

THE SCALE INSECTS OF CALIFORNIA

PART 1

THE SOFT SCALES

(Homoptera:Coccoidea:Coccidae)

by:

Raymond J. Gill
Associate Insect Biosystematist
California Department of Food and Agriculture
Sacramento, California, USA

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Raymond J. Gill

Associate Insect Biosystematist

Analysis and Identification Branch, Division of Plant Industry
California Department of Food and Agriculture
1220 N Street
P. O. Box 942871
Sacramento, California 94721
USA

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The color photograph on the front cover is of the calico scale, *Eulecanium cerasorum* (Cockerell) on liquidamber, taken III-27-80 in Sacramento, Sacramento County California.

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Dedicated to

Roma, Sheri and Susie

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PREFACE

The Soft Scale Insects are a group of animals in the insect family Coccidae, which are in turn included in the suborder Coccoidea in the insect order Homoptera. The Homoptera are separated from other groups of insects by Entomologists primarily because of piercing-sucking types of mouth parts situated near the posterior ventral part of the head. The soft scales, like all other Homoptera, are plant feeders. Many are of economic concern to Agriculture in California and throughout the World. Scale insects are encountered daily by Field Entomologists, County Agricultural and Extension Personnel, University Researchers, Nurserymen, Quarantine Inspectors, Pest Control Advisors and many others. Unfortunately, comprehensive books on the habits and economic importance of these creatures are in short supply. Further, few if any of the scale insects are studied in University and College classes. Hopefully this book will fill some of these gaps.

This book is designed to be both a field guide and a laboratory manual on the soft scales or Coccidae of California. It is the first part of what is hoped will be a five volume set covering all of the scale insects or Coccoidea and the whiteflies of California. The five volumes will be divided as follows: Part 1, The Soft Scales or Coccidae; Part 2, The Miscellaneous Scale Insect Families; Part 3, The Armored Scale Insects or Diaspididae; Part 4, The Mealybugs or Pseudococcidae; and Part 5, The Whiteflies or Aleyrodidae. The volumes are not being produced in any particular phylogenetic order, but rather in the order of need by those field personnel and scientists dealing with scale insects on a day to day basis. The author's reasoning is that two of the three major families of the Coccoidea, the Diaspididae and the Pseudococcidae, have already been thoroughly treated in the two excellent works by Howard McKenzie. However, the soft scales have never been covered in a comprehensive fashion for California and their economic importance dictates that they should be given first priority. All of the remaining scale insect families likewise have never been treated comprehensively in California. Because of this and because of their lesser economic importance, the miscellaneous families are scheduled to be included in the next volume.

While the whiteflies are not part of the same suborder as the scale insects, their appearance and economic status are similar and they will be included in the fifth volume. Like the soft scales, the whiteflies have never been treated comprehensively in the State. There has been much demand for such a treatise. However, the author wishes to postpone publication on the whiteflies of California, at least for a time, because there may be some important changes taking place in California and North American whitefly taxonomy and nomenclature in the next several years.

All of the proposed volumes are essentially written. All that remains is to find the necessary funds for publication and time for the physical typesetting and layout.

This volume is designed with the Field Entomologist and Agriculturalist in mind. Every California soft scale species is listed along with its approved or suggested common name, other historical common names, field characteristics, species which are similar and which are likely to be confused with it in the field, lists of common hosts, general distribution, and summaries of its biology and economic importance. Selected references are provided at the end of each

species treatise. Color photographs of all of the more economic species as well as photographs of some of the less important native or uncommon species are included.

The author has not attempted to give complete host and distributional records for several reasons. Primarily, the Entomology Laboratory Unit, Analysis and Identification Branch, of the California Department of Food and Agriculture, has not kept records of any insect collections or interceptions in any manner except chronological order. With the advent of new and superior computer equipment, it may now be possible to rectify that problem and to get complete host and distributional data for the scale insects. However, data entry will still require years of work and it was deemed more important to publish the volumes without this data in the interests of both time and expense.

Control measures are not included even though they are probably the first concern of the Field Entomologist. With the drastic changes in Pesticide Use Enforcement Regulations that have occurred over the last 10-15 years, the author is really not qualified to dispense such information. Also, several other very useful publications by other authors on the biologies and economic importance of horticultural pests have been removed from circulation because of changes in the legality of use of certain pesticides. It would be an obvious disaster to see this volume follow the same path. However, Biological Control, as it relates to Integrated Pest Management, is not affected by the same restrictions, and references to pertinent literature on natural enemies is included whenever available or appropriate.

For the Laboratory Scientist and Taxonomist, this volume represents a complete checklist and taxonomic treatment of the Coccidae of California. Complete, full scale taxonomic illustrations and keys to the genera and species are provided as well as a complete list of synonymies in most cases. The book is not, however, meant to be a taxonomic review or revision. There are no new species or generic descriptions or changes in synonymies included; they were deemed beyond the scope and general purpose of this book.

This book is meant to compliment the Color and Host Identification Field Keys which are available through this author or the Pest Management and Environmental Monitoring Branch of the California Department of Food and Agriculture, Sacramento.

LIST OF COLOR PHOTOGRAPHS

1. brown soft scale, *Coccus hesperidum* Linnaeus, G. Buxton photo.
2. brown soft scale, *Coccus hesperidum* Linnaeus.
3. brown soft scale, *Coccus hesperidum* Linnaeus.
4. brown soft scale, *Coccus hesperidum* Linnaeus.
5. brown soft scale, *Coccus hesperidum* Linnaeus.
6. brown soft scale, *Coccus hesperidum* Linnaeus.
7. brown soft scale, *Coccus hesperidum* Linnaeus, (parasitized).
8. brown soft scale, *Coccus hesperidum* Linnaeus, (ventral view).
9. orchid soft scale, *Coccus pseudoheperidum* (Cockerell).
10. citricola scale, *Coccus pseudomagnoliarum* (Kuwana).
11. citricola scale, *Coccus pseudomagnoliarum* (Kuwana), (nymphs).
12. long brown scale, *Coccus longulus* (Douglas), T. Kono photo.
13. irregular wax scale, *Ceroplastes irregularis* Cockerell.
14. irregular wax scale, *Ceroplastes irregularis* Cockerell.
15. long brown scale, *Coccus longulus* (Douglas).
16. barnacle scale *Ceroplastes cirripediformis* Comstock.
17. Chinese wax scale, *Ceroplastes sinensis* Del Guercio, T. Kono photo.
18. Chinese wax scale, *Ceroplastes sinensis* Del Guercio, (nymphs).
19. tortoise wax scale, *Ceroplastes cistudiformis* Cockerell.
20. barnacle scale, *Ceroplastes cirripediformis* Comstock.
21. citricola scale, *Coccus pseudomagnoliarum* (Kuwana), G. Buxton photo.
22. calico scale, *Eulecanium cerasorum* (Cockerell), G. Buxton photo.
23. Chinese wax scale, *Ceroplastes sinensis* Del Guercio.
24. Chinese wax scale, *Ceroplastes sinensis* Del Guercio.
25. thorn scale, *Eulecanium tiliae* (Linnaeus).
26. European fruit lecanium, *Parthenolecanium corni* (Bouché), T. Kono photo.
27. European fruit lecanium, *Parthenolecanium corni* (Bouché), Buxton photo.
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31. oak lecanium, *Parthenolecanium quercifex* (Fitch).
32. oak lecanium, *Parthenolecanium quercifex* (Fitch).
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35. Kuno scale, *Eulecanium kunoense* (Kuwana).
36. Kuno scale, *Eulecanium kunoense* (Kuwana).
37. thorn scale, *Eulecanium tiliae* (Linnaeus), (male).
38. thorn scale, *Eulecanium tiliae* (Linnaeus), (male in puparium).
39. thorn scale, *Eulecanium tiliae* (Linnaeus), (nymphs).
40. tessellated scale, *Eucalymnatus tessellatus* (Signoret).
41. calico scale, *Eulecanium cerasorum* (Cockerell), (nymphs).
42. calico scale, *Eulecanium cerasorum* (Cockerell).
43. excrescent scale, *Eulecanium excrescens* (Ferris), (nymphs).
44. excrescent scale, *Eulecanium excrescens*

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- (Ferris).
45. excrescent scale, *Eulecanium excrescens* (Ferris).
 46. black scale, *Saissetia oleae* (Olivier).
 47. Douglas fir scale, *Physokermes taxifoliae* Coleman.
 48. cottony camellia scale, *Pulvinaria floccifera* (Westwood), G. Buxton photo.
 49. nigra scale, *Parasaissetia nigra* (Neitner).
 50. pyriform scale, *Protopulvinaria pyriformis* (Cockerell), G. Buxton photo.
 51. hemispherical scale, *Saissetia coffeae* (Walker).
 52. Fletcher scale, *Parthenolecanium fletcheri* (Cockerell).
 53. Kuno scale, *Eulecanium kunoense* (Kuwana), G. Buxton photo.
 54. frosted scale, *Parthenolecanium pruinatum* (Coquillett).
 55. Douglas fir scale, *Physokermes taxifoliae* Coleman.
 56. lycium soft scale, *Metapulvinaria lycii* (Cockerell), (ovisac).
 57. lycium soft scale, *Metapulvinaria lycii* (Cockerell).
 58. Douglas fir scale, *Physokermes taxifoliae* Coleman.
 59. fir bud scale, *Physokermes concolor* Coleman.
 60. spruce bud scale, *Physokermes hemicryphus* (Dalman).
 61. Monterey pine scale, *Physokermes insignicola* (Craw).
 62. Monterey pine scale, *Physokermes insignicola* (Craw), (nymphs).
 63. pyriform scale, *Protopulvinaria pyriformis* (Cockerell).
 64. black scale, *Saissetia oleae* (Olivier).
 65. Mexican black scale, *Saissetia miranda* (Cockerell and Parrott).
 66. Mexican black scale, *Saissetia miranda* (Cockerell and Parrott).
 67. black scale, *Saissetia oleae* (Olivier).
 68. black scale, *Saissetia oleae* (Olivier),

LIST OF COLOR PHOTOGRAPHS

- (nymphs).
69. irregular pine scale, *Toumeyella pinicola* Ferris.
 70. hemispherical scale, *Saissetia coffeae* (Walker).
 71. hemispherical scale, *Saissetia coffeae* (Walker).
 72. irregular pine scale, *Toumeyella pinicola* Ferris.
 73. cottony maple scale, *Pulvinaria innumabilis* (Rathvon).
 74. cottony maple scale, *Pulvinaria innumabilis* (Rathvon).
 75. cottony maple scale, *Pulvinaria innumabilis* (Rathvon).
 76. cottony camellia scale, *Pulvinaria floccifera* (Westwood).
 77. cottony vine scale, *Pulvinaria vitis* (Linnaeus).
 78. cottony vine scale, *Pulvinaria vitis* (Linnaeus).
 79. cottony camellia scale, *Pulvinaria floccifera* (Westwood).
 80. cottony sagebrush scale, *Pulvinaria bigeloviae* Cockerell, G. Buxton photo.
 81. cottony sagebrush scale, *Pulvinaria bigeloviae* Cockerell.
 82. iceplant scale, *Pulvinaria mesembryanthemi* (Vallot).
 83. iceplant scale, *Pulvinaria mesembryanthemi* (Vallot).
 84. iceplant scale, *Pulvinaria mesembryanthemi* (Vallot), (puparia).
 85. iceplant scale, *Pulvinaria mesembryanthemi* (Vallot), T. Kono photo.
 86. DeLotto iceplant scale, *Pulvinaria delottoi* Gill.
 87. DeLotto iceplant scale, *Pulvinaria delottoi* Gill.
 88. DeLotto iceplant scale, *Pulvinaria delottoi* Gill.
 89. tuliptree scale, *Toumeyella liriodendri* (Gmelin), (puparia).
 90. tuliptree scale, *Toumeyella liriodendri* (Gmelin), (puparia and nymphs).

