual pupation requiring about 1 week. Callow adults are present from July through August, mature adults from mid-July, through the winter and up to May of the following year.

Aborted cones fall from the tree about the time pupation ceases. The brood adults remain in the cones on the ground for at least one winter and a portion of the population may overwinter a second year. Emergence in the spring coincides with strobili elongation.

There is but one fairly well synchronized generation per year in the northern part of the insect's range. It is expected that in California overlapping broods would occur.

Discussion.—Seed losses due to *Conophthorus monticolae* may be high in localized areas but, generally do not, by themselves, pose a great problem. However, when associated with other cone and seed insects, losses inflicted in seed collection areas could be significant.

This species closely resembles *C. lambertianae* and they may be the same species. Adults of *C. monticolae* are slightly smaller, 3.2 to 3.8 mm, the declivity is strongly impressed, and the punctures of stria 2 in the declivity are numerous and close.

Conophthorus contortae Hopkins
(Map 76)

Conophthorus contortae Hopkins, 1915, J. Wash. Acad. Sci., 5:432. Holotype ♀, Newport, Lincoln Co., Oregon (USNM).

Geographic distribution and host range.—*Conophthorus contortae* is reportedly distributed only in coastal Oregon and the Sierra Nevada of California. However, the relatively contiguous, extensive range of its host, lodgepole pine, would suggest a distribution throughout western North America.

California records (map 76).—CALAVERAS Co.: Big Meadows, Stanislaus Natl. For., ex cones *Pinus contorta* (CIS). INYO Co.: Westgard Pass (UCD). TUOLUMNE Co.: 17 mi E. Strawberry, ex cones *P. contorta* (CIS).

Biology. (Keen, 1958; Ruckes, 1963)

The seasonal history and biology of *C. contortae* are practically unknown. In the Sierra, flight and attack of second-year cones occur in late June and July. Both pupae and adults have been observed in overwintering cones.

Discussion.—Adults of this species are from 2.9 to 3.5 mm long and have from one to three granules at the apex of the elytra.

Conophthorus radiatae Hopkins
(Map 76)

Conophthorus radiatae Hopkins, 1915, J. Wash. Acad. Sci., 5:432. Holotype ♀, Pacific Grove, Monterey Co., California (USNM).

Geographic distribution and host range.—*Conophthorus radiatae* is distributed throughout the coastal ranges of California south of San Francisco. The extensive planting of its host, Monterey pine, will extend this distribution to the north and inland.

California records (map 76).—ALAMEDA Co.: Strawberry Canyon, Berkeley Hills, on *Pinus radiata* ex cones (CWOB). MONTEREY Co.: Aromas, on *P. radiata* ex cones (CIS); Asilomar (SJSC); Pt. Lobos State Park, on *P. radiata* ex cones (CIS); Pacific Grove, on *P. radiata* ex cones (CIS); Prunedale, on *P. radiata* ex cones (CIS). SANTA CRUZ Co.: Aptos, on *P. radiata* ex cones (CIS); Correlitas, on *P. radiata* ex cones (CIS); Watsonville, on *P. radiata* ex cones (CIS).

Biology. (Schaefer, 1962, 1963, 1964)

Overwintering adults of *Conophthorus radiatae* emerge in late February and March and attack 2-year-old cones of Monterey pines. First-year cones or mature cones are rarely attacked and are unsuitable for development. Time of emergence depends largely on high humidities coupled with warm to high temperatures. The cones selected for attack are generally 3.75 cm long and 2.5 cm in diameter.

The female, alone, with a male, or with others of both sexes, initiates attack on the underside of the cone near the pedicel. The pitch tube, characteristic of *Conophthorus* attack, does not form for a week or more and is inconspicuous. The female bores toward the center for about 1.5 cm then turns and mines around the central axis to form a spiral gallery similar to that formed by *C. ponderosae*. This portion of the gallery is kept free of frass. After the spiral is complete the female turns and mines distally, parallel to the central axis. The gallery is bored to the end of the cone, then is continued proximally on the other side of the cone. Frass is not eliminated in this section of the gallery. Cones begin to turn brown on the underside and distal half while the base remains green. Eventually the whole cone turns brown and shrinks to about two-thirds of normal size. Currently attacked cones have a reddish-brown hue, older ones are grayish-brown.

Eggs are laid in individual niches along the walls of the gallery and covered with a frass plug but are also laid indiscriminately in the gallery. From 1 to 30 eggs are deposited. After oviposition, the female may feed for a short while and then re-emerge for a second attack. Only those which emerged early in the season participate in this second attack; they also attack the first-year conelets. Those females which stay in the first cone feed on the cone tissues and bore small holes to the exterior similar to the "ventilation holes" made by other scolytids.

Most eggs are laid in March and April and require 25 days for development. The young larvae feed on seed embryos and surrounding cone scale tissue. Developmental time for the two larval stages is 45 to 60 days. The mature larva hollows out a pupal cell; pupation lasts 15 to 20 days.

Most callow adults remain in the cone throughout the remainder of the summer and winter. A small number emerge in the fall and winter and attack first-year conelets or mature cones and overwinter. There is thus only one successful generation per year.

Discussion.—Damage by *Conophthorus radiatae* is variable, up to 90 percent of cones may be destroyed in localized areas. Survival is greatly reduced in areas east of the coastal fog belt due to low humidity, warm to high temperatures, and low precipitation.

Adults of this species range in length from 3.1 to 4.1 mm. They resemble those of *C. contortae* but may be distinguished by the more prominently granulate first declivital interspace.

Genus *Pseudopityophthorus* Swaine

Pseudopityophthorus Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):93. Type-species: *Pityophthorus minutissimus* Zimmerman, original designation.

Members of this genus are primarily found in various species of oak. *Pseudopityophthorus pubipennis*, the most common species in California, also breeds in *Lithocarpus*. In the eastern United States almost all hardwoods may serve as hosts. The genus was revised by Blackman (1931*a*). Eleven species occur in North

America, north of Mexico; of these, three are found in California.

KEY TO THE SPECIES OF PSEUDOPITYOPHTHORUS IN CALIFORNIA

1. First and second suture of antennal club strongly arcuate; body stout, less than 2.8 times as long as wide; declivity somewhat flattened, slightly impressed on each side of suture 2
   First suture of antennal club nearly straight, second more strongly arched; body slender, 3.0 times as long as wide; declivity not flattened or impressed in sutural area ..... *agrifoliae* Blackman
2(1). Smaller, body length 1.7 mm; elytra moderately rounded behind; pubescence very short and fine ..... *pulvereus* Blackman
   Larger, body length 2.0 mm or more; elytra broadly rounded behind with longer and coarser pubescence; first, third, and alternate declivital interspaces with long conspicuous setae (fig. 82). . *pubipennis* (LeConte)

Pseudopityophthorus agrifoliae Blackman

Pseudopityophthorus agrifoliae Blackman, 1931, J. Wash. Acad. Sci., 21:230. Holotype ♀, San Francisco, California (USNM).

Geographic distribution and host range.—*P. agrifoliae* has been collected only in central and southern California. However, since it attacks several species of oak, we suspect the true distribution is more extensive.

California records.—Los Angeles Co.: Big Pines Park, on *Quercus kelloggi* (CIS). Marin Co.: Mill Valley, on *Q. chrysophylla* and on *Q. wislizeni* (DEB).

Biology.—Like other *Pseudopityophthorus* species, *P. agrifoliae* attacks only severely weakened, dying, or dead trees. It is frequently found in great numbers in oak firewood.

The adult gallery is two-branched from the central entrance hole, short, and at right angles to the grain. Eggs are laid on each side of the parent gallery and the short (1 to 2 cms) larval galleries run with the grain. Larvae pupate entirely in the bark. Attacks are often so dense that the inner bark is completely destroyed and the multitude of emergence holes are referred to as "buckshot holes." There are two or more generations per year with overlapping broods.

Discussion.—This is a small species with the adults measuring about 1.9 mm in length. The convex declivity, the small size, and the very short pubescence will distinguish the adults from those of other California species.

Pseudopityophthorus pulvereus Blackman

Pseudopityophthorus pulvereus Blackman, 1931, J. Wash. Acad. Sci., 21:232. Holotype ♀, Chiricahua Reserve, Arizona (USNM).

Geographic distribution and host range.—*P. pulvereus* is reportedly distributed throughout Arizona and in southern California. However, since the adults attack various species of oak, this scolytid is probably more widely distributed than indicated.

California record.—Los Angeles Co.: Brown's Flat, San Gabriel Mtns. (LBSC).

Biology.—Unknown.

Discussion.—This species has not previously been reported from California. Only a very few specimens from southern California have been seen and they are provisionally referred to this species.

This is also a small species; adults are about 1.7 mm long, with the second interspace impressed on the declivity.

Pseudopityophthorus pubipennis (LeConte)

(Figs. 25, 61, 82; map 79)

Tomicus pubipennis LeConte, 1860, Pac. R. R. Explor., 9:59. Syntypes ♂ ♂ and ♀ ♀, California (MCZ).
Pseudopityophthorus pubipennis: Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):93.

Geographic distribution and host range.—The distribution of *P. pubipennis* appears to be from southern British Columbia to southern California, confined to coastal states. Its hosts are various species of true oaks (*Quercus*) and tan-bark oak (*Lithocarpus*). However, because it does occur inland in Sierra Nevada foothills, it is likely that this species will occur in inland western states. The records from chestnut and shrub possibly indicate a wider host range as well.

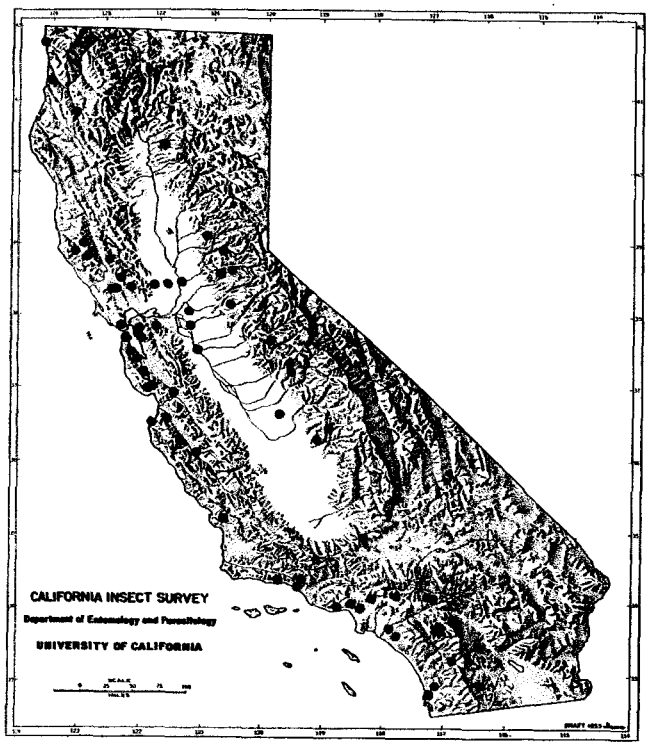
California records (map 79). — Numerous localities in the following counties: Alameda, Calaveras, Contra Costa, Del Norte, El Dorado, Fresno, Humboldt, Kern, Lake, Los Angeles, Madera, Mariposa, Marin, Mendocino, Monterey, Napa, Nevada, Orange, Placer, Riverside, Sacramento, San Bernardino, San Diego, San Francisco, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Siskiyou, Solano, Sonoma, Stanislaus, Trinity, Tulare, Ventura, Yolo, and Yuba.

Biology. (Chamberlin 1958)

Although *P. pubipennis* is one of the most common bark beetles in California, its biology is not well known.

This species attacks only severely injured, dead or dying trees. It often attacks oak cordwood in great numbers.

The adult gallery is two-branched, about 5 cm in total length and is transversely oriented (fig. 25). The gallery is confined to the inner bark and does not score the wood. Egg niches are in the soft portions of the bark. The maximum number of eggs is 88, with a minimum of 10, and an average of 41. Larval mines are found in the inner bark and run with the grain. These mines are about 2.5 cm in length at the maximum. Pupal cells are entirely in the inner bark. There are probably several generations per year in central California.



Map 79. California distribution of *Pseudopityophthorus pubipennis* (LeConte).

Discussion.—This species is frequently encountered in homes where oak firewood is stored. Their prescence may cause considerable concern to the homeowner who fears they may damage the woodwork in the home. Since these beetles attack only where bark is present, such worries are unfounded.

The adults of this species measure 2.1 to 2.3 mm long. They are easily distinguished by the longer setae on the first and third declivital interspaces and by the other characters mentioned in the key.

Genus *Pityophthorus* Eichhoff

Pityophthorus Eichhoff, 1864, Berl. Entomol. Z., 8:39. Type-species: *Bostrichus lichtensteinii* Ratzeburg (Hopkins 1914).

This is the largest genus of Scolytidae in North America. Approximately 120 species have been described in North America, north of Mexico. Thirty-two species are included herein from California.

This genus is closely related to *Myeloborus* Blackman and *Conophthorus* Hopkins. No reliable character exists that will separate *Myeloborus* from *Pityophthorus* but generally the presence of chitinized septa in the antennal clubs should distinguish *Pityophthorus* species (figs. 62–64). The serrate anterior margin of the pronotum and the slender body should distinguish *Pityophthorus* species from *Conophthorus* species.

All species of the genus usually mine under the bark of twigs or branches. In California, all species except one attack coniferous hosts. The exception, *P. juglandis*, attacks walnut in southern California. Because they bore in twigs only, the economic damage is very minor. There are instances, however, of certain species (*P. confertus* and *P. confinus*) attacking and killing the tops of healthy trees. The majority are found in broken, dying, or injured branches and tops.

The taxonomy of this genus is badly in need of revision. From the limited study of the California species, it was found that the "groups" designated by Blackman (1928*b*) need re-evaluation and reconstruction. Several new species were discovered during this study and doubtless more will be found in the future. Realizing these shortcomings, care must be exercised in using the keys. A knowledge of host and distribution coupled with the morphological characters should provide the proper identification for most species.

KEY TO THE GROUPS OF PITYOPHTHORUS IN CALIFORNIA
(After Blackman, 1928*b*)

1. Antennal club of females with first segment notably narrower than any others, widest through third segment, segments 1 and 2 together notably shorter than 3 and 4 together (fig. 62); antennal club of males narrow oval, with segments 1, 2 and 3 subequal in width; ninth interspace sometimes elevated... Group I

   Antennal club of both sexes with first segment as wide as, or slightly narrower, than others, usually widest through second segment, segments 1 and 2 equal to or longer than 3 and 4 together (figs. 63, 64); ninth elytral interspace not elevated..... 2

2(1). Second interspace of declivity not widened or sulcate; suture and third interspace not evidently raised or granulate 3

   Second interspace of declivity definitely sulcate and widened; suture and third interspace raised and usually armed with granules..... 4

3(2). Punctures of striae 1 and 2 distinct and impressed in regular rows on declivity.....Group II

   Punctures of striae 1 and 2 indistinct and hardly visible, if at all, on declivity.....Group III

4(2). Elytra rounded behind, not acuminate; frons variously modified 5

   Elytral apex acuminate; frons of male with a transverse carina, that of female with long, incurved, hairlike setae .....Group VII

5(4). Frons longitudinally carinate in both sexes, carina stronger in male; female frons with inconspicuous setae; declivity not deeply sulcate.....Group IV

   Frons of male only with either longitudinal or transverse carina or both; female frons ornamented with long setae; declivity usually rather deeply sulcate... 6

6. Frons of male longitudinally carinate; strial punctures sometimes confused, but usually with striae nearly regular; interspaces usually with numerous punctures.. Group V

Frons of male transversely carinate, usually with evident longitudinal carina; strial punctures usually rather small and in definite rows, those of interspaces only moderately numerous..... Group VI

KEYS TO THE SPECIES OF PITYOPHTHORUS IN CALIFORNIA

Group I

1. Frons of female distinctly and rather strongly concave; male frons with a very low longitudinal carina..... *scalptor* Blackman

Frons of female broadly flattened, only slightly concave if at all; male frons with a distinctly elevated, toothlike carina or carina weak, evident only on epistoma. 2

2. Anterior margin of pronotum with numerous asperities; carina on male frons weak, evident (tuberculate) only on epistomal margin; body length 2.1 to 2.8 mm; in high altitude pine in Sierra Nevada..... *toralis* Wood

Anterior margin of pronotum with two prominent asperities; carina on male frons distinctly elevated, toothlike; body length 1.5 to 1.8 mm; in low to middle altitude pines in southern California..... *brucki* Bright

Group II

See key to Groups..... *juglandis* Blackman

Group III

1. Frons of both sexes flattened, shining, usually densely punctured and sparsely pubescent; longitudinal carina not evident 2

Frons of male with longitudinal carina (sometimes faint); female frons with abundant setae..... 3

2(1). Anterior margin of pronotum with 2 asperities; elytral suture impressed on declivity below lateral margins... *praealtus* Bright

Anterior margin with 8 or more asperities; elytral suture not impressed on declivity... *punctifrons* Bright

3(1). Anterior margin of pronotum with 4 or more distinct asperities, these relatively equal in size..... 4

Anterior margin of pronotum with 2 to 4 distinct asperities; if 4 then the median pair much longer.. 5

4(3). Carina on male frons strongly elevated, toothlike..... *absonus* Blackman

Carina on male frons faint, only very slightly elevated... *abietis* Blackman

5(3). Female frons flat, not impressed above epistoma; carina on male frons more strongly elevated; on pinyon and limber pines..... *monophyllae* Blackman

Female frons transversely impressed just above epistoma; carina on male frons very faint; on ponderosa pine ..... *dolus* Wood

Group IV

1. Anterior margin of pronotum with 7 to 10 large, nearly equally developed serrations, equal to or longer than the pronotal setae; declivital sulcus very wide, shallow; third interspaces not elevated.. *digestus* (LeConte)

Serrations on anterior margin of pronotum finer, usually shorter than pronotal setae; declivital sulcus moderately shallow, not very wide; third interspace slightly elevated 2

2. Frontal carina of female a faint line, that of male only slightly stronger ..... *idoneus* Blackman

Frontal carina of female evident only just above epistomal margin, that of male very strong and toothlike ..... *tumidus* Blackman

Group V

1. Elytral striae punctured in nearly regular rows..... 2

Elytral striae not punctured in regular rows, punctures randomly placed 7

2(1). Lateral elevations and suture of declivity clothed with long, stout yellowish setae, denser than on other parts of elytra ..... *setosus* Blackman

Lateral elevations and suture without long conspicuous setae, setae placed as on elytral disk..... 3

3(2). Second declivital interspace distinctly widened and sulcate 4

Second declivital interspace not widened or, at most, very slightly so 6

4(2). Carina on male frons strongly elevated, toothlike; declivity of both sexes shallowly sulcate..... *opimus* Blackman

Carina on male frons not strongly elevated, not toothlike; declivity of both sexes rather strongly sulcate.. 5

5(4). Body length 1.7 to 2.1 mm; body color reddish-brown; carina on male frons very faint ..... *deleoni* Bright

Body length 2.4 to 2.7 mm; body color black; carina on male frons more strongly elevated, distinct..... *sierraensis* Bright

6(4). Second declivital interspace moderately to rather deeply sulcate; third declivital interspace elevated higher than suture and distinctly granulate..... *artifex* Blackman

Second declivital interspace faintly sulcate if at all; third declivital interspace not elevated higher than suture and very finely granulate..... *inyoensis* Bright

7(1). Lateral margins of declivity slightly elevated, rounded and granulate; male frons with a distinct elevated longitudinal carina, toothlike in lower portion..... *confinus* LeConte

Lateral margins of declivity strongly elevated and strongly granulate; carina on male frons indicated by only a faint longitudinal line above epistoma..... *singularis* Bright

Group VI

1. Median pair of serrations on anterior margin of pronotum distinctly longer than any others; elytral declivity with sulcus rather shallow and lateral elevations low 2

Median serrations on anterior margin of pronotum not distinctly longer than any others; elytral declivity with sulcus deeper and lateral elevations high..... 4

2(1). Female frons densely punctured and pubescent throughout, concave; elytra coarsely punctured..... *carmeli* Swaine

Female frons smooth and shining in median area, not concave; elytra more finely punctured..... 3

3(2). Female frons shining, mirror-like, with pubescence limited to extreme outer margin; declivital granules

well developed ..... *tuberculatus* Eichhoff
Pubescence of female frons limited to outer margin but with an extension of setae from the vertex to the center; declivital granules very fine . *modicus* Blackman
4(1). Elytra with strial punctures fine and close; declivital sulcus rather wide and only moderately deep..... 5
Elytra with strial punctures coarser, close, in regular rows; declivital sulcus narrower and deeper with lateral elevations strongly developed, punctate, and granulate ..... *nitidulus* (Mannerheim)
5(4). Elytra with strial punctures fine and regular, interspaces sparsely punctured; declivital sulcus shallow and lateral margins not strongly elevated; in *Abies*, *Pseudotsuga*, or *Tsuga*..... *pseudotsugae* Swaine
Elytra with strial punctures fine and irregular, interspaces with numerous punctures; declivital sulcus deeper and lateral margins more strongly elevated; in *Pinus monophylla*..... *blandus* Blackman

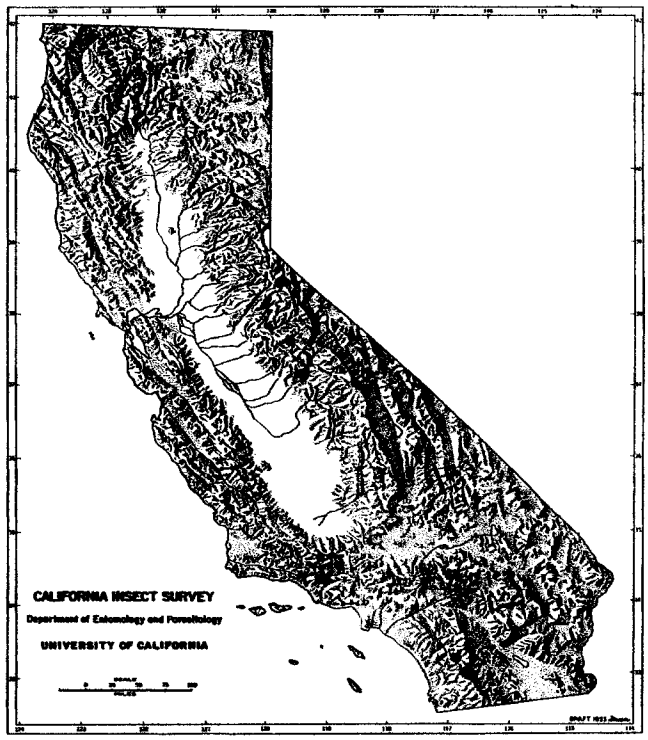
Group VII

1. Pronotal asperities more or less fused to form concentric rows; elytra sub-acuminate behind; frons of both sexes essentially similar..... *jeffreyi* Blackman
Pronotal asperities not fused to form concentric rows; elytra definitely acuminate behind; male frons with transverse carina, female frons variously pubescent.. 2
2(1). Elytral strial punctures varying from slightly irregular (especially in males) to confused; interstrial punctures at least moderately numerous..... 3
Elytral strial punctures in regular rows; interstrial punctures absent or sparse..... 5
3(2). Declivity strongly sulcate, with first and second striae distinctly punctured; frons of male and female transversely impressed below, with transverse carina above ..... *grandis* Blackman
Declivity moderately to strongly sulcate; frons of female flattened, densely and finely punctured, with long hairlike setae 4
4(3). Elytral declivity with sulci very deep, lateral margins strongly and abruptly elevated, much higher than suture, strongly serrate along summit.. *serratus* Swaine
Elytral declivity with sulci of moderate depth, lateral margins only slightly if at all higher than suture, less strongly granulate along summit.. *confertus* Swaine
5(2). Frons of female with extremely short, inconspicuous, setae ..... *murrayanae* Blackman
Frons of female densely pubescent with very long, incurved, yellowish setae..... *aurulentus* Bright

Pityophthorus scalptor Blackman
(Fig. 62, map 80)

Pityophthorus scalptor Blackman, 1928, N. Y. Sch. For. Bull. 1(3-b) Tech. Publ., 25:30. Holotype ♀, Julian, California (USNM).