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And last but not least, thanks for the money, Don.

Family Coccidae
The soft scales
(occasionally called hard scales)

Color Plates 1-90

Field Characteristics: Adult female soft scales are usually 3-9 mm in length and often occur in groups that are readily seen and collected. Soft scales have several distinctive features which aid in their recognition in the field. With the possible exception of very old or very convex individuals, most soft scales have two pairs of white, button-like wax structures on the body margin. One pair will be found about the middle of each side, another pair will be found anterior to these. (See color plate 10). These wax buttons are at the outer end of a furrow which connects each ventral thoracic spiracle with the body margin. The furrows apparently allow air to reach the spiracles since the rest of the venter of the scale is closely pressed against the host surface. If a soft scale is turned over, the four spiracular furrows are distinctive because they are filled with white powdery wax. (See color plate 8). These wax buttons and spiracular furrows aid in separating soft scales from other scale and whitefly groups. Adult soft scales usually grow considerably in size and often change drastically in appearance between maturation and the time that oviposition is complete and the scale dies. Most young adult females are oval in shape, being narrow anteriorly and broader posteriorly, but some species are circular, elliptical, elongate or deltoid. In most species the young adults are flat in profile and press the venter as close as possible to the host surface until oviposition begins. In many adults, at the onset of oviposition, the central areas of the dorsal and ventral epidermis begin to expand upward as a unit while the marginal areas remain fixed to the host. As the central areas elevate the body becomes strongly convex, hemispherical or nearly spherical, forming a cavity under the body where the eggs are protected and incubated. Some soft scales (i.e. *Pulvinaria*) produce white waxy covers or ovisacs over the eggs and do not protect the eggs under the body. Immature female soft scales normally resemble the young adult females in shape and they are usually flat in profile. However, the nymphs of some species may be very different in appearance from the adults. The nymphs of *Ceroplastes* have conical clumps of contrasting white wax which adorn the nymphs, often giving them a star-like appearance. (See color plate 18). Nymphs of some *Eulecanium* species have truncated clumps of transparent wax which give the nymph a crown-like appearance (See color plates 41, 43). The color of the immatures is often similar to that of the adult. Nymphs of species which prefer to feed on the leaves often are a semi-transparent yellow or green; nymphs of species which occur on the twigs are often yellow or gray mottled with brown or black. The early instar male nymphs resemble the female nymphs. However, during the pupal stages the males form a distinctive pupal cell formed of translucent, colorless wax. (See color plates 38, 84). Adult males have well developed legs, antennae, eyes and wings. (See color plate 37).

Biology: Little has been written about the general biologies of the soft scales, but information has been compiled based on in-depth studies of certain species by the following authors: Smith (1944), Kawecki (1958), Phillips (1962), Saakyan-Baranova (1964), Snowball (1970) and Bendov et al. (1975). The majority of California soft scales appear to be parthenogenetic although males occasionally develop in some species. A few species such as *Eulecanium tiliae* are obligatorily biparental. Females of most species undergo five stages including the egg, first instar nymph (crawler), second nymphal instar, third nymphal instar, and the adult. Most

males undergo six life stages including the egg, first instar nymph (crawler), second nymphal instar, prepupal stage, pupal stage and adult. However, Snowball (1970) reports three nymphal instars in the male of *Ceroplastes sinensis*. Most California soft scales have one annual generation. Eggs and crawlers are produced in the spring and summer. Most species probably overwinter as third stage nymphs and reach the adult stage in early spring. However, in some species in the genus *Ceroplastes*, the adult females overwinter. A few species such as brown soft scale, *Coccus hesperidum* and ice plant scale, *Pulvinaria mesembryanthemi* have multiple generations. Black scale, *Saissetia oleae*, normally has one annual generation in California, but it can have two annual generations in certain coastal areas. Most soft scales have well developed legs in all stages and are capable of moving from one location to another. Many soft scales that prefer to feed on the leaves of deciduous hosts during the summer months must move to the twigs and branches before winter leafdrop. Some species of *Pulvinaria* begin their life cycle on the leaves, move to the twigs in winter, then return to the leaves as adult females in the spring. In some genera such as *Toumeyella*, the legs become greatly reduced in the second nymphal stage and therefore only the crawler is mobile.

Families Similar to Soft Scales in the Field: Cottony cushion scale in the family Margarodidae is often confused with soft scales by field entomologists, particularly since the ovisac resembles the ovisacs formed by *Pulvinaria* and other soft scale genera. Cottony cushion scale can be separated from soft scales by the grooved ovisac, red body color and black appendages; soft scales do not have this combination of characters. Early instar soft scales are similar to immature whiteflies in the family Aleyrodidae but normally the four white wax buttons on the sides of the soft scales which are associated with the spiracular furrows will immediately separate the soft scales from whiteflies. Scales in the families Kermesidae and Cerococcidae resemble soft scales. However, scales in these two families occur only on oaks in California and they have a spherical body shape. California soft scales occurring on oaks do not have a spherical body shape. Immature and young adult scales in the families Asterolecaniidae and Lecanodiaspididae resemble soft scales, but they do not have the four white wax buttons on the sides that the soft scales have. However, scales in the Asterolecaniidae and Lecanodiaspididae usually exhibit the white spiracular furrows on the venter like those found in the soft scales. **Hosts:** Most California soft scales are polyphagous, although a few species are narrowly host specific. One generalized statement that can be made about California soft scale host preferences is that species which prefer a subtropical or tropical habitat are usually found on evergreen hosts, other than conifers, while species which prefer more temperate habitats are usually found on deciduous hosts and conifers.

Economic Importance: Many soft scales cause economic injury to ornamental plants and fruit and nut crops. Although few species are known to kill their hosts, many cause reduced host vigor, reduced productivity, defoliation and dieback. Most are phloem feeders and produce large amounts of honeydew. The honeydew is a growth substrate for sooty mold fungi which give the plants an unsightly appearance and is thought to interfere with the photosynthetic processes of the host.

Distribution: Soft scales are native to most of the temperate, subtropical and tropical habitats of the world, and they can be found in all of the subtropical and temperate habitats of California. Two California species of *Luzulaspis* are known from arctic-alpine habitats above 9,000 feet elevation. Many of the economically important species are cosmopolitan and have been introduced into California by man.

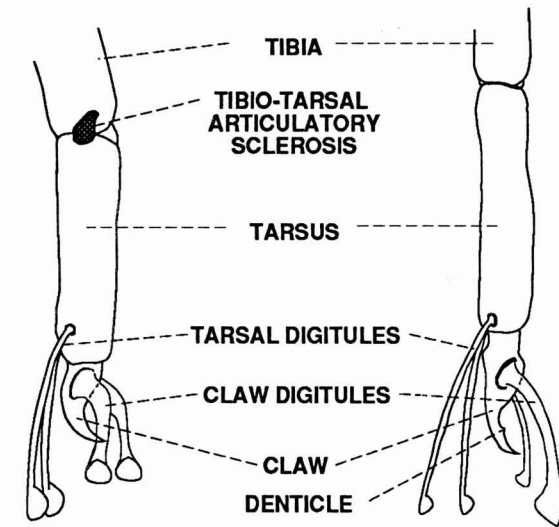
Morphology and Systematics: The family is recognized by a pair of triangular anal plates (opercula) and by the anal cleft which splits the body from the anal plates to the posterior body

margin. The anal plates occur in all stages except the egg, pupal and adult male stages and in the adult females of *Physokermes*. Most species have two pairs of differentiated spiracular (or stigmatic) setae associated with the thoracic spiracles. The spiracular setae are located at the outer ends of the spiracular furrows along the body margin. The spiracular furrows are usually delimited by a band of quinquelocular pores. The other miscellaneous morphological structures which exist on some or all soft scale species are indicated in Figs. 1 and 2.

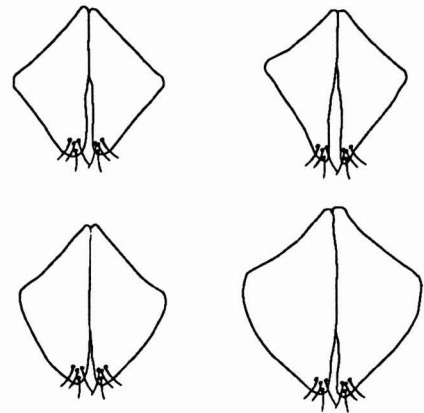
There is no world catalogue of species and the soft scale fauna has been studied comprehensively in only a few countries. Some major works have been produced by Green in Ceylon, Brain and DeLotto in South Africa, Hodgson in Rhodesia, Takahashi in Japan, Borchsenius in U.S.S.R., Kozar and Kosztarab in Hungary, Williams and Kosztarab in Virginia and Hamon in Florida. No comprehensive works exist for all North American species.

Ben Dov, Y., M. L. Williams and C. H. Ray Jr., 1975: Israel J. Entomol. 10: 1-17.
 Kawecki, Z., 1958: Ann. Zool. (Warsaw) 4(9): 135-230.
 Phillips, J. H. H., 1962: Can. Entomol. 94(5):497-502.

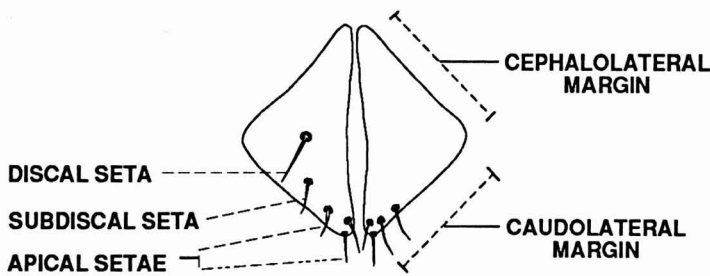
Saakyan-Baranova, A. A., 1964: Entomol. Obozr. 43:268-296. Abstracted in Entomol. Rev. 43:135-147.
 Smith, R. H., 1944: Hilgardia 16(5):225-288.
 Snowball, G. J., 1970: J. Aust. Entomol. Soc. 9:57-64.