Geographic distribution and host range.—Although collected only in California, the diverse locations and pine hosts suggest that *P. scalptor* will be found throughout pine forests in the northwest United States and possibly into northern Mexico. It has been found attacking Coulter, Jeffrey, lodgepole, and ponderosa pines.



Map 80. California distribution of *Pityophthorus scalptor* Blackman.

California records (map 80).—Alpine Co.: Ebbetts Pass, on *Pinus contorta* (DEB). Madera Co.: Northfork, on *P. ponderosa* (CNC). Mariposa Co.: Yosemite Valley, on *P. ponderosa* (USNM); Mt. Laguna, on *P. coulteri* (DEB); Palomar Mountain, on *P. coulteri* (CNC). Ventura Co.: County record only, on *P. jeffreyi* (USNM).

Biology.—Unknown.

Discussion.—Adults of *P. scalptor* are recognized by the pubescent, distinctly concave frons of the female, by the long, low, longitudinal carina on the male frons, by the very slightly impressed, flattened second declivity interspace, and by their larger size.

Pityophthorus toralis Wood

Pityophthorus toralis Wood, 1964, Great Basin Nat., 24(2):59. Holotype ♀, Logan Canyon, Utah (SLW).
Myeloborus confusus Bright, 1966, Pan-Pac. Entomol., 42(4): 295. Holotype ♀, Mt. Tullac, Eldorado Co., California (OSU). New synonymy.

Geographic distribution and host range.—This species is known from various high-altitude (usually) pines from southern British Columbia and Alberta along the mountain chains southward to the central Sierra Nevada in California and the central Rocky Mountains in Utah and Wyoming. Its known hosts are whitebark, limber, and lodgepole pine and it may attack other high-altitude species such as bristlecone pine.

California records.—ALPINE CO.: Ebbetts Pass, on *Pinus contorta* (DEB). ELDORADO CO.: Mt. Tallac, on *P. albicaulis* (OSU, CAS, CIS, CNC). INYO CO.: Onion Valley, on *P. flexilis* (CNC). TUOLUMNE CO.: Tioga Park, Yosemite Natl. Park, on *P. albicaulis* (CIS).

Biology.—Unknown.

Discussion.—Adults of *Pityophthorus toralis* are readily distinguished from other group I species by the very faint carina on the male frons which terminates in an elevated toothlike granule on the epistoma. Adults measure from 2.1 to 2.8 mm. Other useful characters are given in the key.

Pityophthorus brucki Bright

Pityophthorus brucki Bright, 1971, Pan-Pac. Entomol., 47(1):63. Holotype ♀, Mt. Hawkins, San Bernardino Co., California (OSU).

Geographic distribution and host range.—P. brucki was described from sugar pine in southern California. If this is its sole host, the distribution might be expected to extend north into the Sierra Nevada and southern Oregon. If other pines are attacked, the range may be even more extensive.

California records.—RIVERSIDE CO.: Idyllwild, on *Pinus lambertiana* (DEB). SAN BERNARDINO CO.: Mt. Hawkins, on *P. lambertiana* (OSU).

Biology.—Unknown.

Discussion.—Adults of *P. brucki* range in size from 1.5 to 1.8 mm, and average 1.6 mm. In one of the male paratypes the frontal carina extends to the epistomal margin but in three other male paratypes it does not. The characters of the female frons and the declivity of both sexes display little notable variation.

This species illustrates some of the difficulties with Blackman's groups. Based on antennal characters, this species clearly belongs to group I but it lacks the elevated ninth elytral interspace which is supposed to be characteristic of that group. Since Bright (1971) believes the antennal character is a more fundamental character, this species is placed in group I. It appears to be remotely related to *P. scalptor.*

Pityophthorus juglandis Blackman

Pityophthorus juglandis Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:42. Holotype ♀, Lone Mountain, New Mexico (USNM).

Geographic distribution and host range.—P. juglandis is distributed in the southwestern states, Arizona, California, and New Mexico where its hosts, walnut trees, are grown.

California records.—LOS ANGELES CO.: San Fernando, on *Juglans nigra* (CDA); Tarzana, on *J. californica* (USNM).

Biology.—Unknown.

Discussion.—This species is the only representative of Group II found in California. It is a recent introduction to the state; the first record is 1959. Adults of *P. juglandis* may be recognized by the fused pronotal asperities that are arranged in unbroken concentric rows, by the oblique declivity with distinct, strial punctures, by the frontal setae of the female being equal in length and by the host. The beetle is about 1.8 mm long, reddish-brown in color.

Pityophthorus praealtus Bright

Pityophthorus praealtus Bright, 1966, Pan-Pac. Entomol., 42(4): 303. Holotype ♀, Mt. Shasta, California (CAS).

Geographic distribution and host range.—P. praealtus is a subalpine species which is known to attack limber, whitebark, and foxtail pine. From the collecting sites, the distribution should extend north and east in similar locations. Other subalpine pines, such as lodgepole, may also be attacked.

California records.—MONO CO.: 10 mi N. Westgard Pass, on *Pinus aristata* (CNC). SISKIYOU CO.: Mt. Shasta Ski Area, on *P. albicaulis* (CAS); near Callahan, on *P. balfouriana* (CNC).

Biology.—Unknown.

Discussion.—Pityophthorus praealtus is provisionally placed in Group III. It possesses many of the characters of this group but does not seem to be closely related to any known species.

Adults measure about 1.75 mm in length. The frons is flattened in both sexes, that of the female is slightly concave above the epistoma, without any indication of a frontal carina. The anterior margin of the pronotum resembles *P. dolus* in that only two erect asperities are usually present.

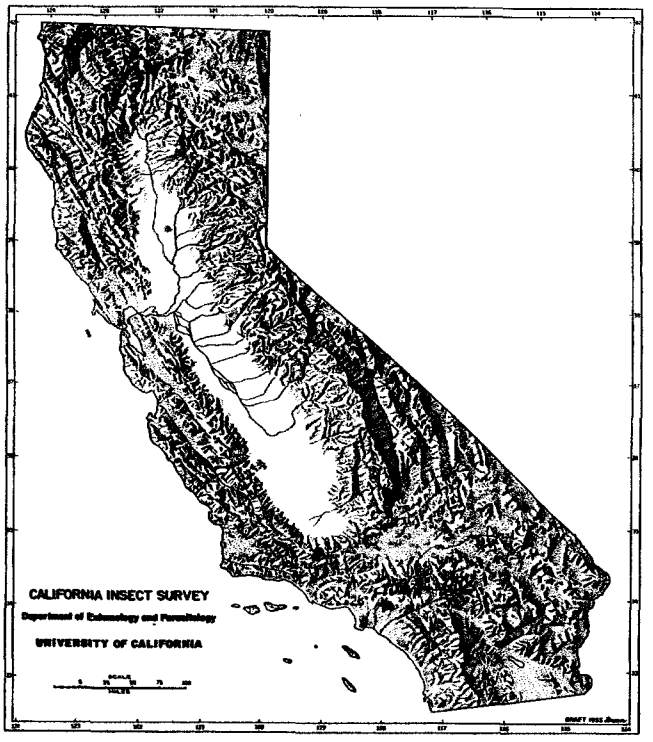
Pityophthorus punctifrons Bright
(Map 81)

Pityophthorus punctifrons Bright, 1966, Pan-Pac. Entomol., 42(4):298. Type ♀, Frazier Park, Kern Co., California (CAS).

Geographic distribution and host range. – Although known only from southern California at present, *P. punctifrons* probably occurs throughout the southwest and into Mexico on its hosts the single-leaf and four-leaf pinyon pines. Other pines may also be attacked.

California records (map 81).—INYO CO.: 6 mi N. Westgard Pass, on *Pinus monophylla* (CNC). KERN CO.: Frazier Park, on *P. monophylla* (CIS); Walker Pass, on *P. monophylla* (CNC). LOS ANGELES CO.: Juniper Hills, near Valyermo, on *P. monophylla* (USNM). SAN BERNARDINO CO.: Wrightwood, on *P. monophylla* (PSW). SAN DIEGO CO.: Mt. Laguna, on *P. quadrifolia* (PSW).

Biology.—Unknown.



Map 81. California distribution of *Pityophthorus punctifrons* Bright.

Discussion.—Adults of this species, which measure about 1.95 mm in length, may be recognized by the strongly punctured frons of both sexes, by the prominent pronotal and elytral punctures, and by their hosts and distribution.

Pityopthorus dolus Wood

Pityophthorus dolus Wood, 1964, Great Basin Nat., 24(2):65. Holotype ♀, McCloud, California (SLW).

Geographical distribution and host range.—Although recorded only from California, *P. dolus* should be found throughout western North America. Its known hosts, ponderosa and sugar pine, suggest that it may attack other pine species.

California records.—MADERA CO.: Bass Lake (CAS). RIVERSIDE CO.: Idyllwild, on *Pinus lambertiana* (PSW). SISKIYOU CO.: McCloud, on *P. ponderosa* (SLW).

Biology.—Unknown.

Discussion.—Adults of this species are about 1.3 mm in length and are very similar to those of *P. monophyllae* but differ by the longer, lower frontal carina of the male, by the transversely impressed female frons and by the coarser punctures of the pronotum and elytra.

Pityophthorus absonus Blackman

Pityophthorus absonus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:35. Holotype ♀, Mineral King, California (USNM).

Geographic distribution and host range.—Although recorded only from California from lodgepole and whitebark pine, it is probable that *P. absonus* will be found at higher elevations throughout western North America and attacking other subalpine pine species.

California records.—MARIPOSA CO.: Lake Tenaya, Yosemite Natl. Park, on *Pinus contorta* (CIS). SHASTA CO.: Hat Creek, on *P. contorta* (SLW); Mt. Lassen, on *P. albicaulis* (OSU). TULARE CO.: Mineral King, on *P. murrayana* (USNM).

Biology.—Unknown.

Discussion.—This species was placed in Group I by Blackman (1928*b*). However, examination of the type series and additional specimens indicate that it belongs in Group III on the basis of characters of the antennal club, elytra, and elytral declivity.

The adults of this species are small, black, and commonly found in twigs. They may be recognized by the elevated, toothlike, longitudinal carina on the male frons, by the very slightly concave female frons, and by the small size.

Pityophthorus abietis Blackman

Pityophthorus abietis Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:49. Holotype ♀, Silver Lake, Utah (USNM).

Geographic distribution and host range.—The recorded distribution of *P. abietis* is Arizona, California, New Mexico and Utah. However, since it attacks true firs, Douglas fir, and pines in these diverse localities, we expect it to be found at least throughout western North America.

California records.—LASSEN CO.: Black's Mtn., on *Abies concolor* (CIS). MENDOCINO CO.: Ocean View Plots, on *A. concolor* (PSW).

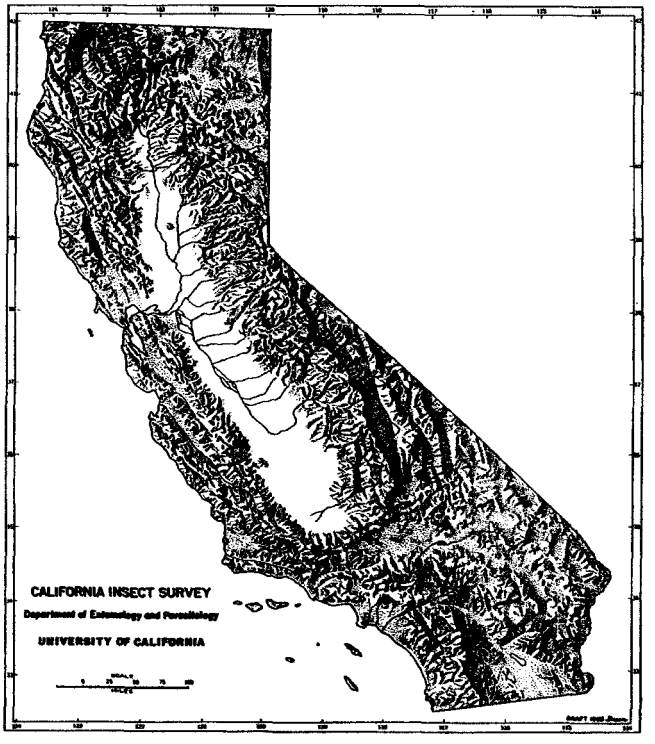
Biology.—Unknown.

Discussion. — Adults of *Pityophthorus abietis* are about 1.6 mm in length. They most closely resemble those of *P. dolus* among the California species, but may be distinguished by the characters given in the key.

Pityophthorus monophyllae Blackman
(Fig. 63; map 82)

Pityophthorus monophyllae Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:47. Holotype ♀, Argus Mountains, California (USNM).

Pityopthorus socius Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Pub., 25:48. Holotype ♀, Argus Mountains,



Map 82. California distribution of *Pityophthorus monophyllae* Blackman.

California (USNM). (Syn. by Bright, 1971.)

Pityopthorus piceus Bright, 1966, Pan-Pac. Entomol., 42(4):297. Holotype ♀, Mt. Pinos, Ventura Co., California (USNM). (Syn. by Bright, 1971.)

Geographic distribution and host range.—The recorded hosts of *P. monophyllae* (including synonyms) include limber, ponderosa, and single-leaf pinyon pine. We expect that other pines will be attacked and that the distribution now thought to be only in the southwestern states, California to New Mexico, will be more extensive.

California records (map 82).—Inyo Co.: Argus Mtns., on *Pinus monophylla* (USNM). Los Angeles Co.: Juniper Hills near Valyermo, on *P. monophylla* (USNM); Valyermo, on *P. monophylla* (OSU). San Bernardino Co.: Sugar Loaf Mt., on pinyon pine (OSU). Ventura Co.: Mt. Pinos, on *P. flexilis* (CAS).

Biology.—Unknown.

Discussion.—The adults of this species may be recognized by the faint, elevated, longitudinal carina on the male frons, by the rounded, unmodified elytral declivity, by the flat, pubescent female frons, and by the hosts.

Pityophthorus digestus LeConte

Pityophthorus digestus LeConte, 1874, Trans. Am. Entomol. Soc., 5:71. Holotype ♀, Mojave, California (MCZ).

Geographic distribution and host range.—The true distribution and host range are unknown. The only known host is single-leaf pinyon pine so we may assume it follows the distribution of this tree species in southwestern United States and Mexico.

California records.—Known only from LeConte's type series collected near Mojave, California.

Biology.—Unknown.

Discussion.—We have not seen California specimens of this species. Judging from the description and a limited examination of several specimens from New Mexico, the wide, flat declivity with low, lateral margins and the prominently serrate anterior margin of the pronotum coupled with a knowledge of host and locality should distinguish this species from related ones in California. Adults of *P. digestus* are 1.6 to 1.9 mm in length and are about 2.7 times as long as wide.

Pityophthorus idoneus Blackman
(Map 83)

Pityophthorus idoneus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:55. Holotype ♀, Centerville, Idaho (USNM).

Pityophthorus hopkinsi Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:56. Holotype ♀, Ventura Co., California (USNM). (Syn. by Bright, 1966.)

Pityophthorus ponderosae Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:57. Holotype ♀, Las Vegas Hot Springs, New Mexico (USNM). (Syn. by Bright, 1966.)

Geographic distribution and host range.—The diverse locations and hosts, lodgepole, Jeffrey, and ponderosa pine, suggest that *P. idoneus* will be found throughout western North America on a variety of pines.

California records (map 83).—Various localities in the following counties: El Dorado, Lassen, Los Angles, Mariposa, Modoc, Plumas, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Tulare, Tuolumne, and Ventura.

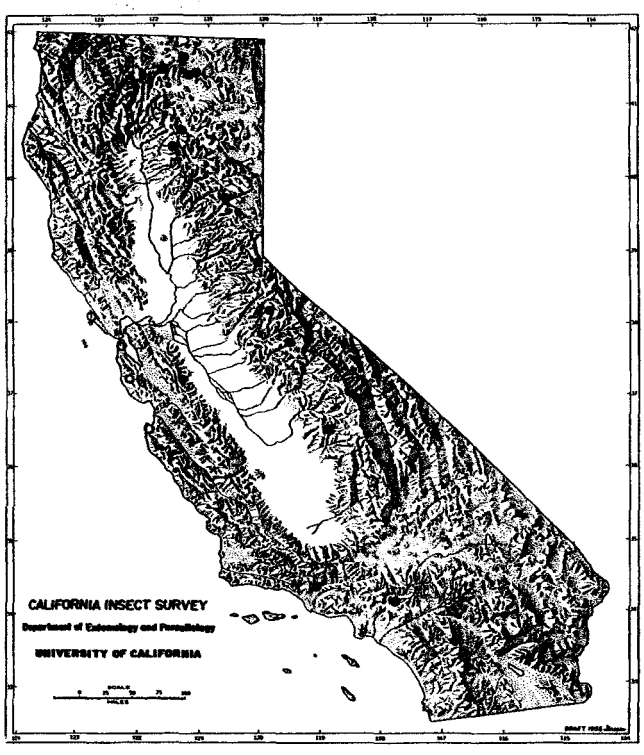
Biology.—Unknown.

Discussion.—*P. idoneus* is the most common species of Group IV encountered in California. The presence of a distinct, although not high, longitudinal carina on the frons of both sexes and the rounded, very slightly sulcate declivity will distinguish its adults from those of other species. The adults range from 1.7 mm to 2.0 mm in length and are 2.5 times as long as wide.

Pityopthorus tumidus Blackman

Pityophthorus tumidus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:58. Holotype ♀, Eureka, California (USNM).

Geographic distribution and host range.—*Pityophthorus tumidus* has been collected in the coastal ranges and interior Califor-



Map 83. California distribution of *Pityophthorus idoneus* Blackman, ● ; *Pityophthorus setosus* Blackman, O .

nia only from ponderosa pine. It will probably be found elsewhere along the coast of western North America on this host and possibly other pines as well.

California records.—HUMBOLDT Co.: Eureka (USNM); Little River (USNM). LASSEN Co.: Penitentiary Flat, Lassen Natl. For., on *Pinus ponderosa* (USNM). MONTEREY Co.: Pacific Grove (CAS).

Biology.—Unknown.

Discussion.—This species is rare in collections. The only specimens seen were the type and paratypes deposited in the U.S. National Museum, and one in the California Academy of Sciences. It appears to be easily distinguished from other species in northern California by the presence of a strongly elevated longitudinal carina on the frons of the male. The adults are about 2.1 mm long, and are 2.8 times as long as wide.

Pityophthorus setosus Blackman
(Map 83)

Pityophthorus setosus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:77. Holotype ♀, Monterey, California (USNM).

Geographical distribution and host range.—P. setosus is apparently restricted to the coastal ranges of central California where it attacks Monterey and Bishop pine. It will probably be found all along the coast in time.

California records (map 83).—MARIN Co.: Pt. Reyes, on *Pinus muricata* (CNC). MONTEREY Co.: Carmel, on *P. radiata* (CIS); Monterey, on *P. radiata* (CIS); Pacific Grove (CAS). SAN FRANCISCO Co.: San Francisco, on *P. radiata* (CWOB). SAN MATEO Co.: Sharp Peak (UCD).

Biology.—Unknown.

Discussion.—Adults of this distinctive species are recognized by the dense, stiff, rather long setae on the third interspace and on the suture on the posterior end of the elytra. They are about 1.9 mm long and 2.8 times as long as wide.

Pityophthorus opimus Blackman

Pityophthorus opimus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:80. Holotype ♀, Capitan Mtns., New Mexico (USNM).

Pityophthorus aristatae Bright, 1964, Pan-Pac. Entomol., 40(3): 166. Holotype ♀, White Mtns., California (CAS). (Syn. by Bright, 1971.)

Geographic distribution and host range.—P. opimus will probably be found in subalpine and alpine areas in the western states where it attacks bristlecone, limber, and whitebark pine. It is presently known to occur in California, Colorado, and New Mexico.

California records.—INYO Co.: 10 mi N. Westgard Pass, on *Pinus aristata* and *P. flexilis* (CNC). MONO Co.: 3 airline mi N. Inyo Co. line, Crooked Creek, White Mtns., 9500′, on *P. aristata* (CIS). SHASTA Co.: Mt. Lassen, on *P. albicaulis* (OSU).

Biology.—Unknown.

Discussion.—The adults of this species are distinguished easily by the toothlike carina on the frons of the male, by the dense pubescence on the frons of the female, by the shallowly sulcate elytral declivity, and by the hosts and distribution.

Pityophthorus deleoni Bright

Pityophthorus deleoni Bright, 1966, Pan-Pac. Entomol., 42(4): 302. Holotype ♀, "Bonnie Doone" [Bonny Doon], Santa Cruz Co., California (USNM).

Geographic distribution and host range.—The known distribution of *P. deleoni* is in those parts of coastal California where knobcone pine occurs and southern California where Jeffrey pine occurs. However, even if restricted to these two pines, the distribution probably extends to southern Oregon and western Nevada.

California records.—SAN DIEGO Co.: Mt. Laguna Recreation Area, on *Pinus jeffreyi* (CNC). SANTA CRUZ Co.: Bonny Doon, on *P. attenuata* (USNM, CIS, CAS, PSW).

Biology.—Unknown.

Discussion.—Adults of this species are small, reddish-brown, and about 1.7 to 2.1 mm in length. The summit of the lateral elevations of the declivity tends to curve toward the elytral suture in many specimens. The female frons is densely pubescent and the frontal carina of the male is very faint.

Pityophthorus sierrensis Bright

Pityophthorus sierrensis Bright, 1971, Pan-Pac. Entomol., 47(1): 64. Holotype ♀, 1 mi S. Onion Valley, Inyo Co., California (CNC).

Geographic distribution and host range.—Although known only from Inyo county, California, at present, it is believed the distribution is more extensive. One of its two hosts, foxtail pine, occurs in subalpine forests in the Sierra Nevada in Tulare county and the mountains of Trinity and Siskiyou county; the other, limber pine, occurs in subalpine forests of mountain ranges from British Columbia to Mexico.

California records.—Inyo Co.: 1 mi S. Onion Valley, Robinson Lake, on *Pinus balfouriana* and *P. flexilis* (CNC).

Biology.—Unknown.

Discussion.—Specimens range in length from 2.4 to 2.7 mm. The frontal carina in some males is more strongly elevated, especially in the lower part, and may be shorter than in other specimens. Usually the punctures of the first striae in the declivity are evident and in some specimens may be as distinct as the punctures of the second and third striae. The height and number of granules on the declivital interspaces also vary between specimens.

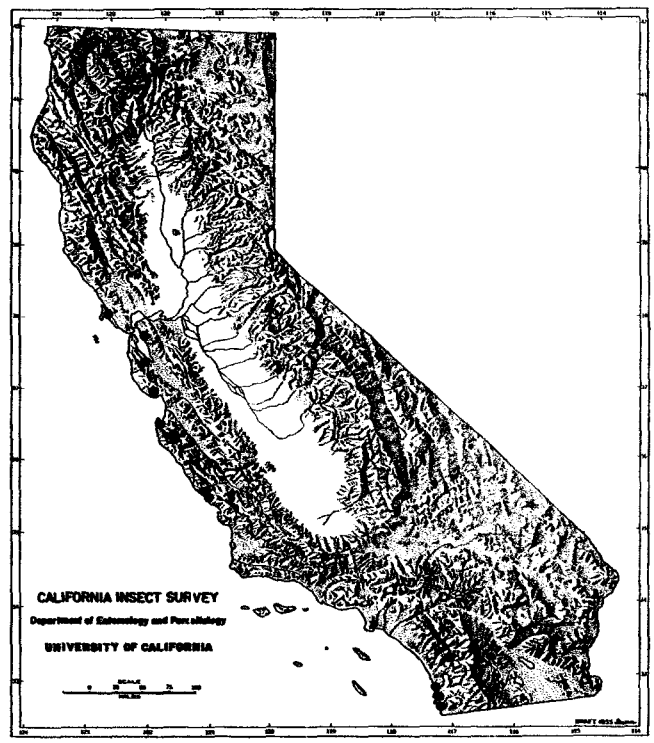
Pityophthorus artifex Blackman
(Map 84)

Pityophthorus artifex Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:76. Holotype ♀, Meyers, California (USNM).

Geographic distribution and host range.—Although known only from California at the present time, we believe that *P. artifex* will be found throughout pine forests in western North America. Its known hosts include bristlecone, Coulter, Jeffrey, and ponderosa pine; other pines are also probably attacked.

California records (map 84).—El Dorado Co.: Meyers, on *Pinus jeffreyi* (USNM). Mono Co.: Blancos Corral, White Mtns., on *P. aristata* (CIS). Monterey Co.: Junipero Serra Peak, on *P. coulteri* (CAS). San Bernardino Co.: Lake Arrowhead (CAS). San Diego Co.: Julian, on *P. coulteri* (PSW); Mt. Laguna, on *P. coulteri* (PSW); Palomar Mtn., on *P. coulteri* (CNC). Trinity Co.: Carrville, on *P. ponderosa* (OSU). Tuolumne Co.: Mill Ck. Camp, 11 mi N. E. Strawberry (CAS). County unknown: Lake Tahoe (USNM).

Biology.—Unknown.



Map 84. California distribution of *Pityophthorus artifex* Blackman, ○ ; *Pityophthorus carmeli* Swaine, ● .

Discussion.—This species is poorly represented in collections. It resembles *P. confinus* in some respects but the deeper elytral declivity and the smaller size should aid in distinguishing it.

Pityophthorus inyoensis Bright

Pityophthorus inyoensis Bright, 1971, Pan-Pac. Entomol., 47(1): 65. Holotype ♀, 1 mi S. Onion Valley, Inyo Co., California (CNC).

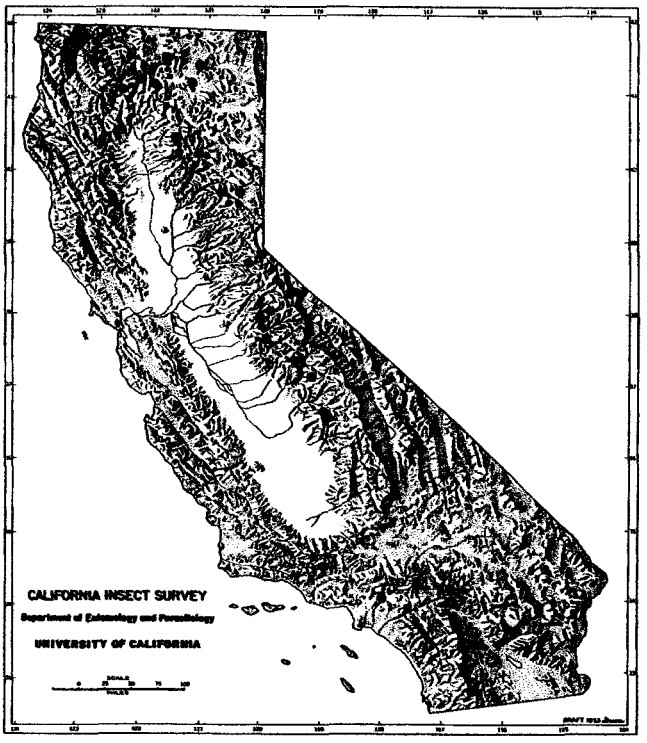
Geographic distribution and host range.—Although known only from Inyo County, *P. inyoensis* will probably be found elsewhere in California mountains where its host, foxtail pine, grows.

California records.—Inyo Co.: Robinson Lake, 1 mi S. Onion Valley, on *Pinus balfouriana* (CNC).

Biology.—Unknown.

Discussion.—Specimens range in length from 2.0 to 2.4 mm. The male carina on the frons varies in height and length but it is always distinctly elevated and tooth-like. The amount of pubescence on the female frons also varies. The second declivital interspace on many specimens is not wider than it is on the disk while in others it is slightly wider.

This species is related to *P. artifex* and *P. venustus* but



Map 85. California distribution of *Pityophthorus confinus* LeConte.

is distinguished by a shorter, higher male frontal carina, by the somewhat less densely pubescent female frons, and by the much shallower second declivital interspace.

P. inyoensis coexists with *P. sierraensis* in *Pinus balfouriana*. The former is known only from *Pinus balfouriana* while the latter is more commonly found in *P. flexilis*.

Pityophthorus confinus LeConte
(Map 85)

Pityophthorus confinus LeConte, 1876, Proc. Am. Philos. Soc., 15:354. Syntypes ♂ ♂ and ♀ ♀, Mojave Region, California (MCZ).

Geographic distribution and host range.—P. confinus is distributed throughout the pine forests of western North America and probably in northern Mexico. It probably attacks all species of pine except the true alpine species. It is known to attack Coulter, Jeffrey, ponderosa, and sugar pine in California.

California records (map 85).—Numerous localities in the following counties: El Dorado, Fresno, Glenn, Lake, Lassen, Los Angeles, Mariposa, Modoc, Mono, Plumas, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Tulare, Tuolumne, and Ventura.

Biology.—Unknown.

Discussion. — *Pityophthorus confinus* has been reported killing the tops of mature ponderosa pine on cutover lands and in virgin stands. Also, it has been found in twigs, tops of trees, and trunks of trees of all ages both as a primary attacker and secondary attacker.

This is one of the largest species of the genus in California (adults are 2.5 to 2.8 mm in length, 2.5 times as long as wide). The declivity is broadly sulcate with very low lateral margins and the male frons has a distinct toothlike longitudinal carina. The elytra are distinctly, rather confusedly punctured.

Pityophthorus singularis Bright

Pityophthorus singularis Bright, 1966, Pan-Pac. Entomol., 42(4): 300. Holotype ♀, 12 mi west of Lone Pine, Inyo Co., California (CAS).

Geographic distribution and host range.—P. singularis has been collected only from single-leaf pinyon pine in California but should be found in other parts of its host's range, i.e., from the east slopes of the Sierra Nevada from Mono county south to Tuolumne county, southern California, Arizona, Utah, and possibly northern Mexico.

California records.—Inyo Co.: 12 mi W. of Lone Pine, on *Pinus monophylla* (CIS); 6 mi N. Westgard Pass, on *P. monophylla* (CNC). San Bernardino Co.: Doble, on pinyon pine (OSU).

Biology.—Unknown.

Discussion.—Adults of this species are 2.0 to 2.7 mm in length, and are distinguished by the very faint longitundinal carina on the male frons, by the strongly granulate declivital elevations, and by the host and distribution.

Pityophthorus carmeli Swaine
(Map 84)

Pityophthorus Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):100. Holotype ♀, Carmel, California (CNC).
Pityophthorus torreyanae Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):101. Holotype ♀, San Diego, California (CNC). (Syn. by Blackman, 1928*b*.)

Geographic distribution and host range.—P. carmeli has been collected in the coastal ranges of California on Bishop, Monterey, and Torrey pines. Its distribution possibly extends into Oregon and Baja California, Mexico, and other coastal pines are probably attacked. The lone record on Coulter pines suggests a possible inland extension of the distribution.

California records (map 84).—Alameda Co.: Berkeley, on *Pinus radiata* (PSW). Marin Co.: Inverness, on *P. muricata* (CIS). Monterey Co.: Carmel, on *P. radiata* (CIS); Jamesburg, on *Pinus coulteri* (HSC); Monterey, on *P. radiata* (CIS); Pacific Grove, on *P. radiata* (CIS). San Diego Co.: Coronado (OSU); San Diego, on *P. torreyana* (CIS); Torrey Pines State

Park, on *P. torreyana* (CWOB). SAN LUIS OBISPO CO.: Cambria Pines (CWOB); San Simeon, on *P. muricata* (CIS). SANTA CLARA CO.: Stanford Univ. (CIS). SANTA CRUZ CO.: Felton (SJSC).

Biology. (Brown and Eads, 1967)

This species attacks only the smaller twigs of pines weakened by drought or by attacks of other bark beetles, such as *Dendroctonus*. It is polygamous and constructs a gallery with a central nuptial chamber with individual egg galleries radiating from it. Because of the confined space the larval galleries and adult galleries overlap and the gallery pattern is often obscured.

There are at least two generations a year but the fact that adults are found throughout the year suggests the possibility of more.

Discussion.—The distinctly concave, entirely pubescent female frons will immediately distinguish this species. Adults are 2.5 to 2.7 mm in length, about 2.9 times longer than wide.

Pityophthorus tuberculatus Eichhoff
(Fig. 64; map 86)

Pityophthorus tuberculatus Eichhoff, 1878, Ratio, descriptio, emandatio, eorum tomicinorum, p. 498. Type ♂, California (destroyed?).

Pityophthorus rugicollis Swaine, 1925, Can. Entomol., 57:193. Holotype ♀, Glen Alpine, California (CNC). (Syn. by Blackman, 1928*b*.)

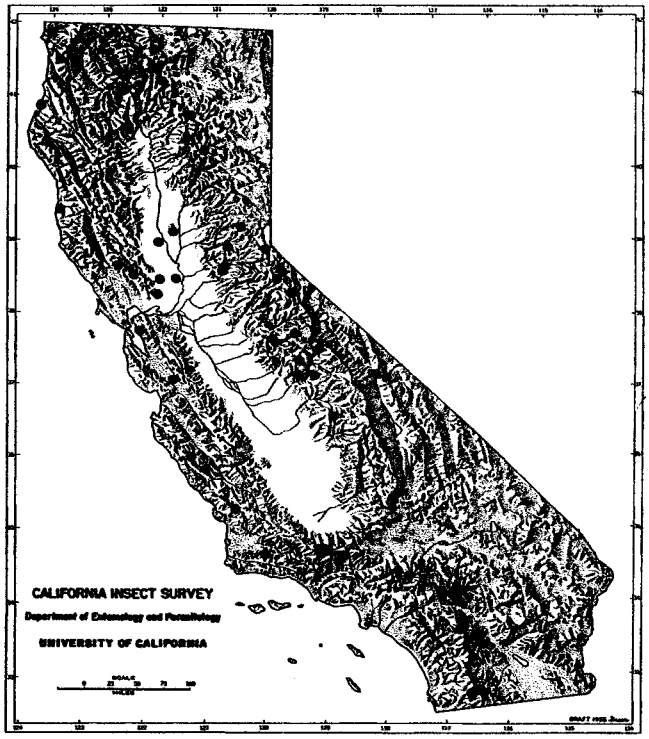
Pityophthorus novellus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3–b) Tech. Publ., 25:96. Holotype ♀, Tehachapi, California (USNM). (Syn. by Bright, 1971.)

Geographic distribution and host range.—P. tuberculatus is widely distributed from South Dakota south to northern Mexico and throughout western North America; it apparently attacks all pine species.

California records (map 86). – Numerous localities in the following counties: Alameda, Alpine, Colusa, Del Norte, El Dorado, Fresno, Humboldt, Inyo, Kern, Lake, Los Angeles, Madera, Mariposa, Mendocino, Mono, Monterey, Napa, Placer, Plumas, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Santa Clara, Shasta, Siskiyou, Solano, Sutter, Trinity, Tulare, Ventura, and Yolo.

Biology.—Unknown.

Discussion.—Pityophthorus tuberculatus is one of the most commonly encountered species of this genus in California. It is easily recognized by the flattened, very shiny female frons which is bordered on the periphery by long, yellowish setae. In other characters, it exhibits a great deal of variation. Blackman (1928*b*) states that specimens from Lake Tahoe, Placerville, and other nearby localities differ enough from the typical form so that they could be considered to be *P. rugicollis* Swaine and that *P. rugicollis* is at best a variety of *P. tuberculatus*. Besides the frontal character of the female, the broadly, shallowly sulcate declivity and the longer median serrations of the anterior margin of the pronotum also serve to distinguish this species. Adults are 1.5 to 2.3 mm in length, 2.7 times longer than wide.



Map 86. California distribution of *Pityophthorus tuberculatus* Eichhoff.

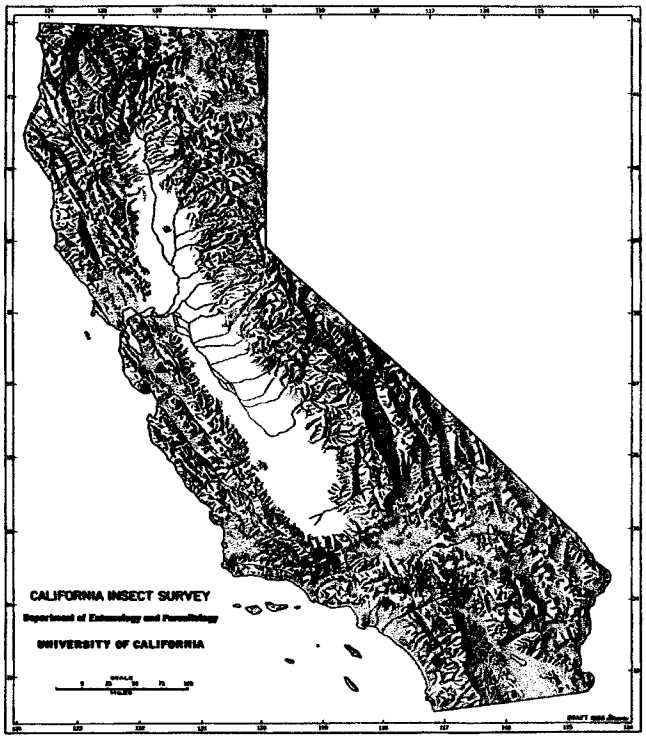
Pityophthorus modicus Blackman
(Map 87)

Pityophthorus modicus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3–b) Tech. Publ., 25:94. Holotype ♀, Las Vegas Hot Springs, New Mexico (USNM).

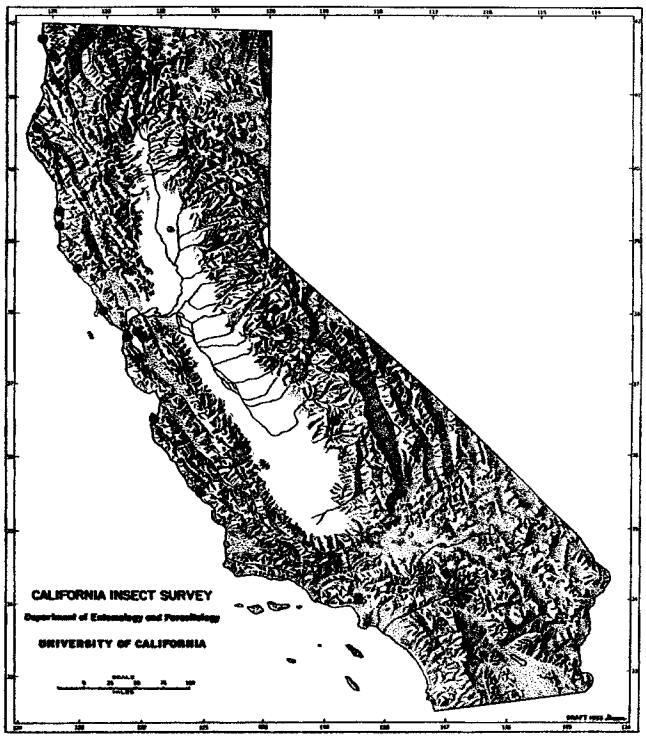
Pityophthorus navus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3–b) Tech. Publ., 25:95. Holotype ♀, Morgan Hill, California (USNM). (Syn. by Bright, 1966.)

Geographic distribution and host range.—P. modicus is distributed throughout the range of its principal host, *Pinus monophylla*, i.e., in Arizona, California, New Mexico, Utah, and Baja California, Mexico. It probably attacks other pinyon pines within this range.

California records (map 87).—LOS ANGELES CO.: Valyermo, on *Pinus monophylla* (OSU). KERN CO.: Frazier Park, on *P. edulis* (USNM). SAN BERNARDINO CO.: San Bernardino Natl. For., on *P. monophylla* (CIS); Wrightwood, on *P. monophylla* (CIS). SAN DIEGO CO.: Morgan Hill (USNM). VENTURA CO.: Frazier Mtn., on *P. monophylla* (OSU); Sandstone Camp, 3 mi S. Pine Mtn. Summit, on *P. monophylla* (CIS).



Map 87. California distribution of *Pityophthorus modicus* Blackman, ● ; *Pityophthorus murrayanae* Blackman, ○ ; *Pityophthorus aurulentus* Bright, ▲ .



Map 88. California distribution of *Pityophthorus nitidulus* (Mannerheim).

Biology.—Unknown.

Discussion.—*P. modicus* is closely related to *P. tuberculatus* but is readily distinguished from that species by the characters of the female frons given in the key. In addition, it can be distinguished by the convex, very slightly sulcate elytral declivity of both sexes. Adults are about 1.8 mm in length, 2.4 times as long as wide.