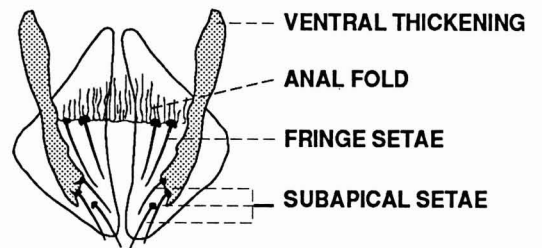
LEG STRUCTURES



ANAL PLATE VARIATIONS IN COCCUS HESPERIDUM



ANAL PLATE STRUCTURES DORSAL VIEW



ANAL PLATE STRUCTURES VENTRAL VIEW

Fig. 1: Morphological structures of the Coccidae.

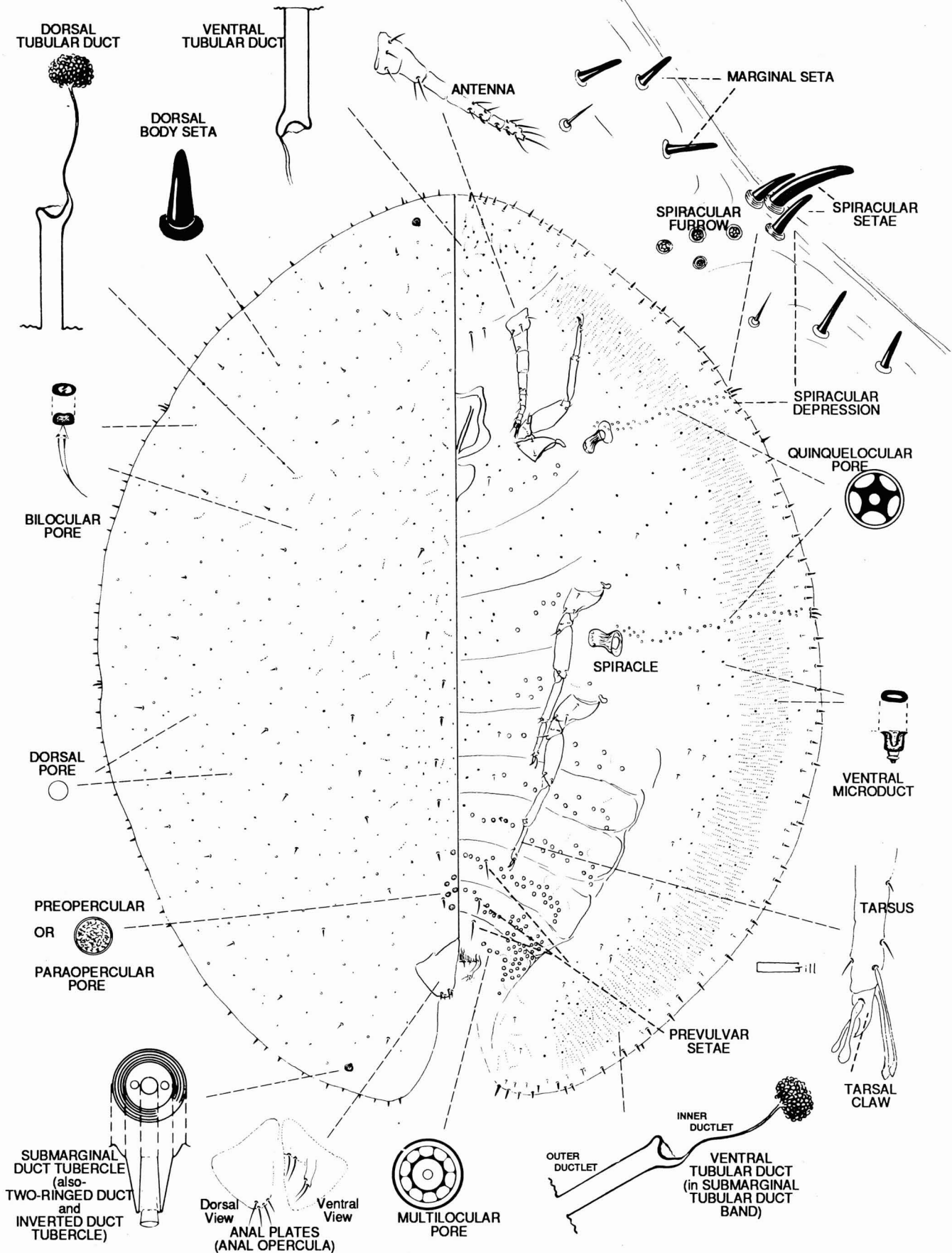
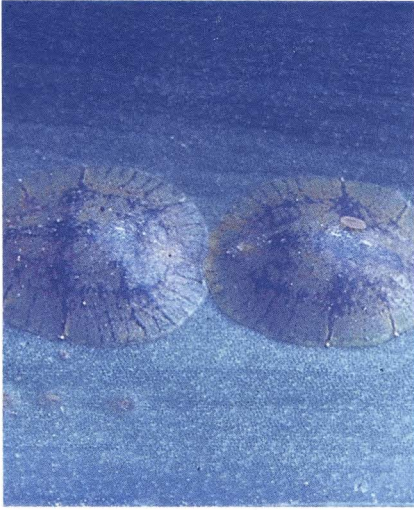


Fig. 2: Morphological structures of the Coccidae

KEY TO THE GENERA OF CALIFORNIA COCCIDAE

- 1 Anal plates absent; legs reduced; on conifers only. *Physokermes*
 Without the above combination of characters. 2
- 2(1) Legs and antennae reduced, usually shorter than the diameter of thoracic spiracles;
 abdominal multilocular pores with predominantly 5 loculi; with numerous thick-
 walled preopercular pores. *Toumeyella*
 Without the above combination of characters. 3
- 3(2) Dorsal setae stout, truncate. *Eriopeltis*
 Dorsal setae small, spine-like or bristle-like, never truncate. 4
- 4(3) Spiracular setae numerous, hemispherical or bullet-shaped; anal plates on a strongly
 sclerotized and usually elevated process; dorsum with sclerotized, irregular trilocu-
 lar, quadrilocular or quinquelocular pores. *Ceroplastes*
 With 3 or fewer cylindrical or elongate spine-like setae in each spiracular depression;
 other characters not as above. 5
- 5(4) With numerous ventral tubular ducts forming a band in the sub-marginal areas of the
 abdomen, thorax or head. 7
 Without such a band of ventral tubular ducts. 6
- 6(5) Dorsal derm with tessellations, forming a mosaic of large polygonal plates (teneral
 individuals will not be tessellated and will key to the genus *Coccus*; see the key to that
 genus). *Eucalymnatus*
 Dorsal derm never tessellated, without large polygonal plates. *Coccus*
- 7(5) Tibio-tarsal articular sclerosis usually absent; tibia and tarsus fused; ovisacs
 absent, eggs incubated in a cavity under body of adult female. 8
 Tibio-tarsal articular sclerosis usually present; tibia and tarsus freely articulating;
 ovisacs usually produced. 11
- 8(7) Dorsal setae cylindrical, often capitate apically; tubular ducts absent from median
 areas of venter; dorsum tessellated, forming a mosaic of small polygonal
 plates. *Parasaissetia*
 Dorsal setae conical, spine-like, with acute apices; tubular ducts present in median
 areas of venter. 9
- 9(8) Each anal plate with one large discal seta; marginal setae hair-like or bristle-like,
 usually bifid or fimbriated apically; dorsum strongly sclerotized with clear cell-like
 areas. *Saissetia*
 Anal plates without discal setae; marginal setae stout, conical, with blunt or acute
 apices; dorsum without dermal clear areas. 10
- 10(9) Spiracular setae in each spiracular depression of 2 sizes, median seta nearly twice as
 long as lateral spiracular setae and marginal setae; marginal setae fewer, with blunt

- apices; multilocular pores few in median areas of thorax; with well defined preopercular pores. *Parthenolecanium*
- Spiracular setae in each depression usually subequal, about same length or shorter than marginal setae; marginal setae many, closely set, separated by a distance about equal to their length, with acute apices; multilocular pores often very numerous in midregion of thorax; preopercular pores not well differentiated from other dorsal discoidal pores. *Eulecanium*
- 11(7) Spiracular setae in groups of 2, usually, but little larger than marginal setae; anal plates with 1 pair of subapical setae; occurring on *Carex* at 9,000 to 10,000 foot elevation. *Luzulaspis*
- Spiracular setae single or in groups of 3, often well differentiated from marginal setae (or not at all differentiated in *Pulvinaria bigeloviae*); anal plates usually with 2 or more pairs of subapical setae; not occurring on *Carex*. 12
- 12(11) Anal plates 1.5 to 4.0 times longer than wide, situated near middle of body; ovisac short, mostly beneath body. *Protopulvinaria*
- Anal plates less than 1.5 times longer than wide, usually quadrate; ovisac usually elongate, projecting posteriorly some distance from body (ovisac absent in *Metapulvinaria*). 13
- 13(12) Dorsal setae present; spiracular setae usually in groups of 3. *Pulvinaria*
- Dorsal setae absent; with only 1 differentiated spiracular seta in each spiracular depression. 14
- 14(13) Anal ring with 6 setae; 1 pair of prevulvar setae; marginal setae spine-like with blunt apices; ovisac absent. *Metapulvinaria*
- Anal ring with 10 setae; 3 pairs of prevulvar setae; marginal setae stout, spine-like, apices pointed; with well-developed ovisac. *Philephedra*
-



1. *Coccus hesperidum*



2. *Coccus hesperidum*



3. *Coccus hesperidum*



4. *Coccus hesperidum*



5. *Coccus hesperidum*



6. *Coccus hesperidum*



7. *C. hesperidum* (parasitized)



8. *C. hesperidum* (ventral view)



9. *Coccus pseudoheperidum*



10. *Coccus pseudomagnoliarum*



11. *C. pseudomagnoliarum* (nymph)



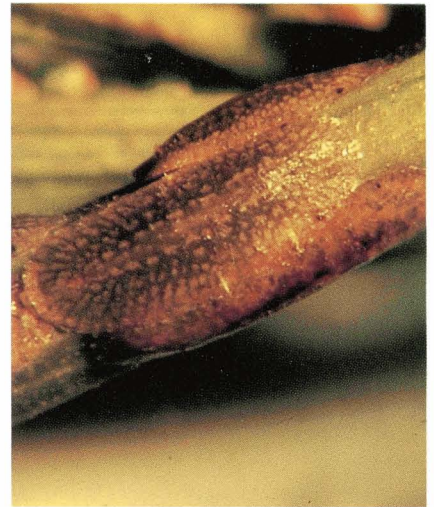
12. *Coccus longulus*



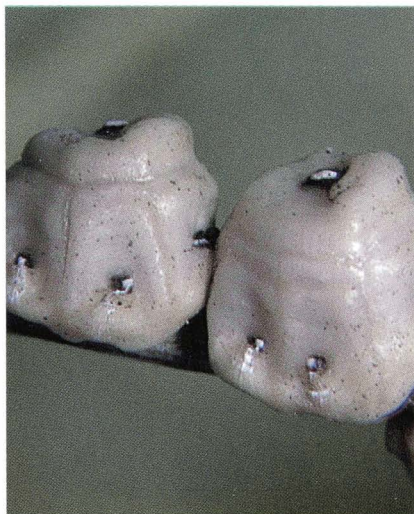
13. *Ceroplastes irregularis*



14. *Ceroplastes irregularis*



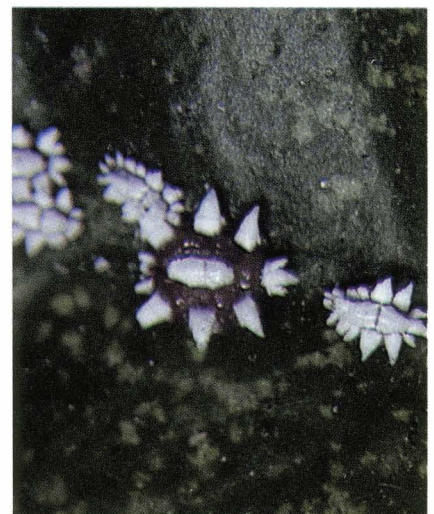
15. *Coccus longulus*



16. *Ceroplastes cirripediformis*



17. *Ceroplastes sinensis*



18. *C. sinensis* (nymphs)