Pityophthorus nitidulus (Mannerheim) (Map 88)

Bostrichus nitidulus Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou, 16:298. Type ♀, Sitka, Alaska (University of Helsinki).

Pityophthorus nitidulus: LeConte, 1876, Proc. Am. Philos. Soc., 15:354.

Cryphalus atratulus LeConte, 1868, Trans. Am. Entomol. Soc., 2:156. Syntypes ♀ ♀, Cabo de los Reyes, California (MCZ). (Syn. by LeConte, 1876.)

Cryphalus puncticollis LeConte, 1874, Trans. Am. Entomol. Soc., 5:71. Holotype ♂, Calaveras, California (MCZ). (Syn. by Blackman, 1928*b*.)

Pityophthorus puncticollis: LeConte, 1876, Proc. Am. Philos. Soc., 15:354.

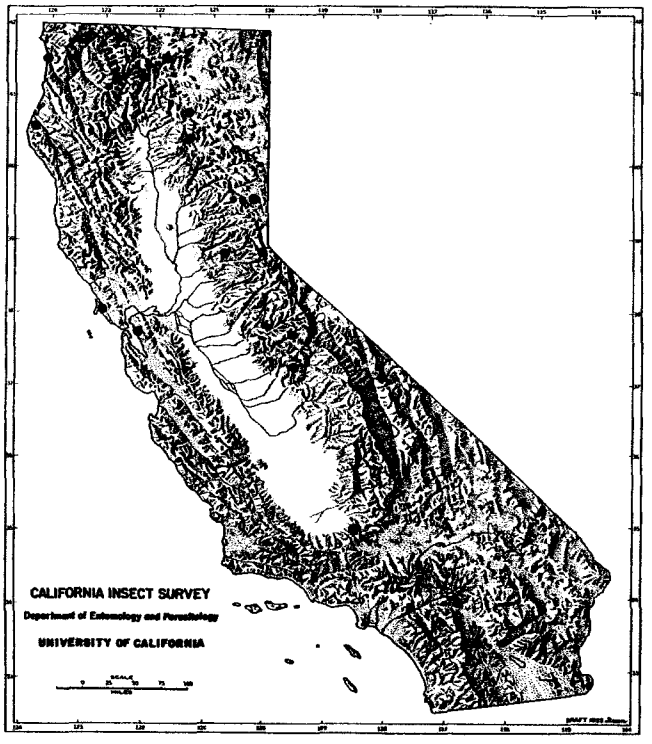
Geographic distribution and host range.—*P. nitidulus* is widely distributed throughout western North America from southeast Alaska south to Guatemala. It attacks all conifers in the family Pinaceae.

California records (map 88).—Numerous localities in the following counties: Alameda, Del Norte, El Dorado, Humboldt, Los Angeles, Marin, Mendocino, Monterey, Placer, San Francisco, San Luis Obispo, Santa Clara, Siskiyou, Sonoma, Tulare, and Tuolumne.

Biology.—Only the gallery system is known. There is a small central chamber from which three or four galleries radiate. The eggs are placed in shallow niches and covered with frass. The larvae mine at right angles to the egg gallery and when mature excavate a pupal cell almost wholly in the bark. The adults emerge directly from the pupal cell.

Discussion.—*P. nitidulus* exhibits a great deal of variation throughout its range but the characters given in the key should suffice for identification. Adults measure about 2.4 mm in length, 3.0 times longer than wide.

Several series from the Sierra Nevada have been examined and differ in a number of respects from specimens from coastal regions. It is possible they represent a distinct species but for the present these specimens from the Sierra are assigned to *P. nitidulus*.



Map 89. California distribution of *Pityophthorus pseudotsugae* Swaine.

Pityophthorus pseudotsugae Swaine
(Fig. 26; map 89)

Pityophthorus pseudotsugae Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):99. Holotype ♀, Vernon, British Columbia (CNC).

Geographic distribution and host range.—P. pseudotsugae is distributed from British Columbia south through the Pacific Coast and Rocky Mountain states. It attacks the true firs, Douglas fir, and hemlock throughout its range. With this diversity of distribution and hosts it undoubtedly occurs more extensively and in other hosts.

California records (map 89).—Various localities in the following counties: Alameda, Del Norte, El Dorado, Humboldt, Inyo, Kern, Madera, Marin, Mariposa, Riverside, San Bernardino, Shasta, Sierra, and Siskiyou.

Biology.—Unknown, except for gallery (fig. 26).

Discussion.—This species is commonly found in the twigs of various firs and Douglas fir throughout California. It is related to *P. tuberculatus* but the adults are easily distinguished by the female frons bearing setae over the entire surface, those on the periphery being longer and incurved and the deeper and slightly more granulate declivity. Adults measure 1.9 to 2.1 mm in length, 2.7 times longer than wide.

Pityophthorus blandus Blackman

Pityophthorus blandus Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:107. Holotype ♀, Argus Mountains, California (USNM).

Geographic distribution and host range.—P. blandus is known from Arizona and California in *Pinus monophylla*. It should be found throughout the southwestern United States and northern Mexico in various species of pinyon pine. The record from *Pinus jeffreyi* is questionable.

California records.—INYO Co.: Argus Mtns., on *Pinus monophylla* (USNM). KERN Co.: Tehachapi Mtn. Park, on *Pinus jeffreyi* (CIS). SAN BERNARDINO Co.: Bear Lake (CAS); Big Bear Lake, on *P. monophylla* (OSU); Doble, on *P. monophylla* (OSU). VENTURA Co.: Frazier Mtn., on *P. monophylla* (OSU).

Biology.—Unknown.

Discussion.—Although closely resembling *P. pseudotsugae*, this species is easily separated by the much broader second declivital interspace and the slightly larger size of the adults, which measure 2.2 mm in length, 2.8 times longer than wide. The host plant will also aid in distinguishing the two species.

A series of specimens from Tehachapi Mountain Park display some differences from the paratypes examined during this study. The asperities on the anterior margin of the pronotum are fewer and longer and the pubescence of the female frons appears longer. These differences may be great enough to warrant proposing a new species for these specimens. However, until more material is available for study, these specimens will be referred to *P. blandus*.

Pityophthorus jeffreyi Blackman

Pityophthorus jeffreyi Blackman, 1928, N. Y. State Coll. For. Bull. 1(3-b) Tech. Publ., 25:113. Holotype ♀, Bishop, California (USNM).

Geographic distribution and host range.—P. jeffreyi has been reported only from Jeffrey pine in Inyo county, California. If restricted to this host, which is unlikely, it should be found throughout the eastern slope of the Sierra Nevada and southern California.

California record.—INYO Co.: Bishop, Inyo Natl. For., on *Pinus jeffreyi* (USNM).

Biology.—Unknown.

Discussion. — Pityophthorus jeffreyi was placed in Group VI by Blackman (1928*b*) but also appeared in his key to Group VII. Because of the subacuminate elytral apex, it is here placed in Group VII. It is characterized by the concentric rows of asperities on the pronotum and by the similar form of the frons in both sexes.

Pityophthorus murrayanae Blackman
(Map 87)

Pityophthorus murrayanae Blackman, 1922, N. Y. State Coll. For. Bull. 22(5) Tech. Publ., 16:138. Holotype ♀, Grand Lake, Colorado (USNM).

Pityophthorus elongatus Swaine, 1925, Can. Entomol. 57:194. Holotype ♀, Midday Valley, Merritt, British Columbia (CNC). (Syn. by Blackman, 1928*b*.)

Geographic distribution and host range.—A subalpine to alpine species, *P. murrayanae* is distributed at higher elevations throughout western North America. It has been collected from bristlecone, limber, and whitebark pine and probably attacks other pines within its range.

California records (map 87).—Inyo Co.: 10 mi N. Westgard Pass, on *Pinus flexilis* and *P. aristata* (CNC); Onion Valley, on *P. flexilis* (CNC). Mono Co.: Blanco's Corral, White Mtns., 10,000′, on *P. aristata* (CIS); Crooked Creek lab, White Mtns., 10,150′, on *P. aristata* (CIS). Siskiyou Co.: Mt. Shasta Ski Area, on *P. albicaulis* (HSC). Trinity Co.: Upper Deadfall Lake, on *P. monticola* (HSC).

Biology.—Unknown.

Discussion.—The dense, very short, inconspicuous hairs on the female frons will distinguish the adults of this species. Adults are about 2.2 mm in length, about 3.1 times longer than wide.

Pityophthorus grandis Blackman

Pityophthorus grandis Blackman, 1928, N. Y. State Coll. For. Bull. 1(3–b) Tech. Publ., 25:119. Holotype ♀, Kaibab National Forest, Arizona (USNM).

Geographic distribution and host range.—*P. grandis* is found from the Black Hills of South Dakota, south to New Mexico and west to eastern and southern California. Although recorded in California only from single-leaf pinyon pine it attacks other species of pine in other parts of its range.

California records.—Riverside Co.: Joshua Tree Natl. Mon., on *Pinus monophylla* (PSW). San Bernardino Co.: Wrightwood, on *P. monophylla* (CIS).

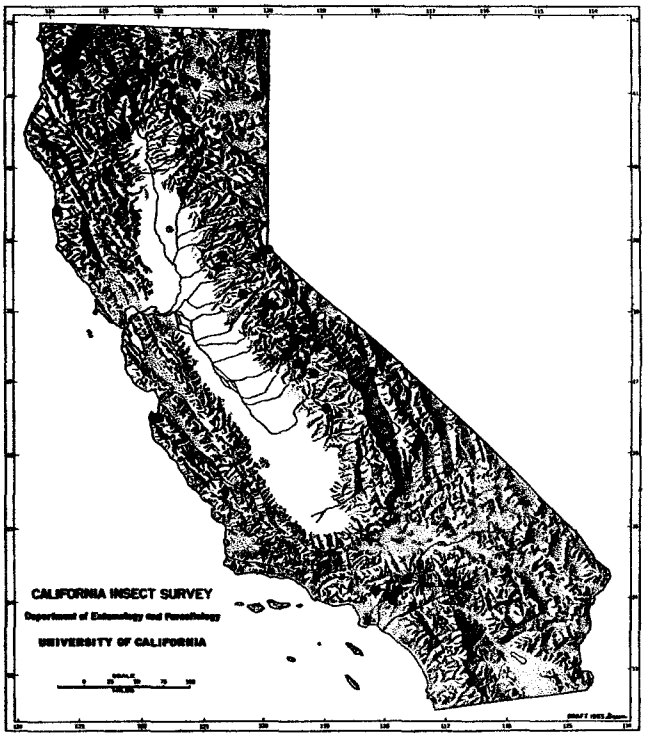
Biology.—Unknown.

Discussion.—This species has not been recorded from California before. Specimens from *Pinus monophylla* were compared with paratypes of this species and agree in most respects. Adults are very large, 2.2 to 3.2 mm in length, with a transversely impressed frons in both sexes, and a deeply sulcate, granulate declivity.

Pityophthorus serratus Swaine

Pityophthorus serratus Swaine, 1918, Can. Dep. Agric. Entomol. Branch Bull., 14(2):103. Holotype ♂, Barkhouse Creek, Siskiyou Co., California (CNC).

Geographic distribution and host range.—Although collected only in California from ponderosa pine, *P. serratus* probably will be found in Oregon, Washington, and British Columbia.



Map 90. California distribution of *Pityophthorus confertus* Swaine.

California records.—Mariposa Co.: Yosemite Valley, on *Pinus ponderosa* (USNM). Siskiyou Co.: Barkhouse Creek, on yellow pine limb (USNM).

Biology.—Unknown.

Discussion.—Adults of this rare species closely resemble those of *P. confertus* in size and general facies. The most distinctive character of *P. serratus* is the very coarsely serrate lateral margins of the declivity. Other characters given in the key will aid in its identification.

Pityophthorus confertus Swaine
(Map 90)

Pityophthorus confertus Swaine, 1917, Can Dep. Agric. Entomol. Branch Bull., 14:27. Lectotype ♀, Adams Lake, British Columbia (CNC).

Pityophthorus burkei Blackman, 1928, N. Y. State Coll. For. Bull. 1(3–b) Tech. Publ., 25:129. Holotype ♀, Meyers, California (USNM). (Syn. by Bright, 1966.)

Geographic distribution and host range.—*P. confertus* is found throughout western North America on a wide range of hosts in the family Pinaceae. It probably extends eastward where contiguous coniferous forests occur.

California records (map 90).—Numerous localities in the following counties: Butte, Calaveras, El Dorado, Del Norte, Fresno,

Humboldt, Inyo, Lassen, Los Angeles, Madera, Mariposa, Mendocino, Modoc, Mono, Monterey, Placer, Plumas, Riverside, San Bernardino, San Diego, Santa Barbara, Shasta, Siskiyou, Trinity, Tulare, and Tuolumne.

Biology.—Unknown.

Discussion.—Pityophthorus confertus is reported to attack slash and limbs of living trees but on occasion attacks tops and even trunks of weakened trees. It is probably the most common species in Group VII encountered in California.

It is closely related to *P. serratus* because of the rather irregularly placed strial punctures and the long pubescence on the frons of the female. Adults of *P. confertus* are easily distinguished by the less strongly granulate lateral margins of the elytral declivity and by the shallower declivity. They are 1.9 to 3.0 mm in length, about 2.9 times longer than wide.

The series from Mahogany Flat in Death Valley is tentatively assigned to this species. The adults differ from typical specimens of *P. confertus* from California by their larger size (up to 3.0 mm), by the more shallowly sulcate elytral declivity, by the more strongly impressed elytral punctures, and by the longer, more abundant pubescence. They closely resemble specimens of *P. agnatus* Blackman, a species found in Arizona and New Mexico. Until more study is possible, the positive identification of these specimens must remain in doubt.

Pityophthorus aurulentus Bright
(Map 87)

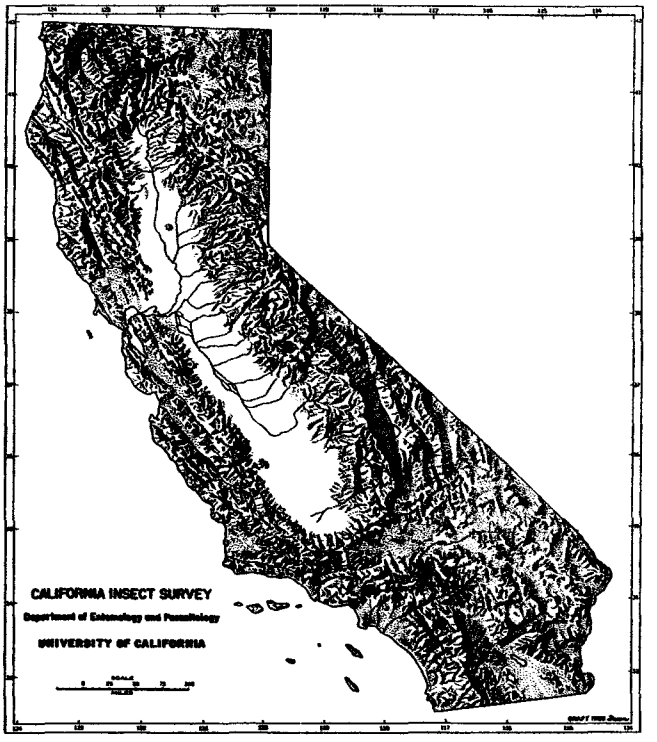
Pityophthorus aurulentus Bright, 1966, Pan-Pac. Entomol., 42(4):301. Holotype ♀, Walnut Creek, Contra Costa Co., California (CAS).

Geographic distribution and host range.—P. aurulentus is distributed in coastal ranges of central and southern California. Its hosts are Bishop and Monterey pine. The distribution probably extends north to Oregon and south to Baja California and all coastal pines are likely hosts.

California records (map 87).—Contra Costa Co.: Walnut Creek, on *Pinus radiata* (CAS); Walnut Creek, on pine (CDA). Santa Barbara Co.: Lompoc, on *P. muricata* (PSW). Santa Clara Co.: San Jose, on *P. radiata* (PSW). Santa Cruz Co.: Felton (SJSC).

Biology.—Unknown.

Discussion. — This species is closely related to *P. gracilis* Swaine but can be recognized by the much more abundant, and longer, frontal hairs of the female, by the shallower elytral declivity, by the smaller punctures of the male pronotum and by the stouter, shorter declivital hairs of the male. It is 1.85–2.25 mm in length, 3.6 times longer than wide.



Map 91. California distribution of *Ancyloderes pilosus* (LeConte).

Genus *Ancyloderes* Blackman

Ancyloderes Blackman, 1938, Proc. Entomol. Soc. Wash., 40:205. Type-species: *Cryphalus pilosus* LeConte, original designation.

Only one species of this genus occurs in North America. It is closely related to *Gnathotrichus* but differs in pronotal, elytral, and antennal characters.

Schedl (1950) considered *Ancyloderes* a synonym of *Conophthocranulus* Schedl, but Wood (1966), after examining the type species of each genus, regarded the two as distinct.

Nothing is known of the habits of the species in this genus. All specimens known were taken at light or in flight in pine-oak woodlands, except for one series taken on *Pinus jeffreyi* in southern California.

Ancyloderes pilosus (LeConte)
(Map 91)

Cryphalus pilosus LeConte, 1868, Trans. Am. Entomol. Soc., 2:154 (spelled *pilosulus* on p. 156). Holotype ♂?, California (MCZ).

Ancyloderes pilosus: Blackman, 1938, Proc. Entomol. Soc. Wash., 40:205.

Ancyloderes saltoni Blackman, 1938, Proc. Entomol. Soc. Wash., 40:206. Holotype (sex?), Flagstaff, Arizona (USNM). (Syn. by Wood, 1966.)

Geographic distribution and host range.—*A. pilosus* has been collected in Arizona, California, New Mexico, Utah, and Mexico (Durango). However, with one exception, no host records have been obtained. We can only assume that since it attacks Jeffrey pine that some other pines within its range may be attacked.

California records (map 91).—Los Angeles Co.: Brown's Flat, San Gabriel Mtns. (LBSC); Glendale (UCD); Pasadena (CAS); Pomona (USNM); Santa Monica (UCR). Madera Co.: Northfork, in flight (USNM). Mariposa Co.: Yosemite Valley (CAS). San Diego Co.: Mt. Laguna, on *Pinus jeffreyi* (USNM). Tulare Co.: Colony Mill (CDA). Ventura Co.: Ojai (USNM).

Biology.—Unknown.

Discussion.—Adults of *Ancyloderes pilosus* are about 2 mm long. The frons is distinctly aciculate, resembling that of *Gnathotricus sulcatus*, and the declivity is distinctly pubescent.

Genus *Gnathotrichus* Eichhoff

Gnathotrichus Eichhoff, 1868, Berl. Entomol. Z., 12:275. Type-species: *Gnathotrichus corthyloides* Eichhoff, monotypic.

Six species of these ambrosia beetles occur in North America and two are found in California. Both California species attack and sometimes coinhabit a wide variety of coniferous trees. The genus was revised by Blackman (1931*b*).

KEY TO THE SPECIES OF GNATHOTRICHUS IN CALIFORNIA

1. Pregula protruding anteriorly; frons punctured on sides, not aciculate ..... *retusus* (LeConte)
   Pregula not protruding; frons distinctly convergently aciculate on sides, not punctured ..... *sulcatus* (LeConte)

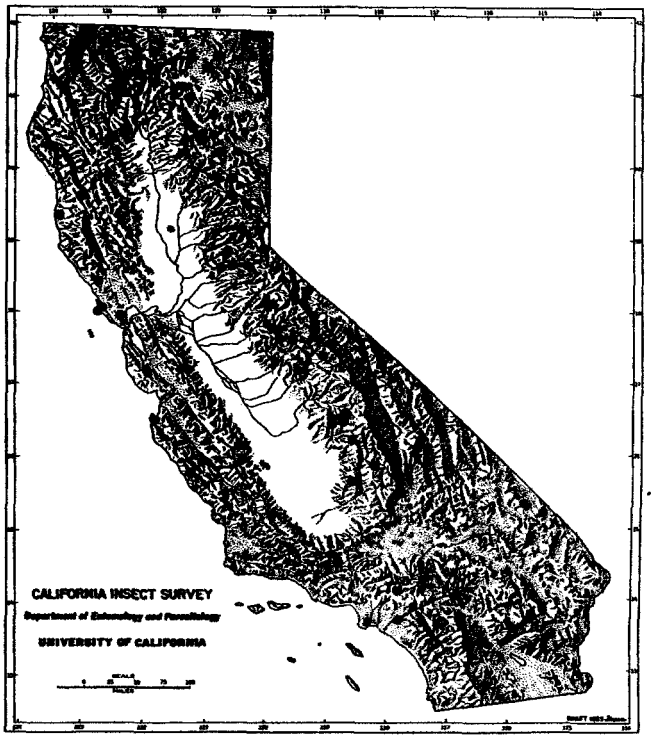
Gnathotrichus retusus (LeConte)
(Figs. 65, 66; map 92)

Cryphalus retusus LeConte, 1868, Trans. Am. Entomol. Soc., 2:155. Syntypes (sex?) California (MCZ).
Gnathotrichus retusus: Eichhoff, 1878, Ratio, descriptio, emandatio, eorum tomicinorum, p. 407.

Geographic distribution and host range.—*G. retusus* is widely distributed throughout western North America on a wide variety of hosts in the family Pinaceae. A record from a wine cask suggests that it may attack wood products in use as well as forest trees.

California records (map 92).—Numerous localities in the following counties: El Dorado, Fresno, Humboldt, Inyo, Kern, Lassen, Los Angeles, Madera, Marin, Mariposa, Mendocino, Modoc, Monterey, Mono, Orange, Placer, Plumas, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Sonoma, Trinity, Tulare, and Tuolumne.

Biology. (Daterman et al., 1965)



Map 92. California distribution of *Gnathotrichus retusus* (LeConte).

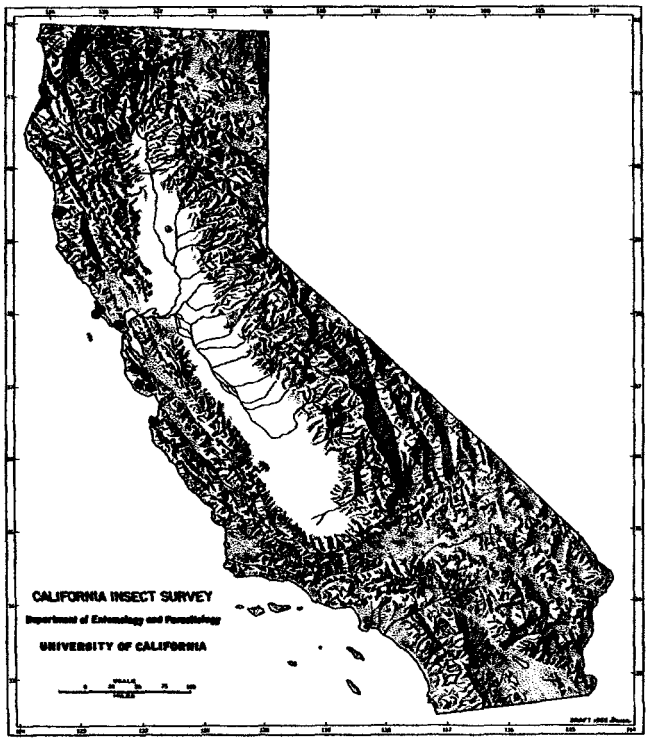
Adults of *Gnathotrichus retusus* mine the sapwood and heartwood of injured, dying or recently killed trees, logs, stumps, and large limbs. Occasionally they are found working in apparently healthy trees but are usually in dead tissue caused by lightning, mechanical injury, or disease.

Flight may occur as early as mid-April but the first massive flight takes place in May followed by slightly lesser ones in late June and mid-July. However, adults may be found in flight throughout the growing season.

The adult penetrates the wood to a depth of 5 to 8 cm where it may construct several irregular branches but all in the same horizontal plane. Usually a long side tunnel is excavated about 2 cm inside the bark or sapwood parallel to the annual rings. Large quantities of fine white boring dust are extruded from the entrance hole and are a good symptom of attack.

Elongate eggs are deposited in single niches or cradles excavated by the female above and below the egg galleries. The larva, upon hatching, lengthens the niche slightly and spends its entire developmental time there. They (and the adults) feed on a species of ambrosial fungus introduced by the parent beetles, which grows on the walls of the tunnels.

There are at least two generations per year and possibly many overlapping broods. Adults are long-lived



Map 93. California distribution of *Gnathotrichus sulcatus* (LeConte).

and continue to extend their galleries and reproduce as long as the host is in the proper condition for fungal growth. Progeny may also reproduce in the same gallery system.

Discussion.—*Gnathotrichus* species, like all ambrosia beetles, are of concern because the stain produced by the ambrosial fungus and by the "pinholes" of their galleries which reduces the market value of lumber products.

The adults of *G. retusus* are 3.5 to 3.8 mm in length and are about 3.2 times longer than wide. In addition, the characters given in the key will easily distinguish the adults of this species.

Gnathotrichus sulcatus (LeConte)
(Figs. 1, 28, 84; map 93)

Cryphalus sulcatus LeConte, 1868, Trans. Am. Entomol. Soc., 2:155. Holotype ♀?, California (MCZ).

Gnathotrichus sulcatus: Eichhoff, 1878, Ratio, descriptio, emendatio, eorum, tomicinorum, p. 408.

Geographic distribution and host range.—*G. sulcatus* occurs throughout western North America and attacks conifers in the family Pinaceae.

California records (map 93).—Various localities in the following counties: El Dorado, Fresno, Humboldt, Lassen, Marin, Mendocino, Modoc, Monterey, Nevada, Plumas, San Mateo, Santa Cruz, Siskiyou, Trinity, and Tulare.

Biology. (Daterman et al., 1965; Prebble and Graham, 1957)

This species works in dying or recently dead trees, logs, tops, stumps, and larger limbs. The first attacks of the season begin in early April and continue through late May. Later in the summer and fall there is a second flight period to logs not attacked in the spring flight as well as to any fresh material.

The initial gallery is begun by the male but the female soon takes over. The galleries are kept clean of boring dust and the accumulation of white powdery material is a characteristic symptom of attack. The excavation and extension of a single gallery system may continue for a year or more. The entrance tunnel runs directly into the sapwood where several branch galleries, usually four, will be found. Galleries may extend 10 to 25 cm or more. The entire gallery system lies in one plane at right angles to the grain (fig. 28). Within a month after attack, black-stalked fruiting bodies of an ambrosial fungus develop; these later stain the wood adjacent to the gallery black.

Eggs are laid singly in niches cut in the end grain of the wood along the galleries and are packed in with fine chips. Up to 60 eggs may be found in a single gallery system. The larvae enlarge their niches as they grow and pupate therein. All stages overwinter in the log.

There are probably two generations per year with overlapping broods. Overwintered brood adults feed on the ambrosial fungus before emerging to begin the spring attack. Their progeny form the second generation in mid-to-late summer which then overwinters.

Discussion.—*G. sulcatus* closely resembles *G. retusus* but the pregular and frontal characters, as given in the key, will easily distinguish the adults of the two species.

It appears from the collection records that *G. sulcatus* is found in *Abies* spp., while *G. retusus* is found in *Pinus* spp. Blackman (1931*b*) states that both species of bark beetles feed in a wide variety of coniferous hosts. The differences found in California could be due simply to a bias in the records or could reflect something of a more fundamental nature.

LIST OF HOST PLANTS AND SCOLYTIDS ATTACKING THEM

All plant names are from Munz and Keck (1959)

CONIFEROPHYTA

CUPRESSACEAE

Chamaecyparis spp.
- *Phloeosinus cristatus*

C. lawsoniana (A. Murr.) Parl.
- *Phloeosinus cupressi*
- *P. sequoiae*

Cupressus spp.
- *Phloeosinus frontalis*
- *P. sequoiae*
- *P. cristatus*

C. arizonica Greene
- *Phloeosinus frontalis*
- *P. sequoiae*
- *P. cristatus*

C. bakeri Jeps.
- *Phloeosinus hoppingi*

C. forbesii Jeps.
- *Phloeosinus cristatus*
- *P. frontalis*

C. goveniana Gord.
- *Phloeosinus cristatus*
- *P. cupressi*

C. macnabiana A. Murr.
- *Phloeosinus hoppingi*

C. macrocarpa Hartw. ex Gord.
- *Phloeosinus cristatus*
- *P. frontalis*
- *P. cupressi*
- *Xyleborus saxesini*

C. quadelupensis S. Nats.
- *Phloeosinus cristatus*
- *P. frontalis*

C. sargentii Jeps.
- *Phloeosinus cristatus*
- *P. cupressi*
- *P. setosus*
- *P. swainei*
- *P. variolatus*

C. stephensonii C. B. Wolf
- *Phloeosinus frontalis*

Juniperus spp.
- *Phloeosinus serratus*
- *P. cristatus*

J. occidentalis Hook.
- *Phloeosinus rugosus*
- *P. serratus*

Libocedrus decurrens Torr.
- *Phloeosinus antennatus*
- *P. cristatus*
- *P. fulgens*
- *P. hoppingi*
- *P. punctatus*
- *P. vandykei*

Thuja spp.
- *Phloeosinus cristatus*

T. occidentalis L.
- *Phloeosinus cupressi*

PINACEAE

Abies spp.
- *Carphoborus simplex*
- *Hylastes nigrinus*
- *Monarthrum scutellare*(?)
- *Pseudohylesinus dispar dispar*
- *P. grandis*
- *P. granulatus*
- *Scolytus abietis*
- *S. praeceps*
- *S. subscaber*
- *S. ventralis*
- *Taenioglyptes ruficollis amabilis*
- *Trypodendron lineatum*(?)
- *Xyleborus scopulorum*

Abies bracteata (D. Don) Nutt.
- *Dolurgus pumilus*
- *Scolytus dentatus*
- *S. praeceps*

A. concolor (Gord. & Glend.) Lindl.
- *Crypturgus borealis*
- *Gnathotrichus sulcatus*
- *Pityokteines elegans*
- *P. minutus*
- *Pityophthorus abietis*
- *P. confertus*
- *P. nitidulus*
- *P. pseudotsugae*
- *Platypus wilsoni*
- *Pseudohylesinus dispar dispar*
- *P. grandis*
- *P. nebulosus nebulosus*
- *Scolytus abietis*
- *S. subscaber*
- *S. ventralis*
- *S. praeceps*
- *Xyleborus scopulorum*

A. grandis (Dougl.) Lindl.
Gnathotrichus sulcatus
Taenioglyptes pubescens
A. magnifica A. Murr.
Crypturgus borealis
Gnathotricus sulcatus
Pityokteines elegans
Pityophthorus nitidulus
P. pseudotsugae
Platypus wilsoni
Pseudohylesinus grandis
Scolytus praeceps
S. subscaber
S. ventralis
Taenioglyptes ruficollis amabilis
Picea Spp.
Hylastes nigrinus
Trypodendron lineatum
T. rufitarsus
P. breweriana Wats.
Carphoborus intermedius
Dendroctonus brevicomis
D. rufipennis
Pityophthorus nitidulus
Scolytus piceae
Trypodendron lineatum
T. rufitarsus
P. engelmanni Parry ex Engelm.
Dendroctonus rufipennis
Gnathotricus retusus
Ips tridens
Pityogenes fossifrons
Pseudohylesinus sitchensis
Scierus annectans
Scolytus piceae
Trypodendron lineatum
Xylechinus montanus
P. sitchensis (Bong.) Carr.
Dendroctonus rufipennis
Dolurgus pumilus
Hylastes nigrinus
Hylurgops rugipennis
Ips concinnus
I. tridens
Pityophthorus nitidulus
Pseudohylesinus sitchensis
Taenioglyptes pubescens
Pinus spp.
Hylastes nigrinus
Ips pini
Pityophthorus abietis(?)
P. digestus(?)
P. nitidulus
Trypodendron lineatum
T. rufitarsus
Xyleborus scopulorum
P. albicaulis Engelm.
Dendroctonus ponderosae
Ips latidens
Myeloborus confusus
Pityogenes fossifrons
Pityophthorus absonus
P. confertus
P. confinus
P. murrayanae
P. opimus
P. praealtus
P. aristata Engelm.
Carphoborus declivis
Hylastes gracilis
Ips latidens
Pityogenes fossifrons
Pityophthorus artifex
P. murrayanae
P. praealtus
P. opimus
P. attenuata Lemmon
Carphoborus simplex
Dolurgus pumilus
Hylurgops porosus
H. rugipennis
Ips sabinianae
I. latidens
I. mexicanus
I. plastographus maritimus
I. paraconfusus
Pityophthorus confertus
P. deleoni
P. tuberculatus
P. balfouriana Grev. & Balf. in A. Murr.
Carphoborus tuberculatus
Dendroctonus ponderosae
Hylurgops pinifex
Pityophthorus inyoensis
P. praealtus
P. sierraensis
P. tuberculatus
P. contorta Dougl. ex Loud.
H. porosus
H. rugipennis
I. mexicanus
I. plastographus maritimus
P. nitidulus
P. tuberculatus
Pseudohylesinus sericeus
P. coulteri D. Don.
Carphoborus pinicolens
C. simplex
D. valens
Hylastes gracilis
Ips latidens
I. paraconfusus
Pityokteines ornatus
Pityophthorus artifex
P. carmeli
P. confinus
P. confertus
P. scalptor
P. tuberculatus
Xyleborus scopulorum
P. edulis Engelm.
Pityokteines ornatus
Pityophthorus modicus
P. flexilis James
Carphoborus pinicolens
C. tuberculatus
Conophthorus flexilis
Dendroctonus ponderosae
Ips integer(?)
I. latidens
Pityogenes carinulatus
P. fossifrons
Pityophthorus confertus
P. monophyllae
P. murrayanae
P. opimus
P. sierraensis
P. toralis
P. tuberculatus
P. jeffreyi Grev. & Balif. in A. Murr.
Ancyloderes pilosus
Cactopinus pini
Carphoborus simplex
Conophthorus ponderosae
Dendroctonus brevicomis
D. jeffreyi
D. valens
Gnathotricus retusus
Hylastes tenuis
Hylurgops pinifex
H. porosus
H. reticulatus
H. subcostulatus
Ips emarginatus
I. latidens
I. mexicanus
I. paraconfusus
I. pini
I. sabinianae
Pityogenes carinulatus
P. fossifrons
Pityokteines ornatus
Pityophthorus artifex
P. confertus
P. confinus
P. deleoni
P. idoneus
P. jeffreyi
P. scalptor
P. tuberculatus
Xyleborus scopulorum
P. lambertiana Dougl.
Cactopinus koebeli
Carphoborus pinicolens
C. simplex
Conophthorus lambertiana
Dendroctonus brevicomis
D. ponderosae
D. valens
Gnathotricus retusus
Hylurgops porosus
H. subcostulatus
Ips latidens
I. paraconfusus
Pityogenes carinulatus
Pityokteines ornatus
Pityophthorus brucki
P. confertus
P. confinus
P. dolus
Xyleborus saxesini

P. monophylla Torr. & Frem.
Cactopinus koebeli
C. pini
Carphoborus frontalis
C. pinicolens
C. simplex
Conophthorus monophyllae
Dendroctonus valens
Ips confusus
Myeloborus keeni
Pityophthorus blandus
P. confertus
P. digestus
P. grandis
P. modicus
P. monophyllae
P. punctifrons
P. singularis
P. tuberculatus
P. monticola Dougl.
Carphoborus tuberculatus
Conophthorus monticolae
Dendroctonus ponderosae
Hylurgops porosus
H. subcostulatus
Ips emarginatus
I. integer(?)
I. latidens
I. montanus
I. paraconfusus
Pityogenes fossifrons
Pityophthorus confertus
P. murrayanae
P. tuberculatus
Trypodendron lineatum
P. muricata D. Don.
Carphoborus simplex
Dendroctonus valens
Dolurgus pumilus
Hylurgops porosus
H. rugipennis
Ips mexicanus
I. paraconfusus
I. plastographus maritimus
Pityophthorus aurulentus
P. carmeli
P. confertus
P. nitidulus
P. setosus
Pseudohylesinus sericeus
P. murrayanae Grev. and Balf. in A. Murr.
Carphoborus declivis
C. pinicolens
Conophthorus contortae
Dendroctonus ponderosae
D. valens
Hylurgops porosus
H. subcostulatus
Ips emarginatus
I. integer
I. latidens
I. mexicanus
I. montanus
I. paraconfusus
I. pini
I. plastographus plastographus
Myeloborus boycei
Orthotomicus caelatus
Pityogenes carinulatus
P. fossifrons
P. knechteli
Pityophthorus absonus
P. confertus
P. idoneus
P. scalptor
P. tuberculatus
P. ponderosa Dougl. ex P.&C. Lawson
Carphoborus pinicolens
C. ponderosae
C. simplex
Conophthorus ponderosae
Dendroctonus brevicomis
D. jeffreyi
D. ponderosae
D. valens
Dryocoetes autographus
Gnathotricus retusus
Hylastes longicollis(?)
Hylurgops pinifex
H. porosus
H. reticulatus
H. rugipennis
H. subcostulatus
Ips calligraphus calligraphus
I. emarginatus
I. integer
I. latidens
I. mexicanus
I. paraconfusus
I. pini
I. sabinianae
Pityogenes carinulatus
Pityokteines ornatus
Pityophthorus artifex
P. confertus
P. confinus
P. dolus
P. idoneus
P. scalptor
P. serratus
P. tuberculatus
P. tumidus
Xyleborus scopulorum
P. quadrifolia Parl. ex Sudsw.
Pityophthorus punctifrons
P. radiata D. Don.
Carphoborus radiatae
C. simplex
Conophthorus radiatae
Dendroctonus brevicomis
D. ponderosae
D. valens
Dolurgus pumilus
Hylastes tenuis
Hylurgops porosus
H. rugipennis
Ips mexicanus
I. paraconfusus
I. plastographus maritimus
Pityophthorus aurulentus
P. carmeli
P. confertus
P. nitidulus
P. setosus
Pseudohylesinus sericeus
P. sabiniana Dougl.
Cactopinus rhois (?)
Carphoborus simplex
Hylastes gracilis
H. tenuis
Ips latidens
Ips paraconfusus
I. sabinianae
Pityophthorus confertus
P. confinus
P. modicus
P. tuberculatus
P. torreyana Parry ex Carr.
Pityophthorus carmeli
Pseudotsuga spp.
Trypodendron lineatum
P. macrocarpa (Vasey) Mayr
Carphoborus blaisdelli
Pseudohylesinus nebulosus serratus
Scolytus oregoni
P. menziesii (Mirb.) Franco
Carphoborus vandykei
Dendroctonus pseudotsugae
Dryocoetes autographus
Gnathotricus retusus
G. sulcatus
Hylastes nigrinus
P. confertus
P. pseudotsugae
Platypus wilsoni
Pseudohylesinus grandis
P. nebulosus nebulosus
Scolytus unispinosus
Taenioglyptes pubescens
Trypodendron lineatum
Tsuga spp.
Hylastes nigrinus
Scolytus abietis
Trypodendron lineatum
T. heterophylla (Raf.) Sarg.
Pseudohylesinus grandis
P. tsugae
T. mertensiana (Bong.) Carr.
Pityophthorus pseudotsugae
Scolytus tsugae

TAXODIACEAE
Sequoia sempervirens (D. Don.) Endl.
Monarthrum scutellare
Phloeosinus sequoiae
Taenioglyptes pubescens
Trypodendron lineatum
Sequoiadendron giganteum (Lindl.) Bochh.
Phoeosinus punctatus

ANTHOPHYTA

ACERACEAE
Acer spp.
- *Xyleborus saxesini*

ANACARDIACEAE
Rhus spp.
- *Cactopinus rhois*
- *Chaetophloeus hystrix*
- *C. penicillatus*
- *Hylocurus hirtellus*
- *Stenoclyptes rhois*

BETULACEAE
Alnus spp.
- *Alniphagus aspericollis*
- *A. hirsutus*
- *Xyleborus saxesini*

BURSERACEAE
Bursera microphylla Gray.
- *Cactopinus desertus*
- *Dendroterus striatus*

COMPOSITAE
Encelia californica Nutt.
- *Chaetophloeus maclayi*
- *Hypothenemus calif. californicus*

E. farinosa Gray.
- *Chaetophloeus pruinosus*

CUCURBITACEAE
Cucurbita foetidissima HBK
- *Dendrocranulus californicus*

ERICACEAE
Arbutus spp.
- *Hylocurus hirtellus*

FAGACEAE
Juglans californica Wats.
- *Monarthrum dentiger*
- *Pityophthorus juglandis*

Lithocarpus densiflora (H. & A.) Rehd.
- *Monarthrum scutellare*
- *Pseudopityophthorus pubipennis*
- *Xyleborus saxeseni*

Myrica spp.
- *Hylocurus hirtellus*

Quercus spp.
- *Chramesus dentatus*
- *Monarthrum dentiger*
- *M. scutellare*
- *Pseudopityophthorus agrifoliae*
- *P. pubipennis*
- *P. pulvereus*
- *Xyleborus saxeseni*

Q. agrifolia Neé
- *Monarthrum dentiger*
- *M. scutellare*
- *Pseudopityophthorus agrifoliae*
- *P. pubipennis*
- *Xyleborus saxeseni*

Q. chrysolepis Liebm.
- *Hylocurus hirtellus*
- *Pseudopityophthorus agrifolia*
- *Xyleborus saxeseni*

Q. garryana Dougl.
- *Pseudopityophthorus pubipennis*

Q. kelloggi Newb.
- *Monarthrum scutellare*
- *Pseudopityophthorus agrifoliae*
- *P. pubipennis*

Q. lobata Neé
- *Pseudopityophthorus pubipennis*

Q. wislizeni A.DC.
- *Pseudopityophthorus agrifolia*

LAURACEAE
Persea americana Mill.
- *Monarthrum dentiger*
- *Xyleborus saxeseni*

Umbellaria spp.
- *Hylocurus hirtellus*

LEGUMINOSEAE
Amorpha californica Nutt.
- *Chramesus asperatus*

Cercidium floridum Benth.
- *Chaetophloeus parkinsoniae*

C. microphyllum (Torr.) Rose & Jtn.
- *Chaetophloeus parkinsoniae*
- *Hylocurus parkinsoniae*

Cytisus scoparius (L.) Link
- *Hylastinus obscurus*

Lupinus spp.
- *Hylastinus obscurus*

Parkinsonia microphylla Torr.
- *Chaetophloeus parkinsoniae*
- *Hylocurus parkinsoniae*

Prosopis spp.
- *Chaetophloeus fasciatus*

Vicia spp.
- *Hylastinus obscurus*

LORANTHACEAE
Phoradendron spp.
- *Thysanoes phorodendri*

MALVACEAE
Malacothamnus fasciculatus (Nutt.) Greene
- *Hypothenemus calif. californicus*
- *Pseudothysanoes bartoni*