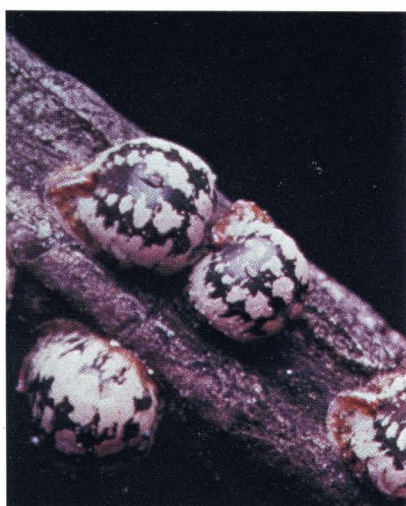
19. *Ceroplastes cistudiformis*



20. *Ceroplastes cirripediformis*



21. *Coccus pseudomagnoliarum*



22. *Eulecanium cerasorum*



23. *Ceroplastes sinensis*



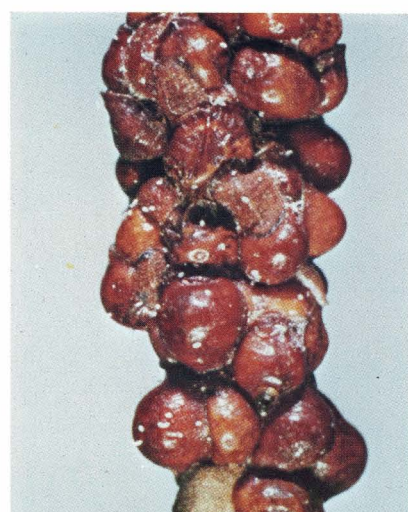
24. *Ceroplastes sinensis*



25. *Eulecanium tiliae*



26. *Parthenolecanium corni*



27. *Parthenolecanium corni*



28. *Parthenolecanium corni*



29. *Parthenolecanium persicae*



30. *Parthenolecanium persicae*



31. *Parthenolecanium quercifex*



32. *Parthenolecanium quercifex*



33. *P. quercifex* (male & pupae)



34. *E. kunoense* (pupae)



35. *Eulecanium kunoense*



36. *Eulecanium kunoense*



37. *Eulecanium tiliae* (male)



38. *E. tiliae* (male pupa)



39. *Eulecanium tiliae* (nymphs)



40. *Eucalymnatus tessellatus*



41. *E. cerasorum* (nymphs)



42. *Eulecanium cerasorum*



43. *E. excrescens* (nymphs)



44. *Eulecanium excrescens*



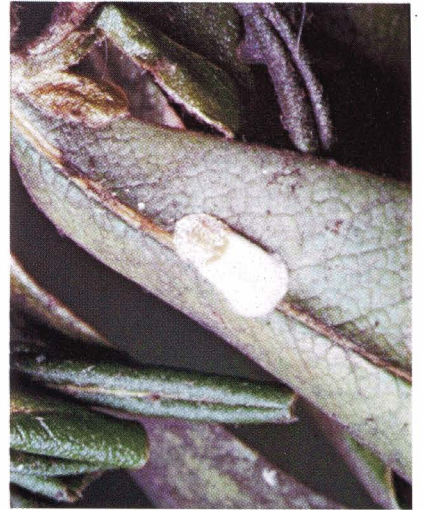
45. *Eulecanium excrescens*



46. *Saissetia oleae*



47. *Physokermes taxifoliae*



48. *Pulvinaria floccifera*



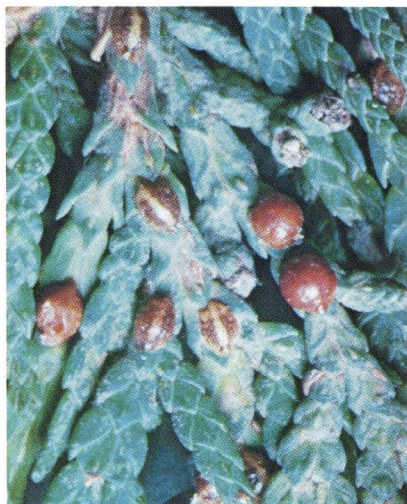
49. *Parasaissetia nigra*



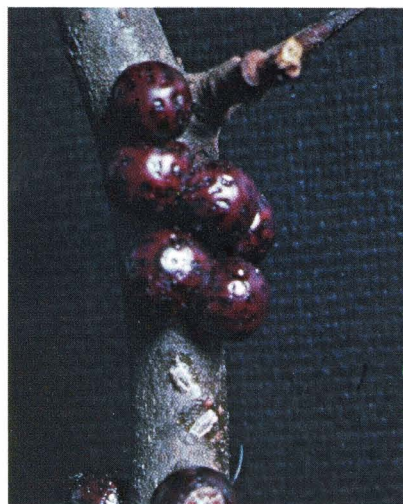
50. *Protopulvinaria pyriformis*



51. *Saissetia coffeae*



52. *Parthenolecanium fletcheri*



53. *Eulecanium kunoense*



54. *Parthenolecanium prunosum*



55. *Physokermes taxifoliae*



56. *M. lycii* (ovisac)



57. *Metapulvinaria lycii*



58. *Physokermes taxifoliae*



59. *Physokermes concolor*



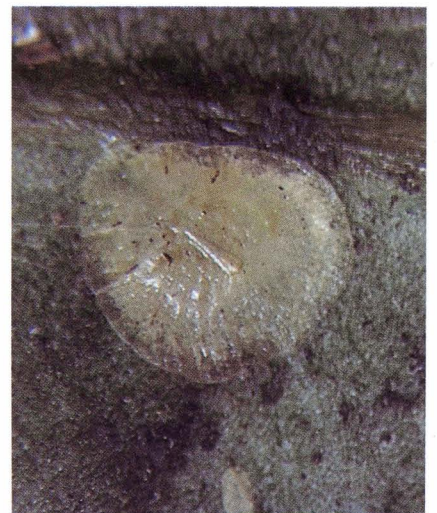
60. *Physokermes hemicyphus*



61. *Physokermes insignicola*



62. *P. insignicola* (nymphs)



63. *Protopulvinaria pyriformis*



64. *Saissetia oleae*



65. *Saissetia miranda*



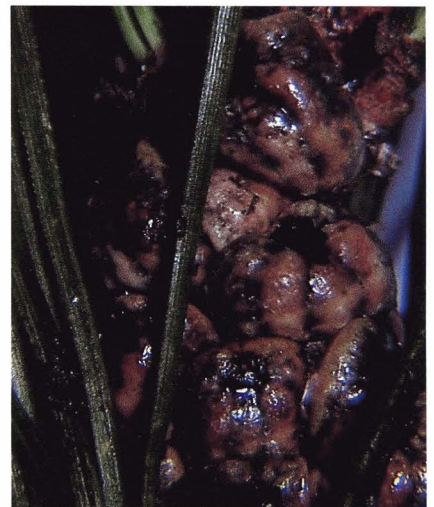
66. *Saissetia miranda*



67. *Saissetia oleae*



68. *Saissetia oleae* (nymphs)



69. *Toumeyella pinicola*



70. *Saissetia coffeae*



71. *Saissetia coffeae*



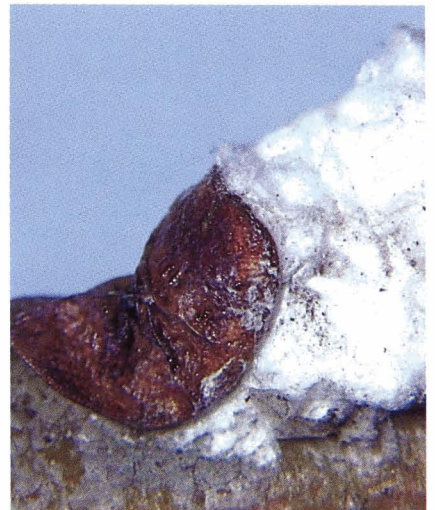
72. *Toumeyella pinicola*



73. *Pulvinaria innumerabilis*



74. *Pulvinaria innumerabilis*



75. *Pulvinaria innumerabilis*



76. *Pulvinaria floccifera*



77. *Pulvinaria vitis*



78. *Pulvinaria vitis*



79. *Pulvinaria floccifera*



80. *Pulvinaria bigeloviae*



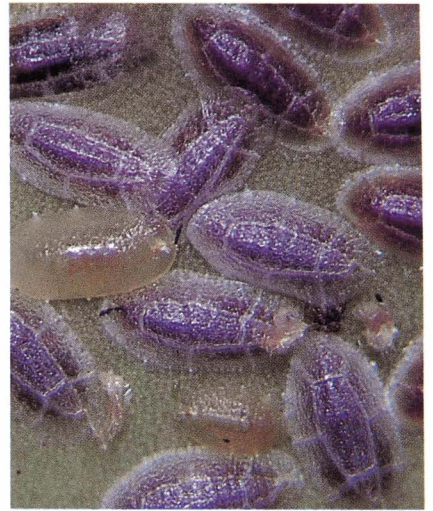
81. *Pulvinaria bigeloviae*



82. *Pulvinaire mesembryanthemi*



83. *Pulvinaire mesembryanthemi*



84. *P. mesembryanthemi* (pupae)



85. *Pulvinaire mesembryanthemi*



86. *Pulvinaire delottoi*



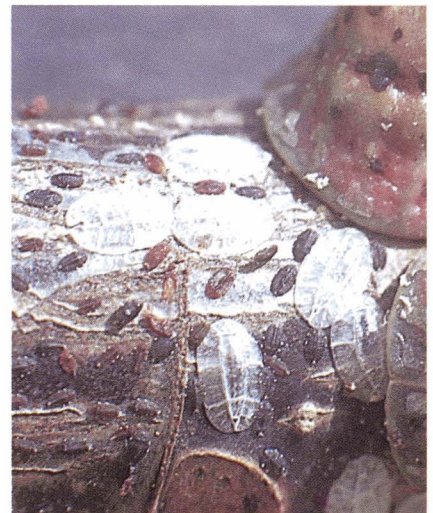
87. *Pulvinaire delottoi*



88. *Pulvinaire delottoi*



89. *Toumeyella liriodendri* (pupae)



90. *T. liriodendri* (nymphs-pupae)

Genus *Ceroplastes* Gray, 1828 The Wax Scales

Specimens of this genus of soft scales are characteristically hemispherical in shape and are completely covered by a thick layer of oily wax. The patterns and colors of these waxes are somewhat useful in field identification. A field key to common North American species which uses these characteristics has been developed by Gimpel et al. (1974). Gimpel et al. (1974) also give an excellent account of the structure and formation of the wax cover which consists of white dry wax found in the rosette-like nymphal stages and wet wax which is produced primarily by the adult.