OLEACEAE
Fraxinus spp.
- *Leperisinus californicus*

Olea spp.
- *Leperisinus californicus*

PALMACEAE
Phoenix spp.
- *Coccotrypes dactyliperda*

RHAMNACEAE
Ceanothus spp.
- *Hylocurus hirtellus*
- *Stenoclyptes sulcatus*

ROSACEAE
Cercocarpus ledifolius Nutt.
- *Chaetophloeus heterodoxus*

Heteromeles arbutifolia M. Roem.
- *Chaetophloeus hystrix*

Malus spp.
- *Scolytus rugulosus*

Prunus spp.
- *Chaetophloeus fasciatus*
- *C. heterodoxus*
- *Scolytus rugulosus*
- *Xyleborus saxesini*
- *X. dispar*

P. ilicifolia (Nutt.) Walp.
- *Chaetophloeus fasciatus*
- *C. heterodoxus*

Purshia spp.
- *Chaetophloeus fasciatus*

Pyrus spp.
- *Scolytus rugulosus*

SALICACEAE
Populus tremuloides Michx.
- *Cryphalus thatcheri*
- *Trypodendron retusum*

Salix spp.
- *Hylocurus hirtellus*
- *Micracis swainei*
- *Procryphalus utahensis*

STERCULIACEAE
Fremontia spp.
- *Pseudothysanoes hopkinsi*

ULMACEAE
Ulmus spp.
- *Scolytus multistriatus*

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PLATES

PLATE 1

Figs.1–9. Parent (egg) galleries of some California Scolytidae.
Fig. 1. *Platypus wilsoni* (upper winding gallery) and *Gnathotrichus sulcatus* (lower "laddered" gallery).
Fig. 2. *Scolytus rugulosus.*
Fig. 3. *Scolytus ventralis.*
Fig. 4. *Scolytus unispinosus.*
Fig. 5. *Dendroctonus brevicomis.*
Fig. 6. *Dendroctonus ponderosae.*
Fig. 7. *Pseudohylesinus nebulosus nebulosus.*
Fig. 8. *Pseudohylesinus grandis.*
Fig. 9. *Leperisinus californicus.*

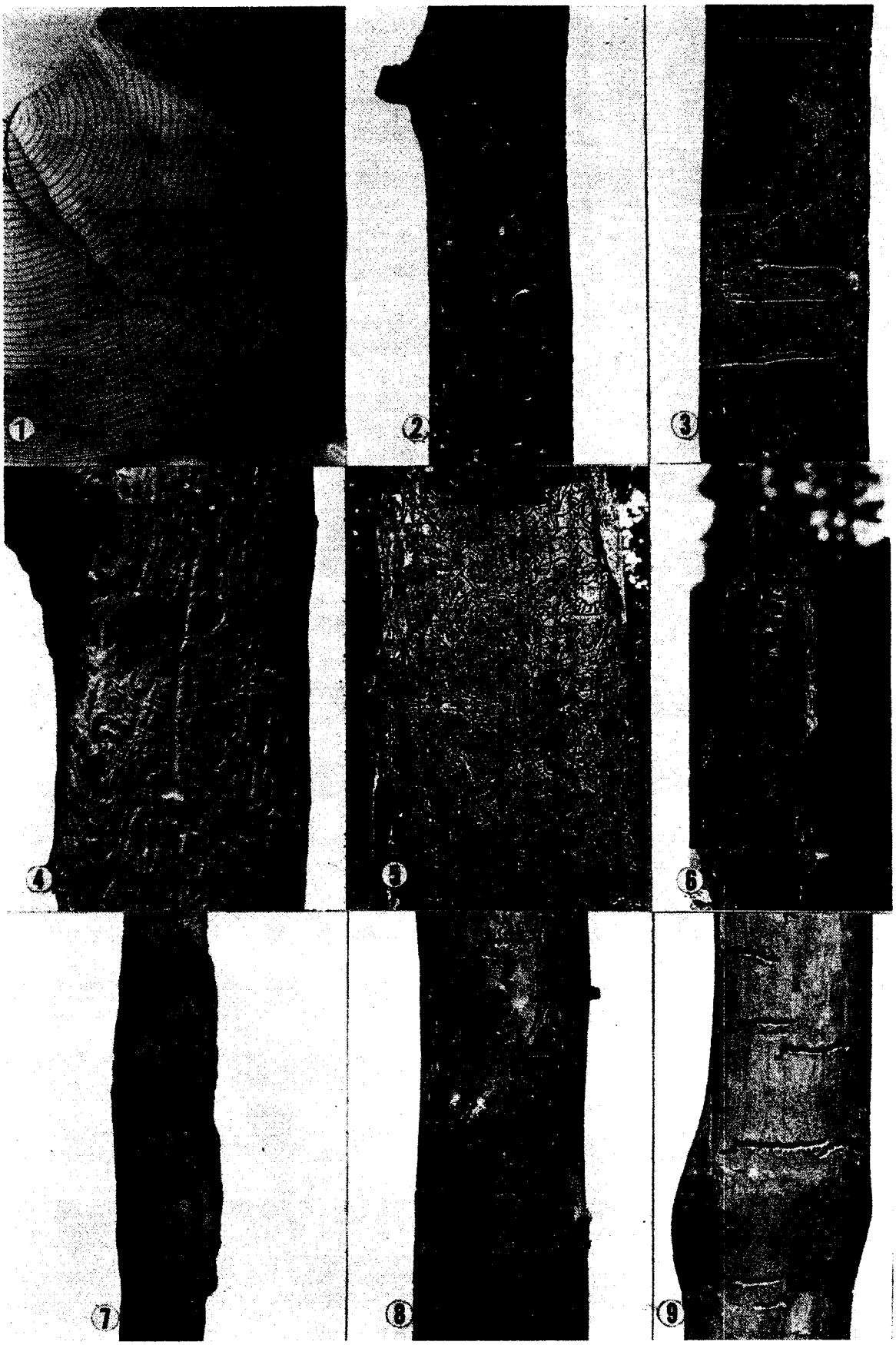
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PLATE 2

Figs. 10–18. Parent (egg) galleries of some California Scolytidae.
Fig. 10. *Alniphagus aspericollis.*
Fig. 11. *Phloeosinus fulgens.*
Fig. 12. *Phloeosinus punctatus.*
Fig. 13. *Phloeosinus variolatus.*
Fig. 14. *Phloeosinus cupressi.*
Fig. 15. *Phloeosinus cristatus.*
Fig. 16. *Chaetophloeus heterodoxus.*
Fig. 17. *Cactopinus desertus.*
Fig. 18. *Cactopinus rhois.*

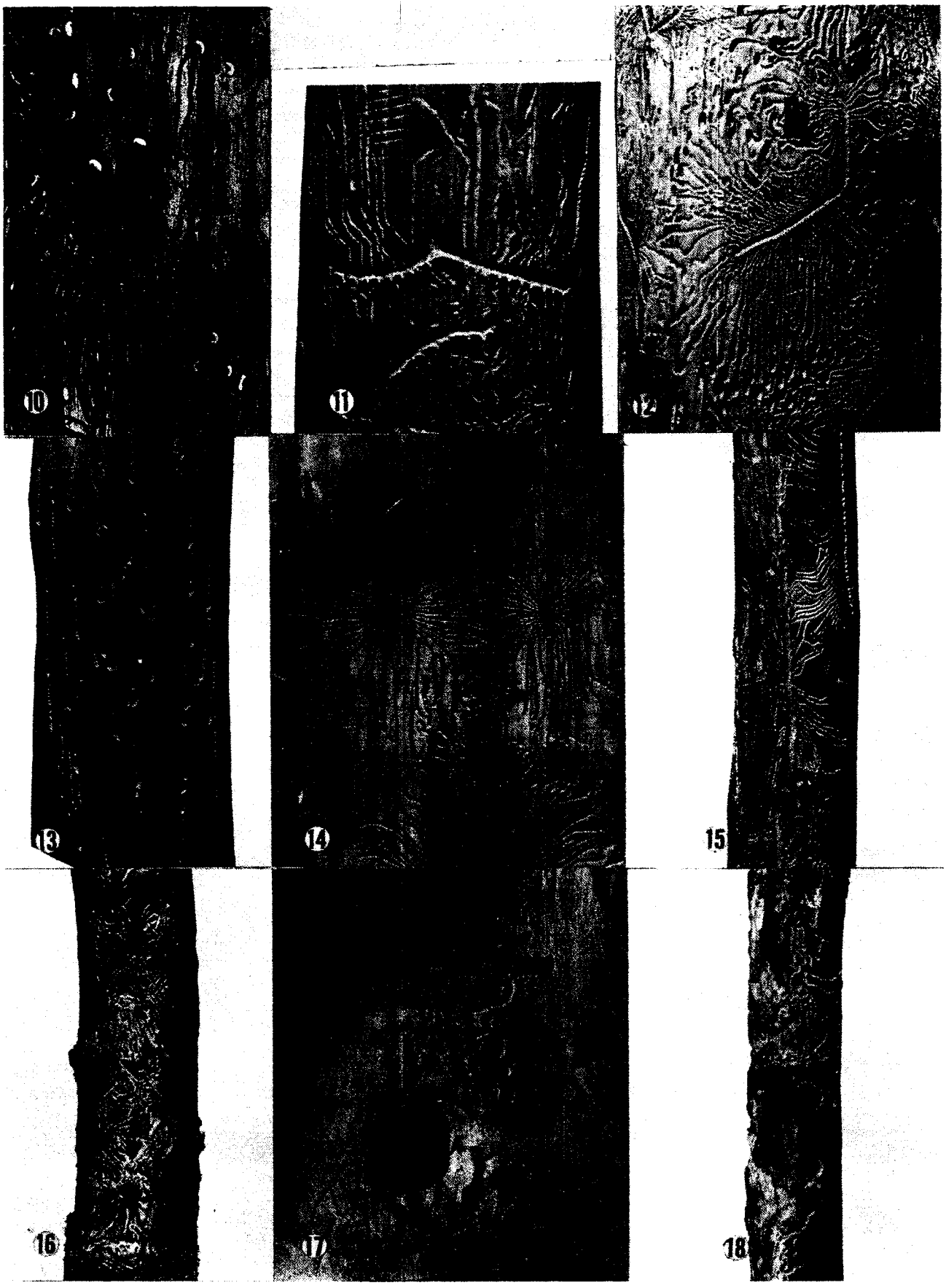
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PLATE 3

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Fig. 19. *Pseudothysanoes hopkinsi.*
Fig. 20. *Trypodendron lineatum.*
Fig. 21. *Pityogenes fossifrons.*
Fig. 22. *Ips mexicanus.*
Fig. 23. *Ips latidens.*
Fig. 24. *Dendroterus striatus.*
Fig. 25. *Pseudopityophthorus pubipennis.*
Fig. 26. *Pityophthorus pseudotsugae.*
Fig. 27. *Monarthrum scutellare.*

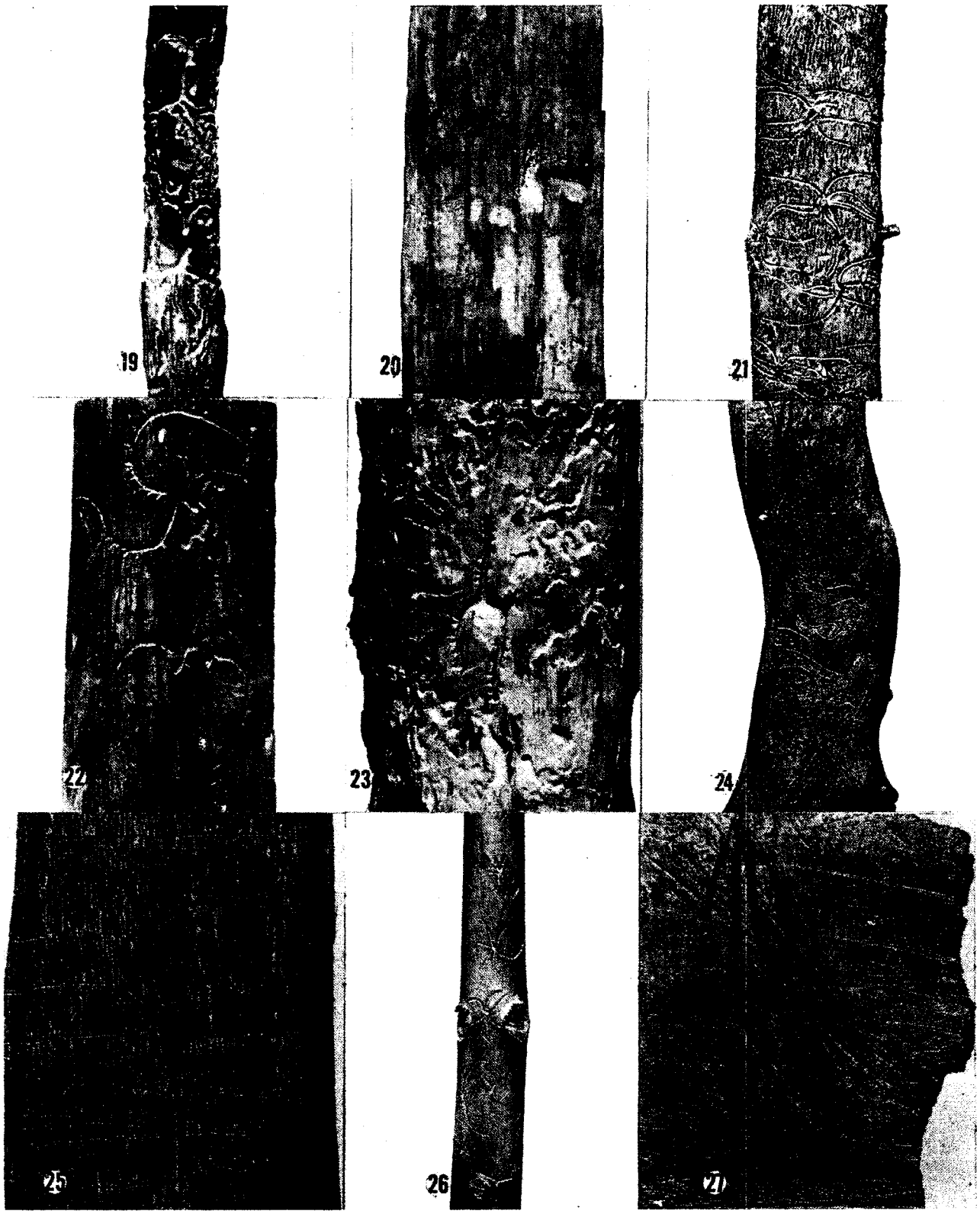
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Fig. 28. Adult gallery of *Gnathotrichus sulcatus* showing egg and larval "cradles."

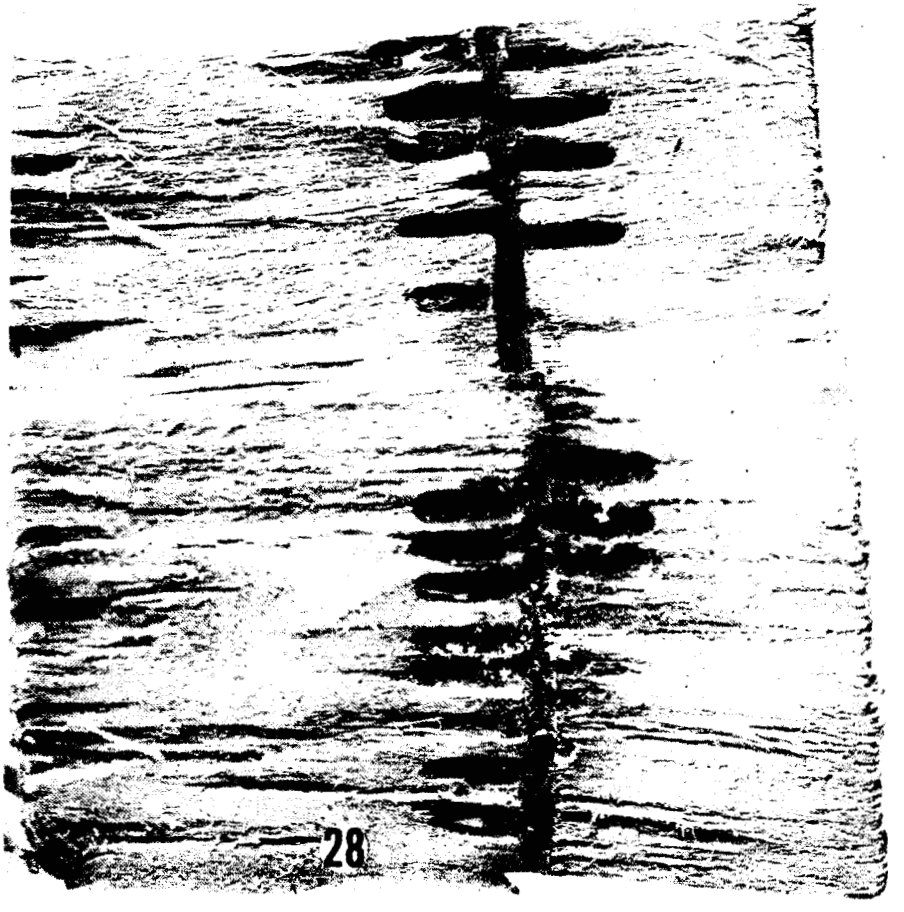
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Fig. 29. Lateral view of *Dendroctonus valens* illustrating various morphological characters used in the keys.
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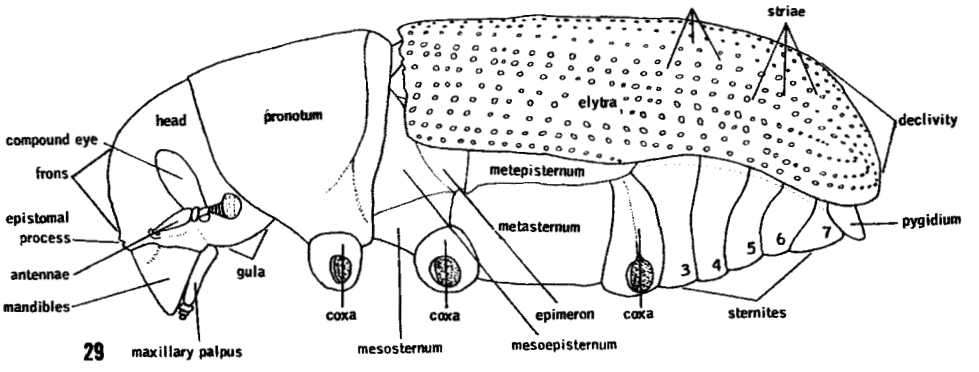
Fig. 33. Fore-leg of *Dendroctonus valens.*
Fig. 34. Fore-leg of *Platypus wilsoni.*



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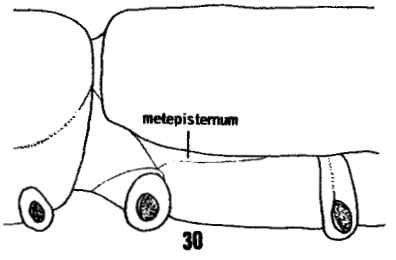

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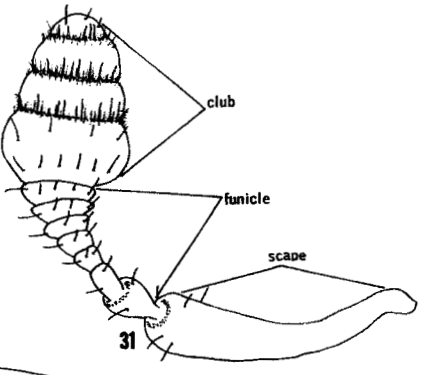

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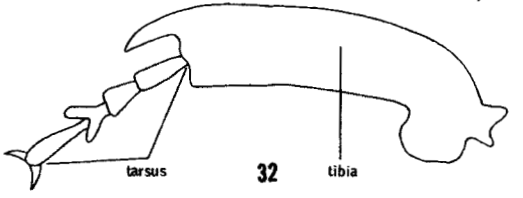

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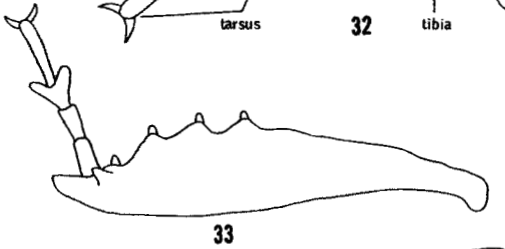

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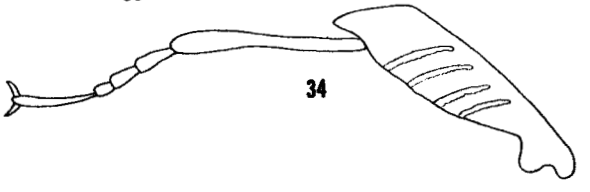

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Fig. 39. *Alniphagus aspericollis.*
Fig. 40. *Phloeosinus punctatus.*
Fig. 41. *Chramesus asperatus* ♂ (including scape).
Fig. 42. *Chramesus dentatus* ♀.
Fig. 43. *Chramesus dentatus* ♂ (including scape).
Fig. 44. *Chaetophloeus parkinsoniae.*
Fig. 45. *Chaetophloeus hystrix.*
Fig. 46. *Carphoborus vandykei.*
Fig. 47. *Carphoborus radiatae.*
Fig. 48. *Pseudothysanoes hopkinsi.*
Fig. 49. *Micracis swainei* ♀ (including scape).
Fig. 50. *Taenioglyptes pubescens.*

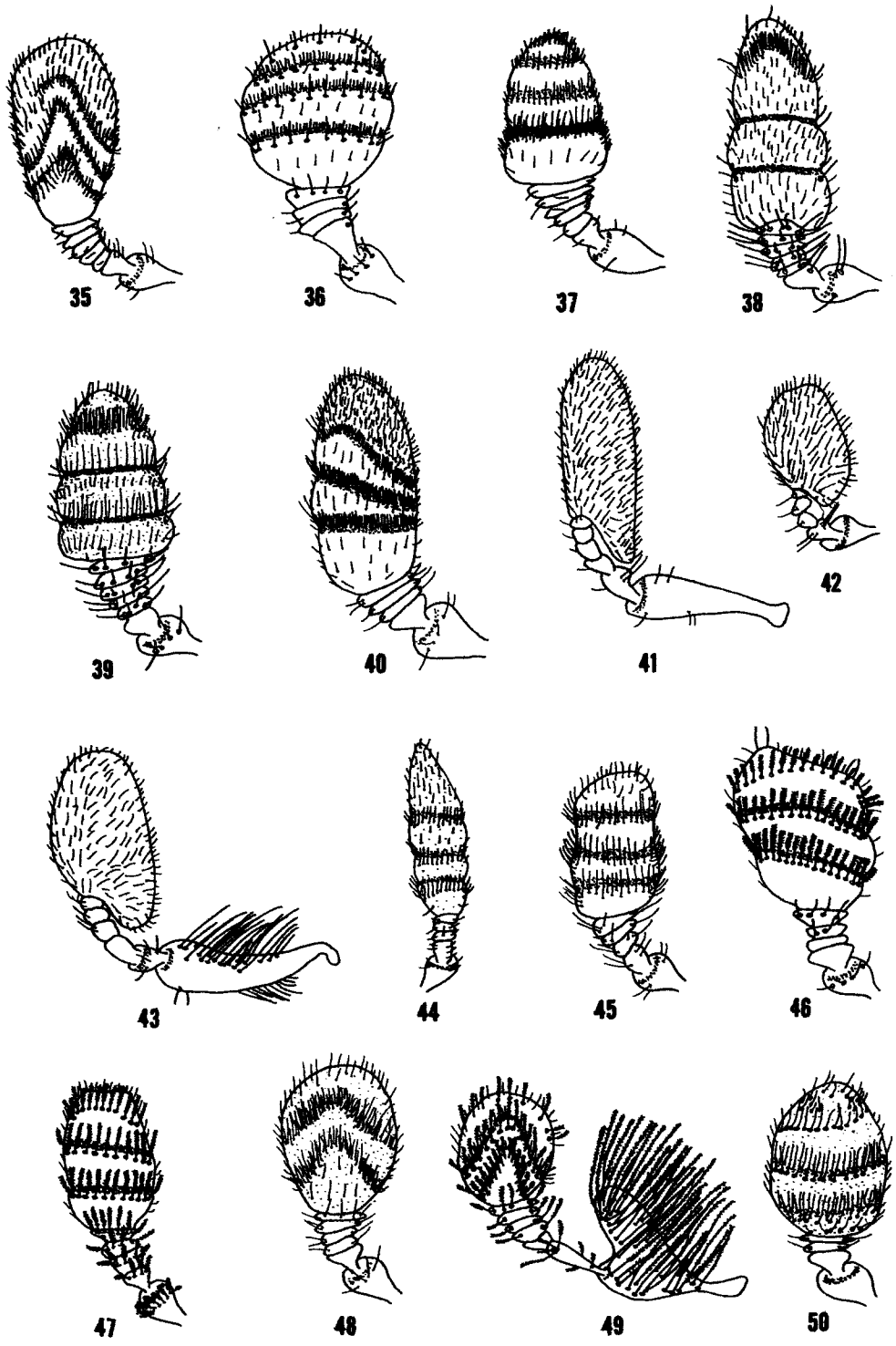
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Fig. 52. *Dolurgus pumilis.*
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Fig. 54. *Dryocoetes autographus.*
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Fig. 65. *Gnathotrichus retusus* ♀.
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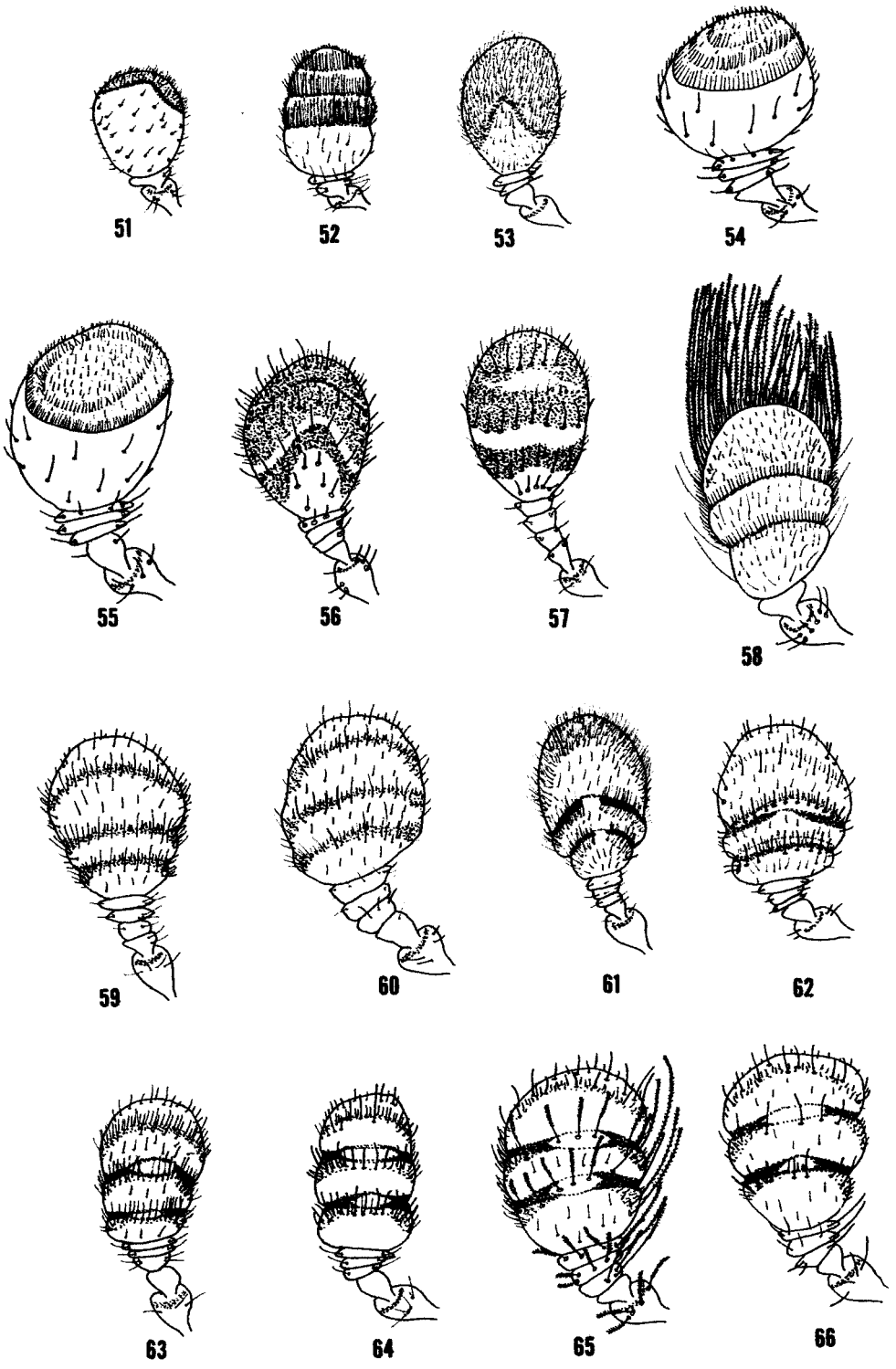
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Fig. 67. *Scolytus ventralis.*
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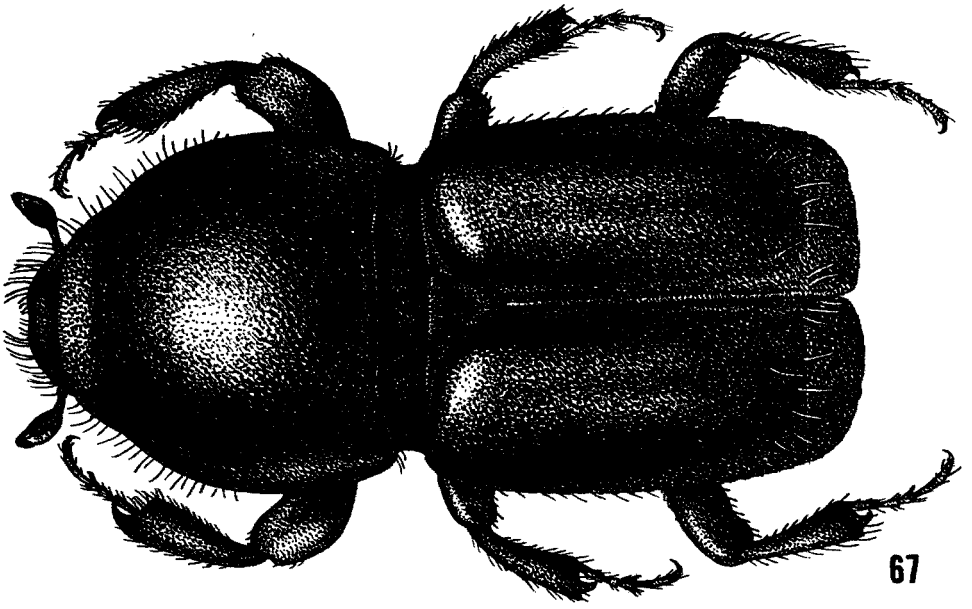

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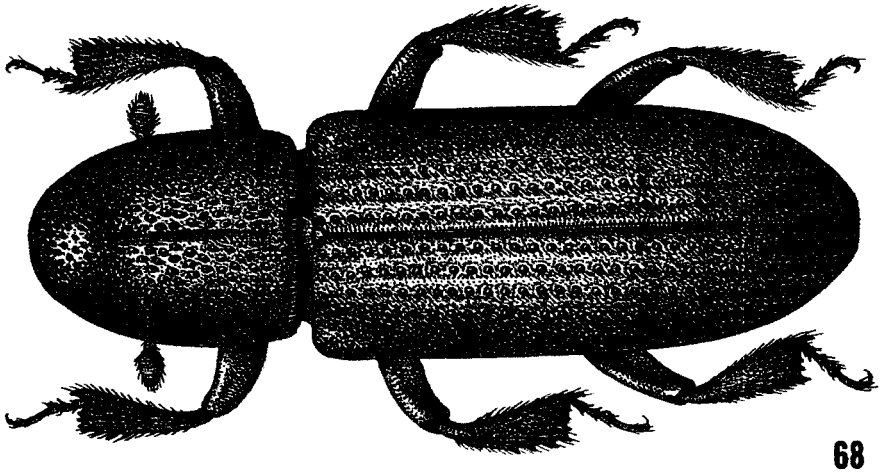

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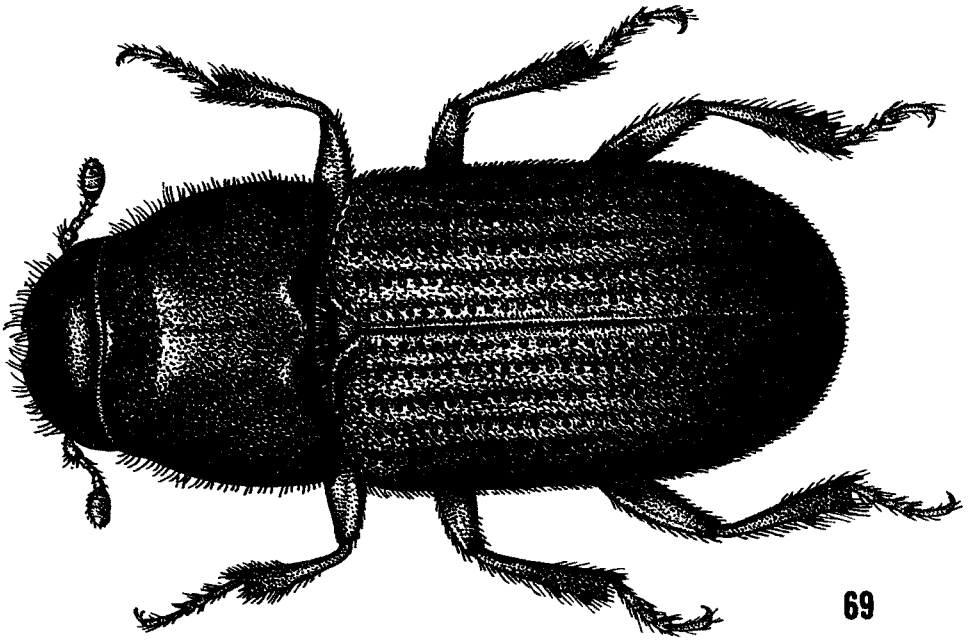
Fig. 69. *Dendroctonus brevicomis.*
Fig. 70. *Pseudohylesinus nebulosus nebulosus.*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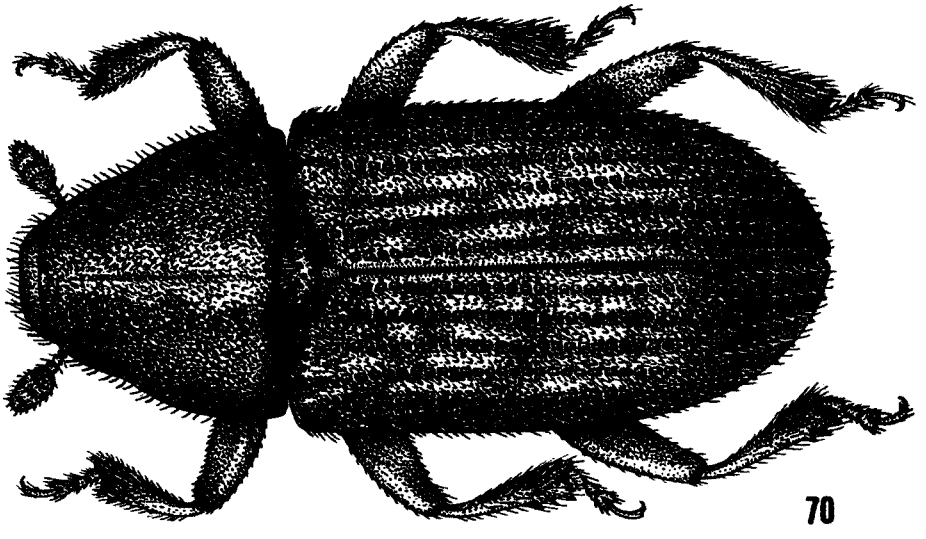
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Fig. 71. *Leperisinus californicus.*
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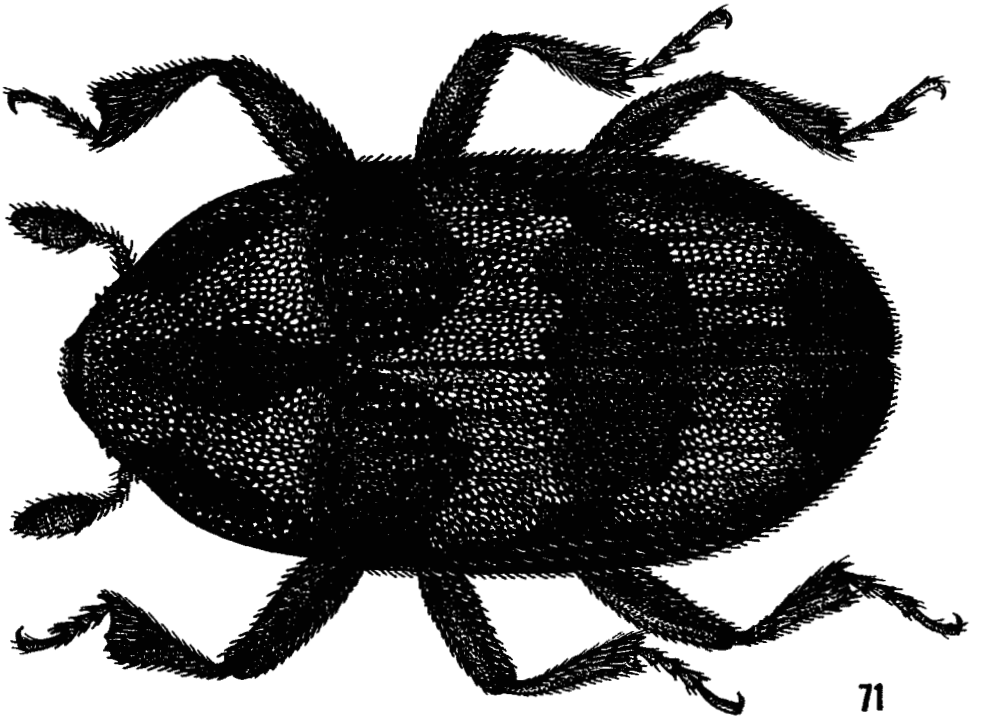

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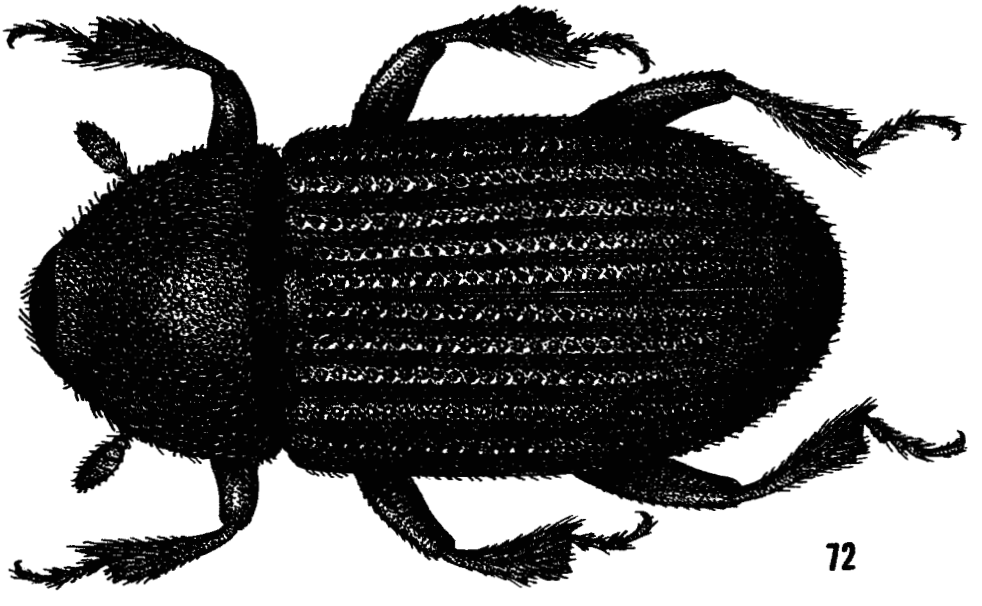

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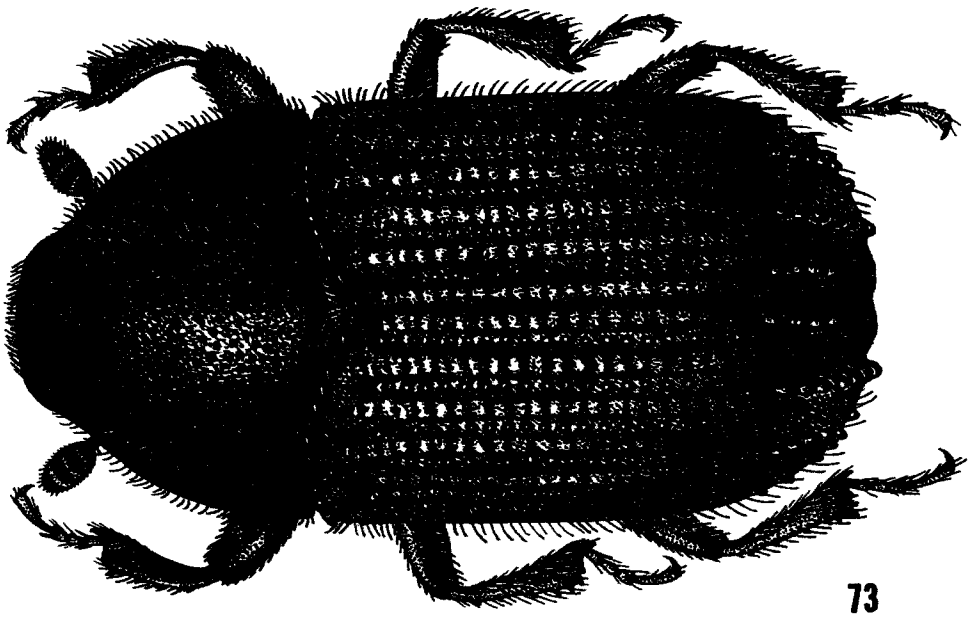