These scales as a rule are non-economic in California but they occasionally develop large populations. One California species, *Ceroplastes sinensis*, does have the potential to become a pest as do other species such as *C. floridensis* Comstock and *C. cerifera* (Fabricius), which currently do not occur in California.

The systematics of the North American species have been thoroughly worked out by Gimpel et al. (1974). Morphologically, the wax scales differ from other California soft scales in that they possess groups of more than three short, stout spiracular setae in each spiracular furrow, rather than one long and two short setae as found in most other California genera.

There are 11 species known from the U.S. and about 157 species are known worldwide, some of which have been placed in other genera such as *Cerostegia*, *Gascardia* and *Waxiella*.

Gimpel, W. F., D. R. Miller and J. A. Davidson, 1974: University of Maryland Agr. Exp. Sta. Misc. Publ. 841: 1-85.

KEY TO THE CALIFORNIA SPECIES OF *CEROPLASTES*

- 1 Spiracular setae absent from posterior spiracular depression. *irregularis*
Spiracular setae present in posterior spiracular depression. 2

- 2(1) Spiracular setae confined to spiracular depression; spiracular setae arranged in 5-6
irregular rows. *cistudiformis*
Spiracular setae extending along margin beyond limits of spiracular depression; spiracu-
lar setae arranged in 3 irregular rows. 3

- 3(2) Ventral marginal filamentous ducts present*; multilocular pores absent from thorax and
anterior abdominal segments. *sinensis*
Ventral marginal filamentous ducts absent; multilocular pores on anterior abdominal
segments and thorax. *cirripediformis*

*These ducts may be almost impossible to find in poorly prepared specimens or in older individuals.

Ceroplastes cerifera (Fabricius), 1778
Indian wax scale

Other common names:

Indian white wax scale,
Japanese wax scale,
Mexican wax scale,
Chinese wax scale.

Synonymy:

Coccus ceriferus Fabricius,
Coccus chilensis Gray,
Ceroplastes australiae Walker,
Columnea cerifera (Fabricius),
Lacca alba Signoret,
Gascardia cerifera (Anderson).

Essig (1915, 1958) lists this species as occurring in greenhouses throughout the State. It is not presently known to occur in the State and

specimens have not been seen which could confirm its earlier presence here. It will, therefore, not be considered a part of the California fauna. For more information on this species, see Gimpel et al. (1974).

Essig, E. O., 1915: Injurious and Beneficial Insects of California. (2nd. ed.) Calif. Dept. Mon. Bull. Suppl. 4(4):1-541.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Gimpel, W. F., D. R. Miller and J. A. Davidson, 1974: Univ. Maryland Agric. Exp. Stn. Misc. Publ. 841: 1-85.

Ceroplastes cirripediformis Comstock, 1881
barnacle scale (ESA approved)

Fig. 3, Color Plates 18, 21

Synonymy:

Ceroplastes euphorbiae Cockerell,
Ceroplastes mexicanus Cockerell,
Ceroplastes plumbaginus Cockerell.

Field Characteristics: Adult females 2 to 5 mm long, convex to hemispherical. Scale bodies reddish brown to brown, completely covered with a thick layer (test) of pearly-grey wax which is divided into distinct plates by thin depressed lines. There is a large dorsal plate, an anterior plate, 4 lateral plates and a large (double) posterior plate. Each plate has a small darkened central area with a white button-like filament of wax except for the posterior plate, which has a central button associated with the opercula and one button on each side of the opercula. The buttons on the anterior and posterior plates may be composed of several individual triangular filaments. Overall appearance suggests a barnacle, hence the common name. For a

complete description of the wax test, see Gimpel et al. (1974). Immatures reddish but partially or nearly covered with a stellate (rosette) pattern of pure white conical wax plates which correspond to the white wax filaments (buttons) on mature females.

Biology: Apparently has one generation per year. Adults present from late July through winter. Early instar nymphs usually found on the upper leaf surfaces of the hosts. Third instar nymphs return to the twigs where maturation and egg laying take place. Males rare. For more information see Gimpel et al. (1974).

Similar Species: Tortoise wax scale is nearly identical but darker than barnacle scale. Chinese wax scale is similar but less convex in profile and more irregular in shape.

Hosts: Polyphagous. In California, prefers citrus and gardenia. For a complete host list see Merrill (1953) and Gimpel et al. (1974).

Economic Importance: Has never been abundant enough in California to cause injury to commercial crops. Heavy, debilitating populations are seen occasionally on dooryard gardenia plants in Southern California. For information on natural enemies see Bartlett (1978).

Distribution: Common in Southern California and in the San Joaquin Valley as far north as Fresno. Has been collected in other counties and in the San Francisco Bay area on nursery stock, but has never become established. Does not overlap the range of Chinese wax scale except in Santa Barbara County. Also occurs in Arizona, Texas, southeastern United States, Hawaii, the Philippines, Mexico, Central and South America and the Caribbean Islands. Probably native to the Caribbean Islands and the southern United States (Gimpel et al., 1974).

Diagnosis: Morphologically most similar to tortoise wax scale and Chinese wax scale. Separated from Chinese wax scale by its lack of ventral marginal filamentous ducts, by having multilocular pores on anterior abdominal segments and thorax, and by having generally fewer loculi (3) in the dorsal pores. Separated from tortoise wax scale because the spiracular setae extend along the margin beyond the spiracular furrow, rather than being confined to the spiracular furrows as in *C. cistudiformis*.

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- Bartlett, B. R., in C. P. Clausen, Ed., 1978: U.S. Dept. Agric. Handb. 480: 1-545.
 Gimpel, W. F., D. R. Miller and J. A. Davidson, 1974: Univ. Maryland Agric. Exp. Stn. Misc. Publ. 841: 1-85.
 Merrill, G. B., 1953: Fla. State Plant Board Bull. 1:1-143.

Ceroplastes cistudiformis Cockerell, 1893
tortoise wax scale

Fig. 4, Color Plate 19

Synonymy:

Ceroplastes psidii cistudiformis Cockerell.

Field Characteristics: Adult females 2 to 5 mm long, hemispherical. Nearly identical to barnacle scale but darker (dingy) grey without pearly luster and occasionally with a less convex profile. For further information on field characteristics see comments under barnacle scale.

Biology: Probably one generation per year. Fully mature adults have been collected in November and May in San Diego County.

Similar Species: Nearly identical to barnacle scale. See Field Characteristics.

Hosts: Polyphagous. Mainland California records include shrimp plant, *Beloperone guttata* and oleander, *Nerium oleander*, recorded from *Citrus* elsewhere.

Distribution: First collected in California in 1897 at Claremont. Since then, has been collected only at four locations in San Diego County, the most recent at Escondido in 1987. Common on urban plantings on Santa Catalina Island (D. R. Miller, pers. comm.). Also known from Mexico and Central America.

Diagnosis: The only California *Ceroplastes* in which all four sets of spiracular setae are confined to the spiracular furrows.

Ceroplastes irregularis Cockerell, 1893
irregular wax scale

Fig. 5, Color Plates 13, 14

Synonymy:

Ceroplastes irregularis var.
rubidus Cockerell.

Other Common Names:

desert wax scale.

Field Characteristics: Adult females 5 to 8 mm long, round, flat to convex in profile and usually irregular. Dorsal wax plate often deeply concave in young adult females. Dorsal wax color varies from creamy white through pinkish to almost reddish brown.

Biology: Probably one generation per year. According to Essig (1958), this scale congregates in masses on the twigs and branches of the host and even on the crowns below ground.

Similar Species: Based on hosts, distribution and external appearance, should not be confused with any other species in California. Chinese wax scale is the most similar California species.

Hosts: Prefers *Atriplex*. Has also been found

on *Suaeda*, *Eurotia*, *Chrysothamnus*, *Artemisia* and *Tamarix*.

Economic Importance: None. The wax produced by this scale insect was used by the California Indians for mending pottery, waterproofing baskets and other purposes (Essig, 1931).

Distribution: Southern California and the southern San Joaquin Valley; prefers arid habitats. Native to California, Arizona, New Mexico, Texas, Nevada, Idaho and Mexico.

Diagnosis: The only California *Ceroplastes* with spiracular setae absent in the posterior spiracular furrows.

Essig, E. O., 1931: A History of Entomology, The MacMillan Co., New York. 1029 pp.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Ceroplastes sinensis Del Guercio, 1900
Chinese wax scale

Fig. 6, Color Plates 16, 17, 23, 24

Synonymy:

Ceroplastes cirripediformis Del Guercio
(as a mis-identification).

Field Characteristics: Adult females 3 to 7 mm long, moderately convex in profile. Upper surface divided into dorsal and lateral plates but not as noticeably as in barnacle scale. There is a deep depression associated with the white wax buttons (dry wax) on each plate. Anterior portion of scale slightly lower than posterior; in profile, the scale appears to be sloping forward. Anterior half white,

posterior half light brown or pinkish brown; the depressions associated with wax buttons dark brown. Resultant multicolored effect is characteristic of living adult females in California. Older females and post reproductive dead specimens almost totally white. Gregarious, shape of individual specimens often distorted from clumping together. Immature stages, normally found on upper leaf surfaces, have conical, rosette-shaped wax plates like those of barnacle scale.

Biology: One generation per year in Austra-

lia; eggs hatch November-March; up to 3,844 eggs per female (Snowball, 1970). In Virginia, eggs are laid in late May and hatch in late June (Williams and Kosztarab, 1972). In Australia, nymphs feed on leaves; young adult females move to twigs for oviposition. In Virginia, third instar nymphs transfer to twigs and stems. California collection records indicate that adult females are present May-September; eggs probably hatch in autumn. Males occur but are rare. For more information see Borchsenius (1957), Snowball (1970) and Williams and Kosztarab (1972).

Similar Species: Distribution, distinctive shape and color pattern of this species should aid in separating it from other California wax scales.

Hosts: Polyphagous. Common on *Citrus*, *Schinus*, *Ilex*, *Baccharis*, *Escallonia* and *Umbellularia* in California. For additional hosts see Constantino (1930), Borchsenius (1957), Snowball (1970) and Williams and Kosztarab (1972).

Economic Importance: A sporadic pest of citrus in Spain and Italy. Often requires chemical control measures on citrus in Australia. Elsewhere it is considered to have some potential as a pest but it is currently of little importance because populations tend to fluctuate drastically and never become large enough to cause economic injury. For more information on the economics of this species see Freeborn (1931), Beattie (1976-1978) and Snowball (1970). For information on natural enemies see Snowball (1970) and Williams

and Kosztarab (1972).

Distribution: Restricted to the San Francisco Bay area and to Orange and Santa Barbara counties. Also found in North Carolina, Virginia, and Mexico. Known from USSR (Western Caucasus, Central Asia), Iran, Algeria, Italy, Spain, New Zealand and Australia.

Diagnosis: The only California *Ceroplastes* with the marginal row of filamentous tubular ducts on the venter. Indian wax scale, *C. cerifera* (Fabricius) also has these tubular ducts but lacks the mediodorsal clear area, tibiotarsal schlerosis and the 7-segmented antennae of *C. sinensis*. For a detailed morphological description, see Gimpel et al. (1974). To separate this species from barnacle scale, see comments under that species.

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- Beattie, G. A. C., 1976-1978: Dept. Agric. N. S. Wales Res. Rpt. pp. 75-76.
- Borchsenius, N. S., 1957: Akad. Nauk. Zool.Inst. (n.s. 66) 9:1-493.
- Constantino, G., 1930: Est. IL. COLTIVATORE SICILIANO. 9(5):1-9.
- Freeborn, S. B., 1931: J. Econ. Entomol. 24(5):1025-1031.
- Gimpel, W. F., D. R. Miller and J. A. Davidson, 1974: Univ. Maryland Agr. Exp. Stn. Misc. Publ. 841:1-85.
- Snowball, G. J., 1970: J. Aust. Entomol. Soc. 9:57-64.
- Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.

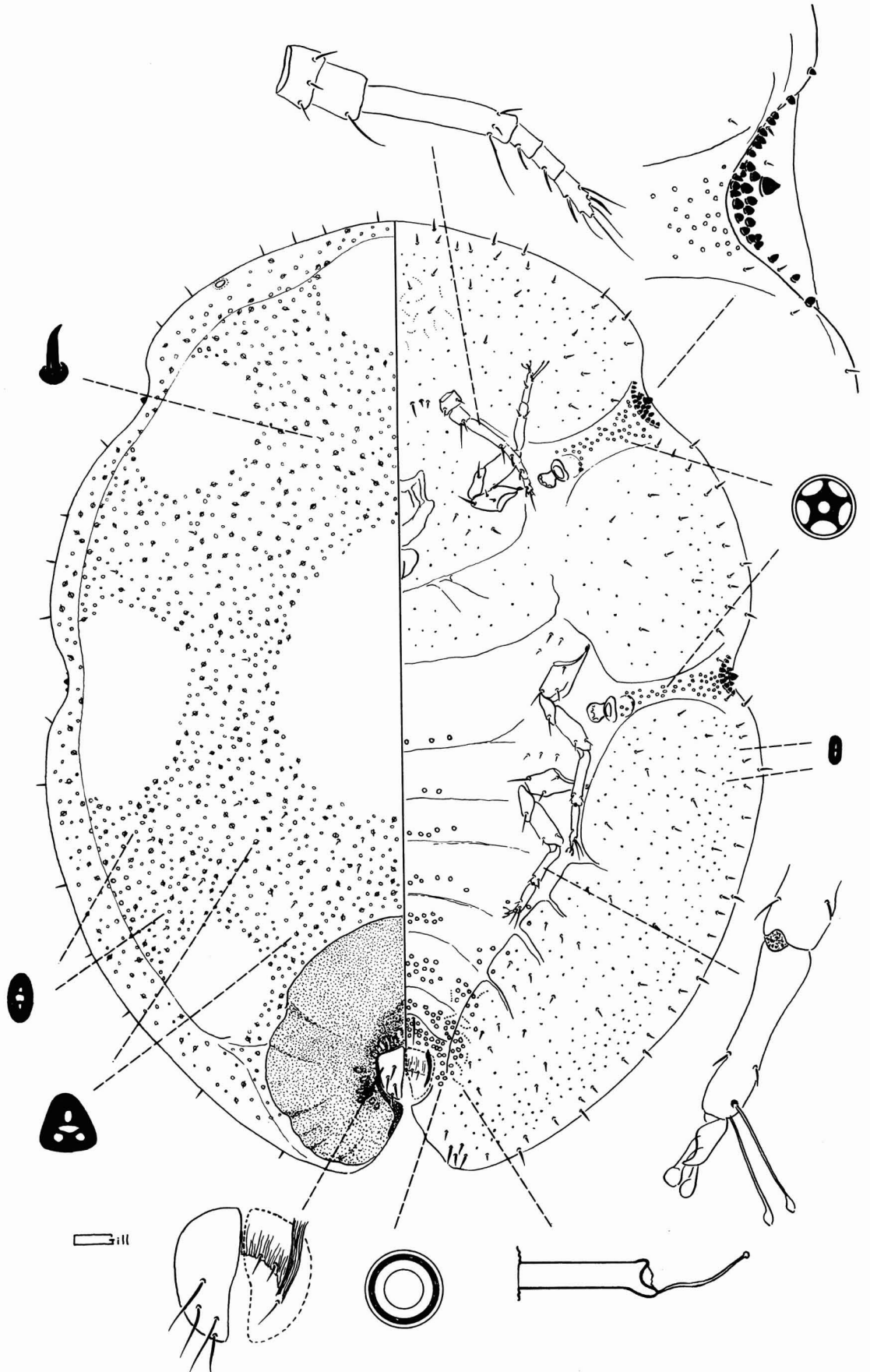


Fig. 4: *Ceroplastes cistudiformis* Cockerell.

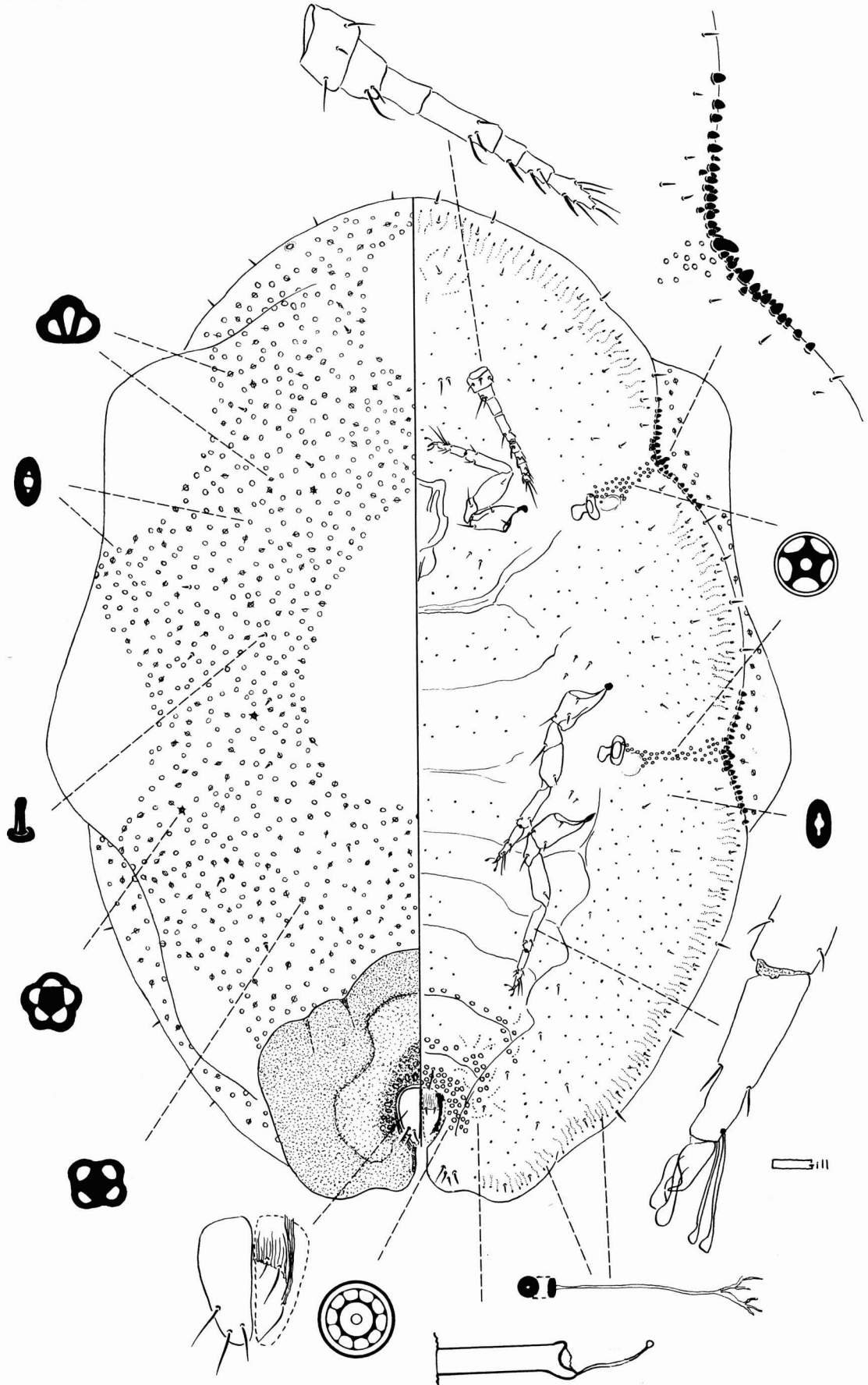


Fig. 6: *Ceroplastes sinensis* Del Guercio.

Genus *Coccus* Linnaeus, 1758 The Brown Soft Scales

This genus is characterized by drab, ovoid or elongate species which are flat in profile throughout life. Several rank among the most economically important species in the family Coccidae. Morphologically, the genus is best recognized by its general lack of outstanding taxonomic characters. Ventral submarginal tubular duct bands and freely articulating tibio-tarsal joints are not present. For a complete update on the nomenclature status of *Coccus*, descriptions, biologies and key to the North American species, see Gill et al. (1977). There are 8 species known from North America and approximately 72 species are known worldwide.

KEY TO THE CALIFORNIA SPECIES OF *COCCUS* AND *EUCALYMNATUS* Adapted from Gill et al. (1977)

- 1 Dorsal setae straight, spine-like and cylindrical, clavate or capitate. 2
Dorsal setae curved, tapered; apices pointed or blunt. 3
- 2(1). Submarginal duct tubercles present; antenna 7- segmented; ventral tubular ducts present near attachments of mesothoracic legs. *hesperidum*
Submarginal duct tubercles absent; antennae 8- segmented; ventral tubular ducts absent near attachments of mesothoracic leg. *pseudomagnoliarum*
- 3(1) Legs well developed with tibio-tarsal articulatory sclerosis; preopercular pores on abdomen only. 4
Legs greatly reduced, tibio-tarsal articulatory sclerosis absent; preopercular pores in longitudinal band or groups on mid-region of abdomen and thorax; on Orchidaceae. *pseudohesperidum*
- 4(3) Anal operculum with subdiscal seta; apical setae not set along lateral margin, fringe setae 7-8; marginal setae mostly simple, a few bifid or slightly fimbriate. . *longulus*
Anal operculum without subdiscal seta, 2 apical setae set along lateral margin; marginal setae mostly bifid or fimbriate, few simple; dorsal derm becoming tessellated with advancing maturity. genus *Eucalymnatus*

Coccus hesperidum Linnaeus, 1758 brown soft scale (ESA approved)

Fig.7, Color Plates 1-8

Other Common Names:

soft scale,
soft brown scale.