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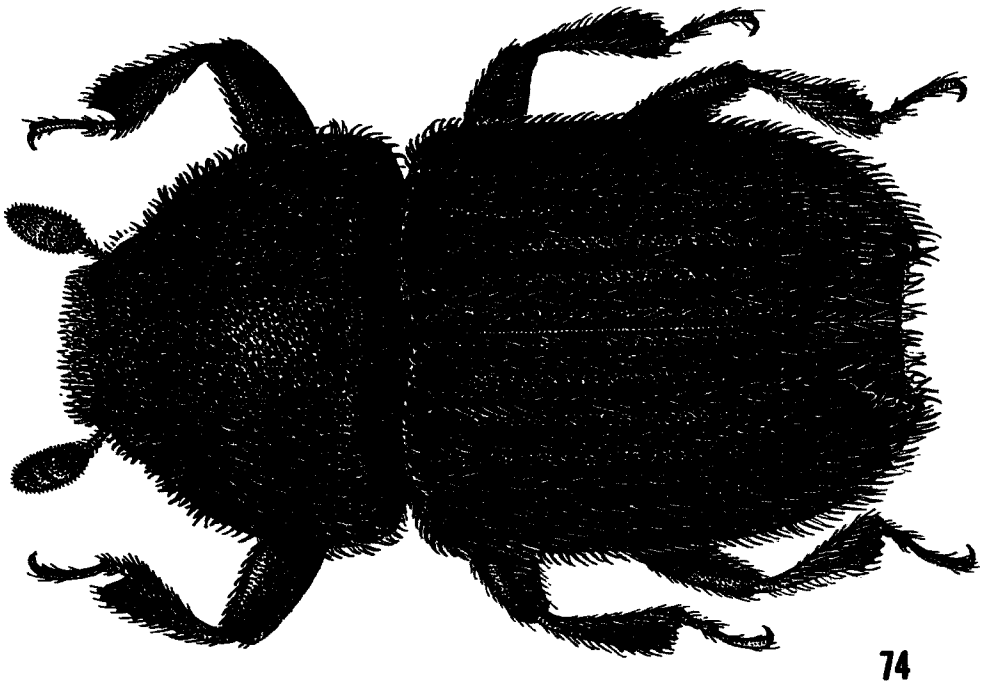

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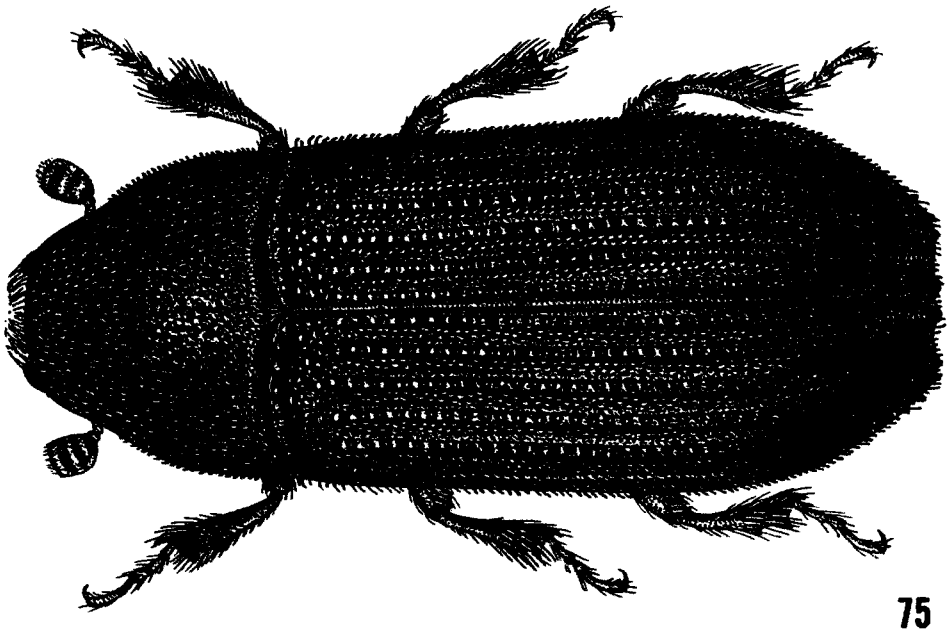
Fig. 76. *Cactopinus desertus.*



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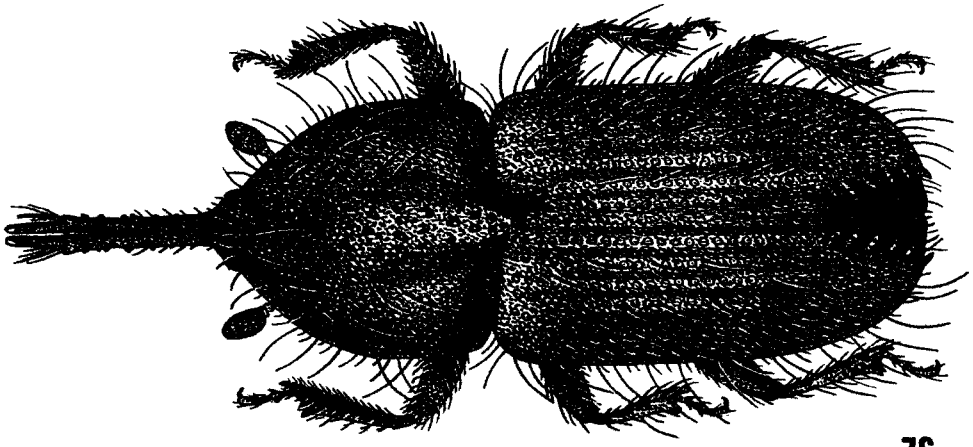

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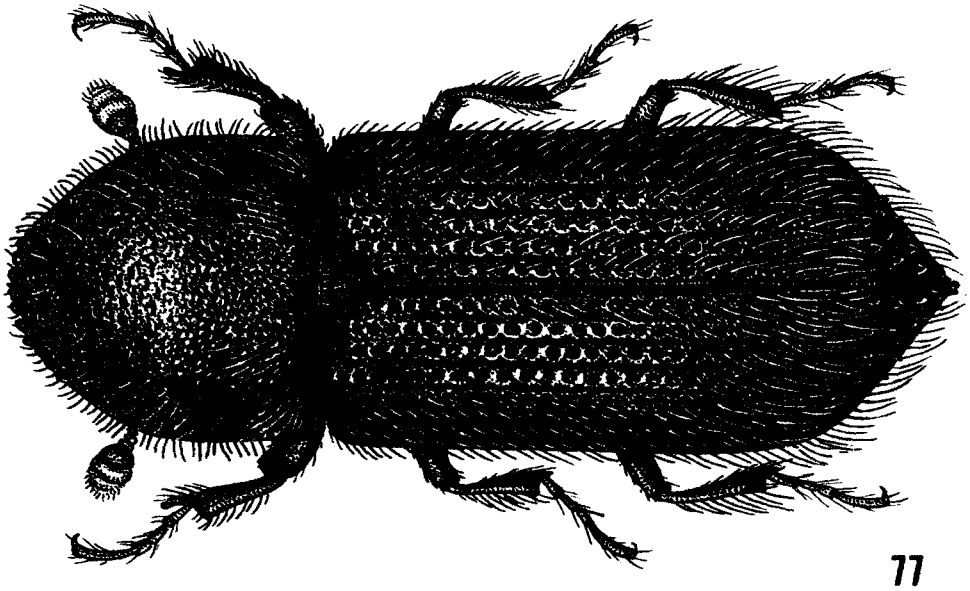
Fig. 78. *Taenioglyptes pubescens.*



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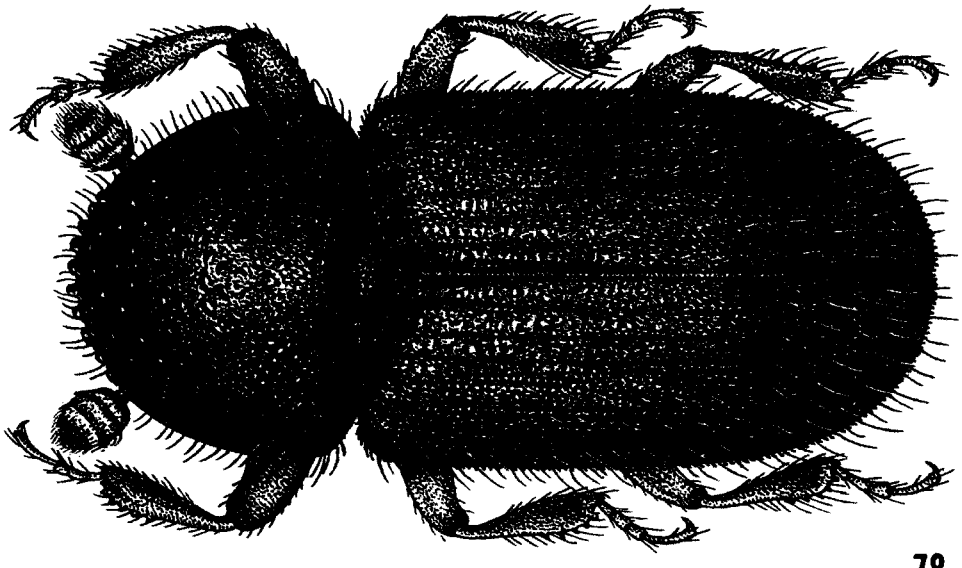

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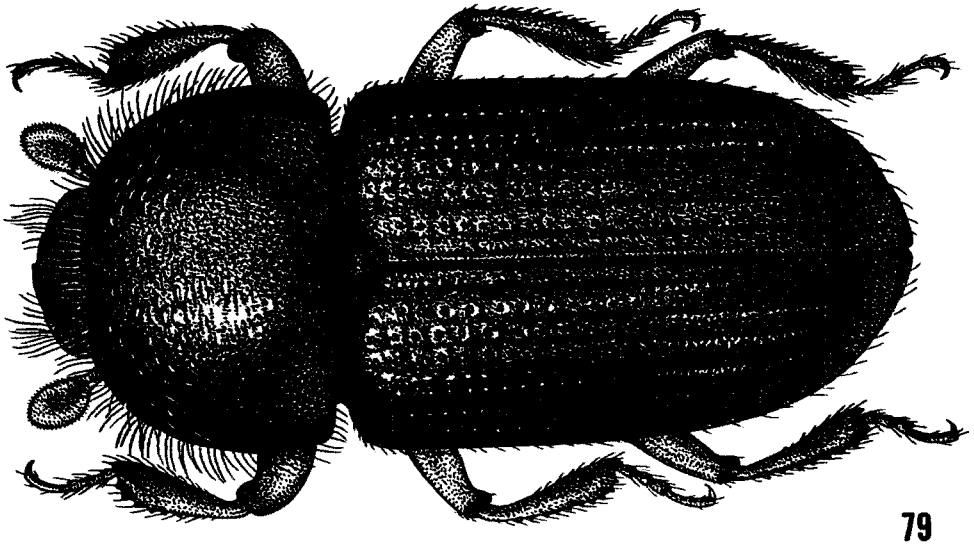

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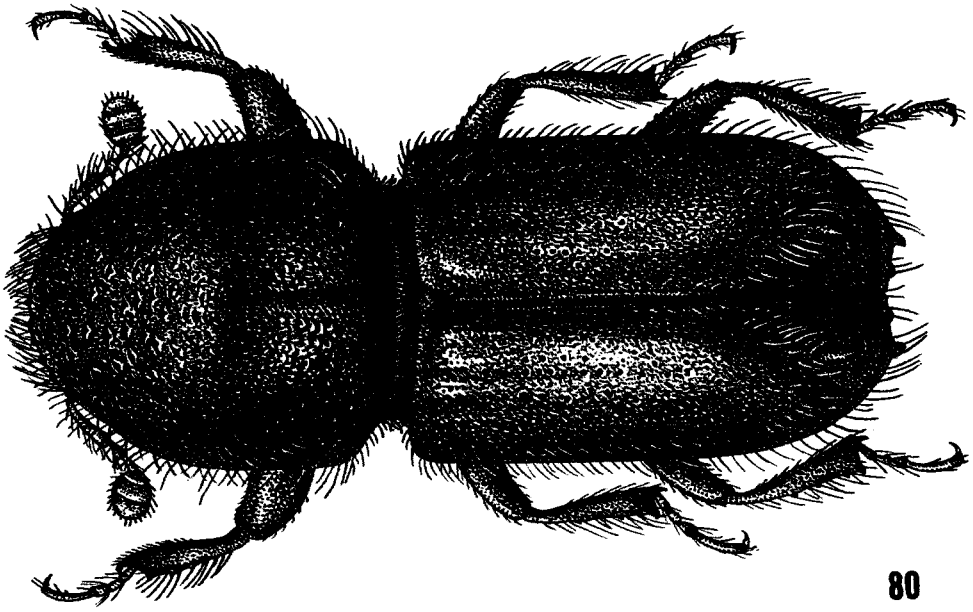

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Fig. 81. *Ips paraconfusus.*
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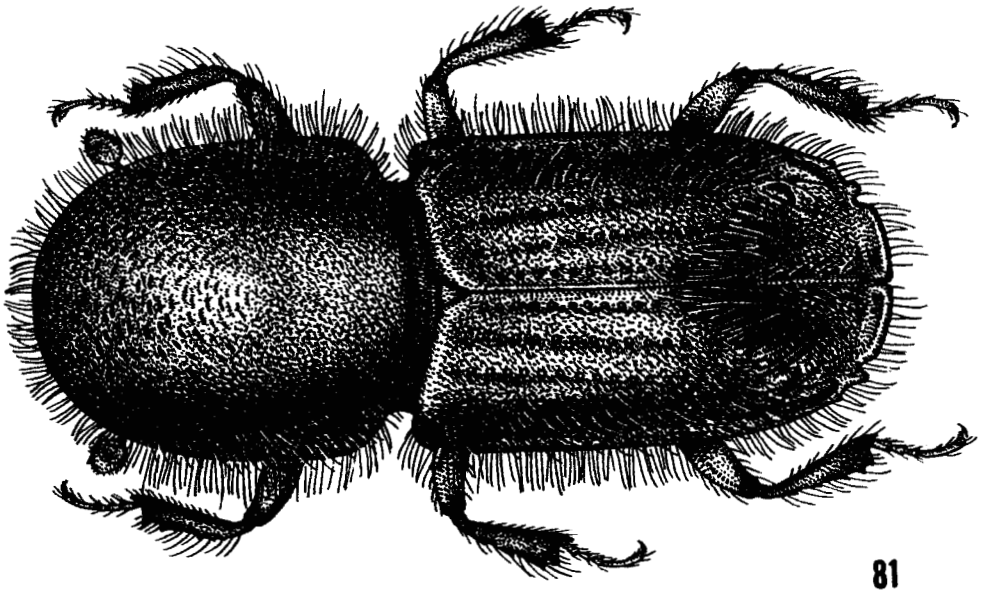

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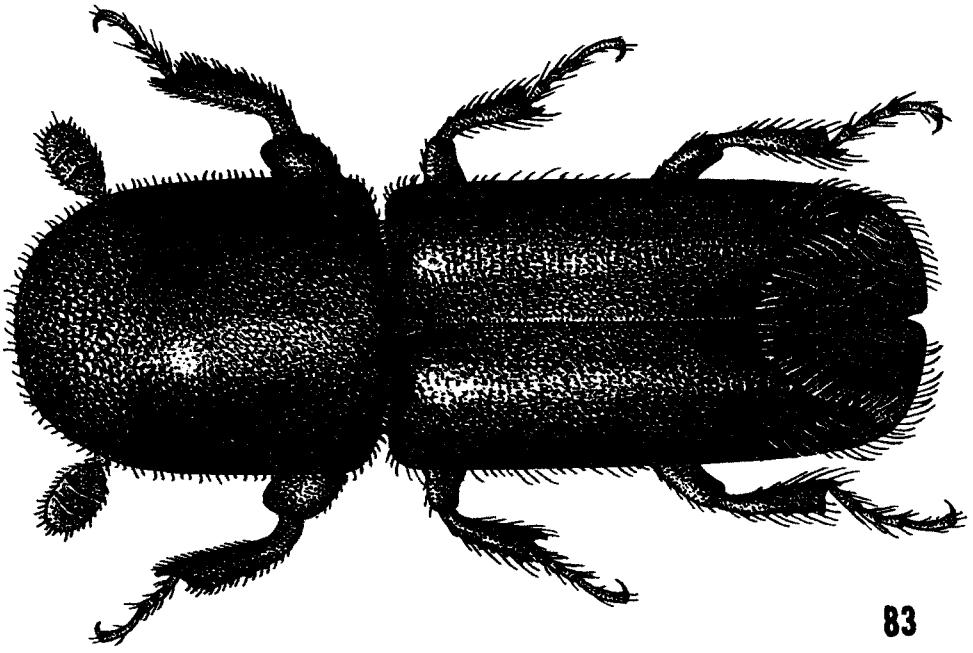

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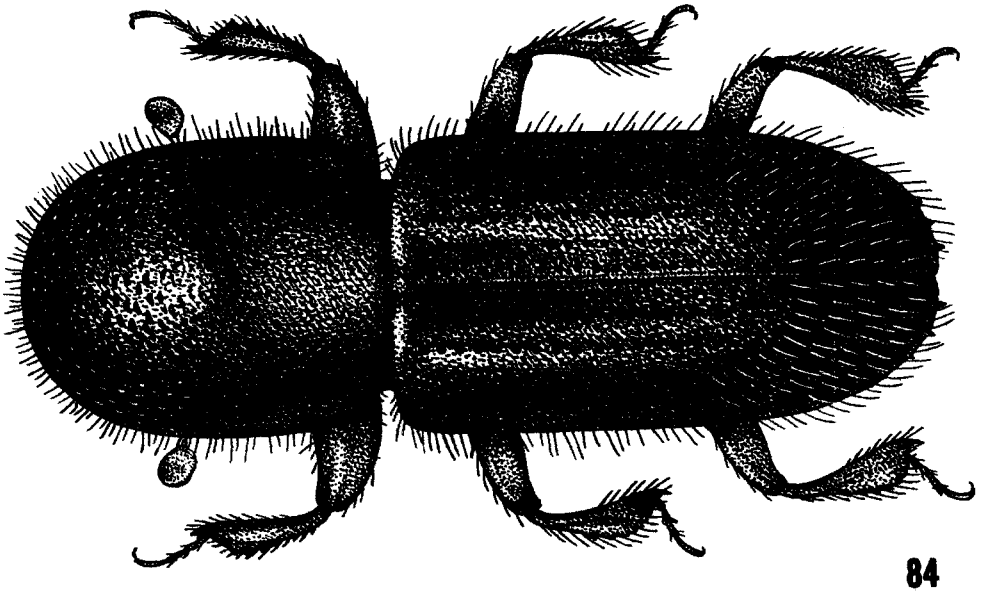

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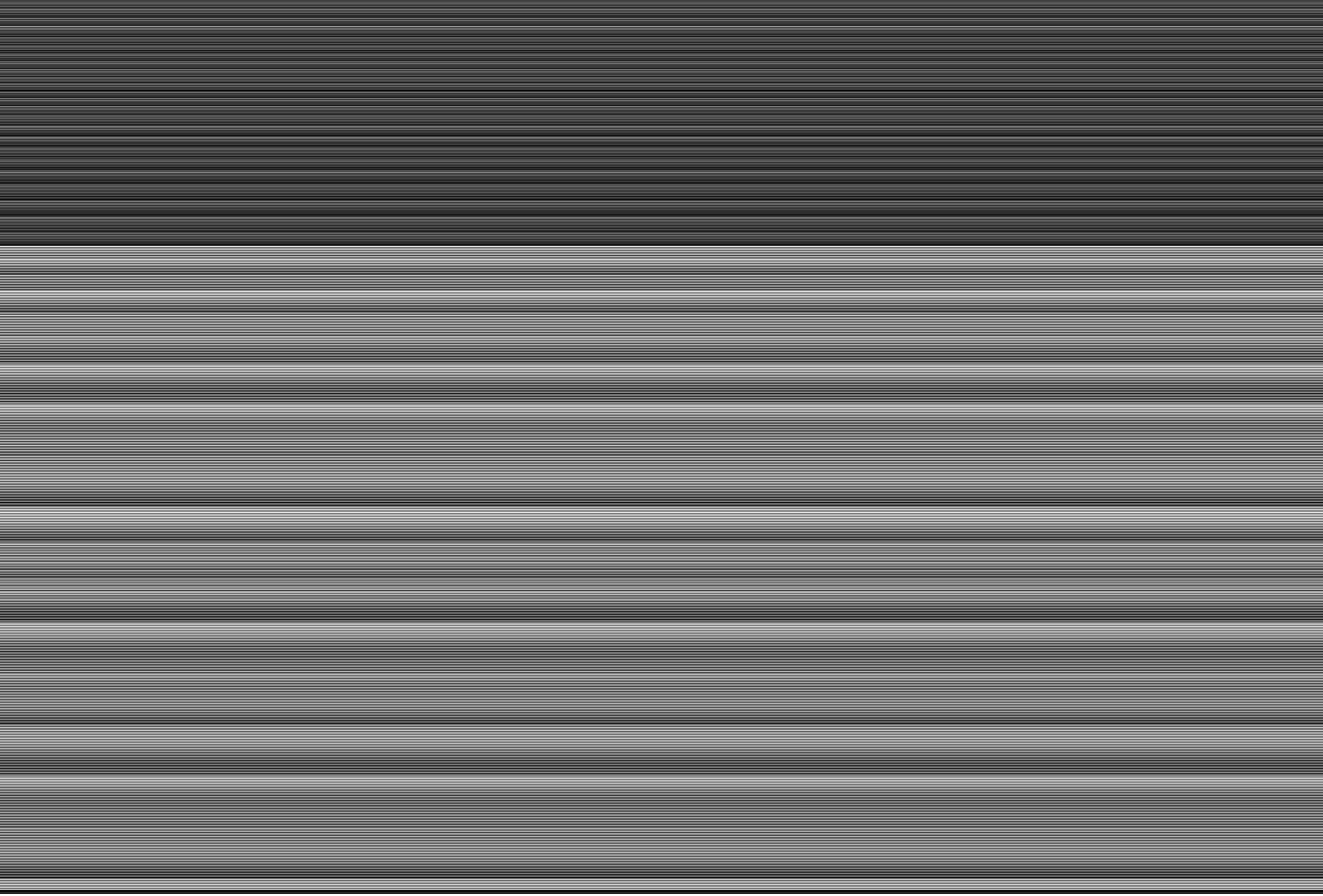

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