Synonymy: For a complete list of synonyms see Gill et al. (1977).

Field Characteristics: Adult females 1.5 to 4.5 mm long, fairly flat in profile. Young adults yellowish-green to yellowish-brown, usually flecked with brown spots which occasionally

coalesce into mottled patterns. The brown spots are a field recognition character. Specimens from stems and twigs (normally a rare occurrence) may be uniform brown. Immatures, yellowish or yellowish-green.

Biology: Three-to-five generations outdoors in Southern California; up to 7 generations recorded in greenhouses in other countries. One generation takes 40-60 days in summer.

Since a female may produce 2 to 3 crawlers per day during a 30-60 day period, the generations overlap and all stages can be found at the same time. Females ovoviviparous, parthenogenetic. There is a crawler stage and 3 nymphal instars. Saakyan-Baranova (1964) has found males rare in the greenhouse in Russia; they have never been observed elsewhere. The above biological information summarized from the following sources: Quayle (1938), Bodenheimer (1951), Ebeling (1959), Saakyan-Baranova (1964) and Avidov and Harpaz (1969).

Similar Species: European fruit lecanium, *Parthenolecanium corni*, resembles this species in early spring. Long soft scale, *Coccus longulus* is more elongate, has a different color pattern and is rare in California. Citricola scale, *Coccus pseudomagnoliarum*, is very similar but normally has a distinctive color pattern. Moreover, there is only one generation of citricola scale per year and therefore only one stage and one relative size of living scales are found on the host at the same time.

Hosts: Extremely polyphagous; has been found on almost every kind of plant except grasses. Prefers evergreen plants; commonly found on citrus. For more information on hosts see Merrill (1953), Borchsenius (1957), Essig (1959), DeLotto (1959), Saakyan-Baranova (1964) and Gill, et al. (1977).

Economic Importance: Prolific under certain conditions; populations can build up rapidly. A phloem feeder, causing injury primarily by removal of plant sap which results in reduced vitality of the host. Production of copious amounts of honeydew and resultant sooty-mold reduces the aesthetic value of the host. It seldom kills the host. An occasional pest of commercial citrus in California; a serious pest of this crop in other countries. Also a pest of greenhouse and outdoor ornamental plants but normally controlled effectively by natural enemies. For more information on the economic importance of this species see Ebeling (1959), Williams and Kosztarab (1972), Talhouk (1975), Bartlett (1978) and Gill et al.

(1977). For information on natural enemies see Ebeling (1959), Avidov and Harpaz (1969), Williams and Kosztarab (1972) and Bartlett (1978).

Distribution: Cosmopolitan. Found throughout the warmer areas of California. Probably occurs throughout the State on indoor plants.

Diagnosis: The spine-like dorsal setae, shape of the marginal setae, presence of submarginal duct tubercles and ventral thoracic tubular ducts will separate this species from other *Coccus* species in California.

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- Avidov, Z. and I. Harpaz, 1969: Plant Pests of Israel. Isr. Univ. Press, Jerusalem. 549 pp.
- Bartlett, B. R., in C. P. Clausen, Ed., 1978: U.S. Dept. Agric. Handb. 480: 1-545.
- Bodenheimer, F. S., 1951: Citrus Entomology in the Middle East. Dr. W. Junk, The Hague. 663 pp.
- Borchsenius, N. S., 1957: Akad. Nauk. Zool. Inst. (n.s. 66) 9:1-493.
- DeLotto, G., 1959: J. Entomol. Soc. South Afr. 22:150-173.
- Ebeling, W., 1959: Subtropical Fruit Pests. Univ. Calif. Div. Agric. Sci. Bull., Los Angeles. 436 pp.
- Essig, E. O., 1958: Insects and Mites of Western North America, The MacMillan Co., New York. 1050 pp.
- Gill, R. J., S. Nakahara and M. L. Williams, 1977: Calif. Dept. Food Agric. Occas. Pap. Entomol. 24:1-44.
- Merrill, G. B., 1953: Fla. State Plant Board Bull. 1:1-143.
- Quayle, H. J., 1938: Insects of citrus and other subtropical fruits. Comstock Publ. Co., Ithaca, New York. 583 pp.
- Saakyan-Baranova, A. A., 1964: Entomol. Obozr. 43:268-296. Abstracted in: Entomol. Rev. 43:135-147.
- Talhouk, A. S., 1975: Ciba-Geigy Agrochem. Tech. Monogr. 4:1-88.
- Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.

Coccus longulus (Douglas), 1887
long brown scale

Fig.8, Color Plates 3, 6

Other Common Names:

elongate soft scale.

Synonymy:

Lecanium longulum Douglas,

L. chirimoliae Maskell,

L. ficus Maskell,

L. wistariae Brain,

L. frontale Green,

L. celtium Kuwana,

L. elongatum Signoret,

L. kraunhiarum Lindinger,

Coccus elongatus (Signoret),

Parthenolecanium wistaricola Borchsenius.

Field Characteristics: Adult females 2 to 6 mm long, elongate oval, slightly convex in profile. Color of young adults yellow with dense brown mottling in patterns of lines and spots. Color of older specimens uniform brown.

Biology: Little is known except that females are parthenogenetic.

Similar Species: Adult females similar to brown soft scale and to slender soft scale, *Coccus acutissimus* (Green). The normally elongate oval shape and color pattern of adult females should aid in recognition.

Hosts: Polyphagous. Prefers *Acacia* and carob (*Ceratonia siliqua*) in California. For a complete host list see Gill et al. (1977).

Economic Importance: Non-economic. For information on natural enemies see Ferris (1948).

Distribution: Rare in California. Usually found outdoors in coastal southern and central California. Also occurs in Florida and Texas, and indoors in many other states.

Diagnosis: Has slender, curved dorsal setae, well-developed legs and 8-segmented antennae; lacks submarginal duct tubercles and ventral tubular ducts. The only other North American *Coccus* with slender, curved dorsal setae is *C. pseudohesperidum*, which has reduced legs and fewer-segmented antennae.

Ben-Dov, Y., 1976: Bull. Entomol. Res. 67:89-95.

Ferris, G. F., 1948: in Zimmerman, E. C., Insects of Hawaii, Homoptera: Sternorhyncha. Vol. 5, Univ. Hawaii Press, Honolulu.

Gill, R. J., S. Nakahara and M. L. Williams, 1977: Calif. Dept. Food Agric. Occ. Pap. Entomol. 24:1-44.

Coccus pseudohesperidum (Cockerell), 1895
orchid soft scale

Fig.9, Color Plate 9

Other Common Names:

soft black orchid scale.

Synonymy:

Lecanium pseudohesperidum Cockerell.

Field Characteristics: Adult females 4 to 7 mm long, elongate oval in shape and slightly convex in profile. Color yellowish with a dark

brown or olive mottling in young adult females to a uniform brown color in older adult females. Young adults have most of the dorsum mottled brown, but the margins are yellow with alternating bands of brown. Polygonal transparent wax plates may be present on the dorsum.

Biology: Unknown except that males apparently are common.

Similar Species: Brown soft scale is the only California species occurring on orchids that may be mistaken for this species. However, the color patterns of the two are quite different and male puparia will not be found in brown soft scale infestations.

Hosts: Apparently restricted to orchids although there is one record from iris in North Carolina.

Economic Importance: Although listed by Steinweden (1945, 1948) as a pest of orchids in California, it is not presently a pest and not known as a pest in other parts of the world.

Distribution: Found on orchids in Los Angeles and in a number of locations around the San Francisco Bay region prior to 1948. Has

not been collected since, probably no longer occurs in California. Known from a number of other states including Hawaii, and from Europe, Central and South America and Asia. Probably native to tropical America.

Diagnosis: The only *Coccus* species in the U.S. with a combination of curved dorsal setae and reduced legs. For more information on morphology see Gill et al. (1977).

Gill, R. J., S. Nakahara and M. L. Williams, 1977: Calif. Dept. Food Agric. Occ. Pap. Entomol. 24:1-44.

Steinweden, J. B., 1945: Orchid Dig. 9(2):264-267.

Steinweden, J. B., 1948: Orchid Dig. May-June: 105-111.

***Coccus pseudomagnoliarum* (Kuwana), 1914
citricola scale (ESA approved)**

Fig.10, Color Plates 7, 8, 21

Other Common Names

grey citrus scale.

Synonymy:

Lecanium pseudomagnoliarum Kuwana,

Coccus citricola Campbell,

Coccus aegaeus DeLotto.

Field Characteristics: Adult females 2 to 7 mm long, elongate oval, slightly convex in profile. With a distinct roughened or granular dorsal surface. Color grey with dark brown mottling in adult females and late instar nymphs. Older adult females dark grey. Early instar nymphs transparent yellowish.

Biology: One generation per year. Adults reach maturity in April and May. Up to 2,000 eggs per female may be laid over a 1-2 month period. Crawlers hatch immediately or over a period of several days, then crawl to the undersides of the leaves where they develop until November, when they become darker in color and return to the green twigs. Nymphs spend the winter on the twigs where they

mature. Males have been mentioned in the literature but their actual existence is questionable at this time. The above biological information summarized from the following sources: Quayle (1938), Essig (1958), Ebeling (1959), Barbagallo (1974), Tranfaglia (1974), Argyrious and Ioannides (1976) and Oncüer and Tuncyurek (1976).

Similar Species: Host restrictions and coloration should help in recognizing this species. Similar to brown soft scale but adult females darker brown with uniform mottled coloration. Brown soft scale females are light yellowish-brown with brown dots or variable brown mottling. Also, a population of citricola scale usually consists of individuals of the same life stage because there is only one generation per year. In brown soft scale, all stages are often present on the host at the same time. Adult females are found primarily on the twigs, while adults of brown soft scale are commonly found on the leaves. Early stages

of black scale are similar to citricola scale, but they have the distinctive dorsal "H" pattern characteristic of the black scales.

Hosts: Prefers *Citrus* and hackberry (*Celtis*) in California; rarely found on other plants. For a complete host list see Gill et al. (1977).

Economic Importance: Causes tree decline and reduced fruit set by removing large quantities of sap. Honeydew secretions and sooty mold fungi are a problem on the fruit. Was a serious pest of citrus in the San Joaquin Valley prior to 1945. Presently not a serious pest because of natural enemies and improved pesticides, although treatments in some groves is occasionally necessary to control minor outbreaks. The above information on the economic importance of this species summarized from the following sources: Quayle (1938), Gressitt et al. (1954), Ebeling (1959), Barbagallo (1974), Oncüer (1974), Talhouk (1975) and Bartlett (1978). For information on natural enemies see Quayle (1938), Bartlett (1953, 1978), Gressitt et al. (1954), Ebeling (1959) and Oncüer (1974).

Distribution: Most common in the San Joaquin Valley. Occasionally found in the Sacramento Valley and Southern California. Also, known from Arizona, Mexico, Japan, Australia, France, Sicily, Greece (Rhodes), Turkey, USSR (Georgia, Armenia) and Iran. Probably native to arid regions of Asia; introduced into California before 1904, probably from Japan.

Diagnosis: Field appearance and habits will aid in the identification of this scale. Recognized morphologically by the lack of submarginal duct tubercles and ventral thoracic

tubular ducts. For more morphological information see Gill et al. (1977).

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- Argyriou, L. C. and A. G. Ioannides, 1976: Bull. SROP 5:161-162. Abstracted in Rev. Appl. Entomol. 64(10):1703.
- Barbagallo, S., 1974: Entomologica 10:121-139.
- Bartlett, B. R., 1953: J. Econ. Entomol. 46:25-28.
- Bartlett, B. R., in C. P. Clausen, Ed., 1978: U.S. Dept. Agric. Handb. 480: 1-545.
- Ebeling, W., 1959: Subtropical Fruit Pests. Univ. Calif. Div. Agric. Sci. Bull., Los Angeles. 436 pp.
- Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.
- Gill, R. J., S. Nakahara and M. L. Williams, 1977: Calif. Dept. Food Agric. Occ. Pap. Entomol. 24:1-44.
- Gressitt, J. L., S. E. Flanders and B. Bartlett, 1954: Pan-Pac. Entomol. 30(1):5-9.
- Oncüer, C., 1974: Bitki Koruma Bull. Suppl. 1:1-59. Abstracted in Rev. Appl. Entomol. 64(3).
- Oncüer, C. and M. Tuncyureck, 1976: Bull. SROP 5:255-257. Abstracted in Rev. Appl. Entomol. 64(10):1706.
- Quayle, H. J., 1938: Insects of citrus and other subtropical fruits. Comstock Publ. Co. Ithaca. 583 pp.
- Talhouk, A. S., 1975: Ciba-Geigy Agrochem. Tech. Monogr. 4:1-88.
- Tranfaglia, A., 1974: Boll. Lab. Entomol. Agrar., Portici 35:141-144.

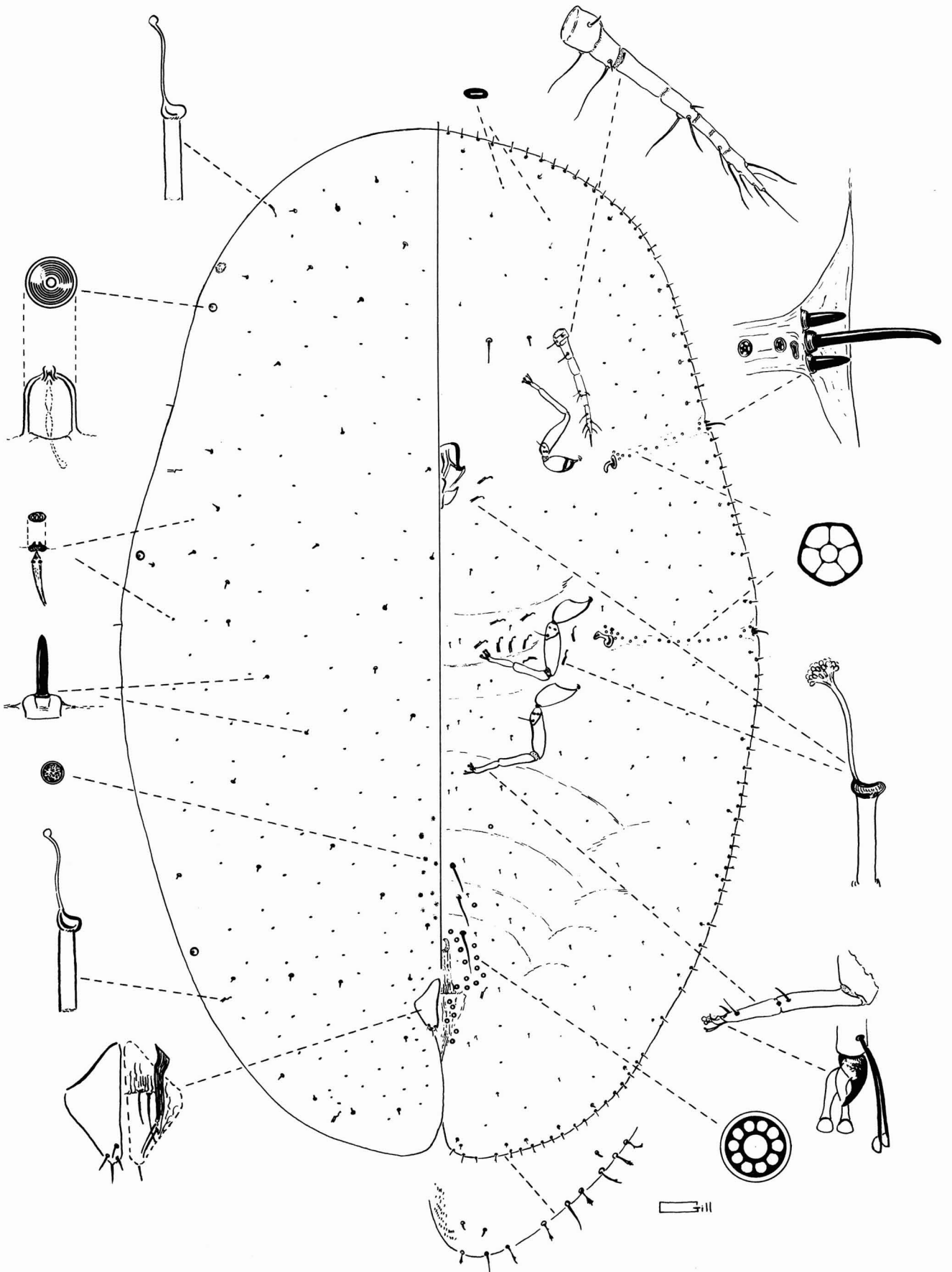


Fig. 7: *Coccus hesperidum* Linnaeus.

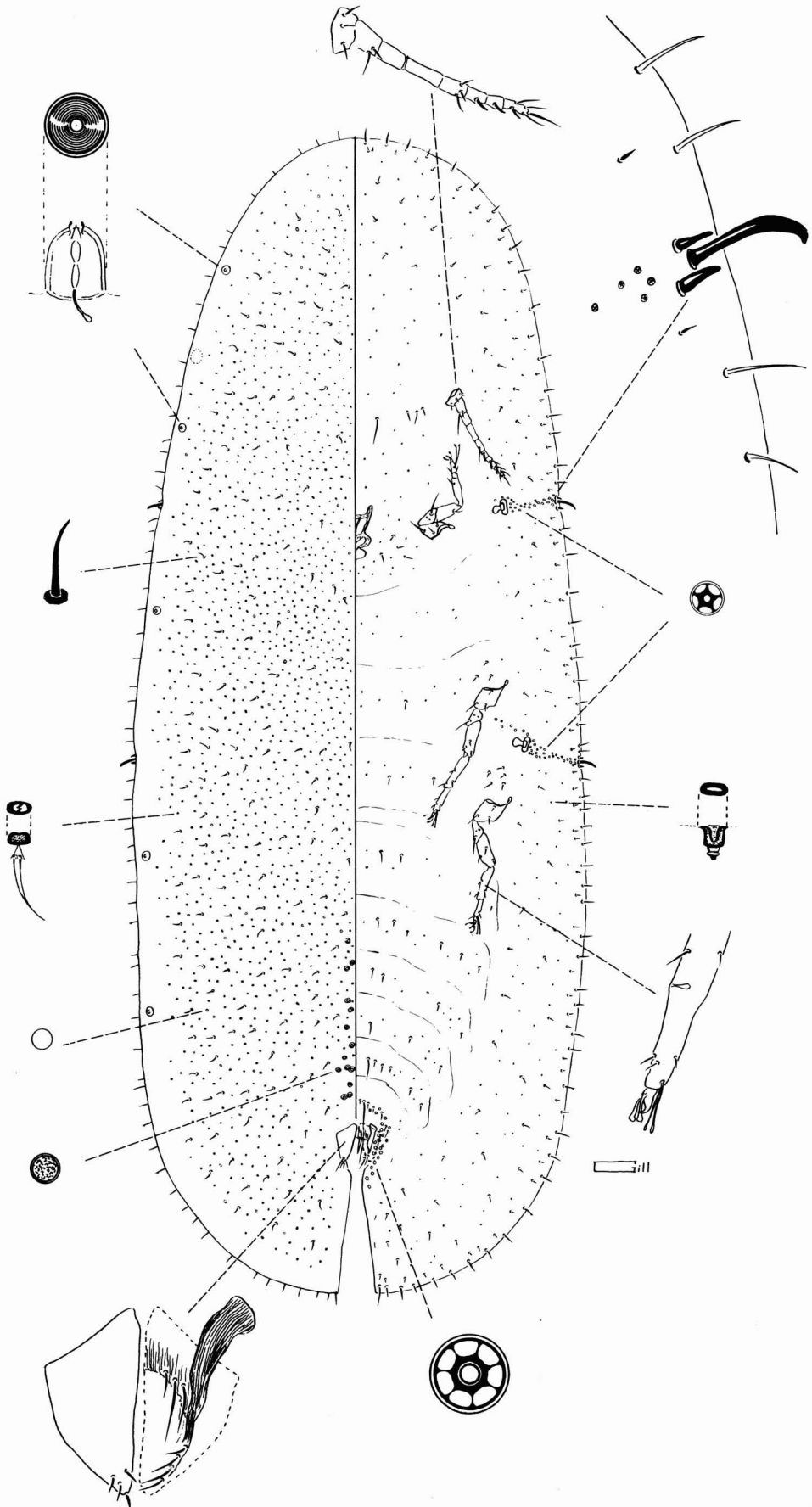


Fig. 8: *Coccus longulus* (Douglas).

Genus *Eriopeltis* Signoret, 1872 The Smallreed or Cottony Grass Scales

This genus is part of the tribe Eriopeltini which is composed of 9 genera of grass and sedge feeding scales. The genus is readily recognized by the large truncate dorsal setae and the ovisacs that completely or partially enclose the mature females. Most of the species in the genus are Palearctic in origin. The species are difficult to separate morphologically, especially since they are quite variable depending on the type of grass host that they infest. In North America *E. festucae* (Fonscolome) is reported from Virginia, Maine, the Dakotas, Indiana, Illinois and Nova Scotia in Canada. According to Koteja (personal communication) *E. coloradenis* Cockerell from Colorado is indistinguishable from *E. festucae* (Fonscolombe) and there is also confusion on the specific limits between *E. festucae* and *E. stammeri* Schmutterer, another European species. King (1901) and Danzig (1975) list *festucae* as having been introduced into Canada and the U.S. There are approximately 23 described species worldwide. Because of these facts, the identity of *coloradenis* and of *festucae* are uncertain, and the *Eriopeltis* species from the Western United States cannot be positively identified at this time. The following species account assumes that the California species is *festucae*.

Danzig, E. M., 1975: Entomol. Rev. 54(4):69-72.

King, G. B., 1901: Can. Entomol. 33(7):193-200.

Eriopeltis festucae (Fonscolombe), 1834 cottony grass scale

Fig. 11

Field Characteristics: Adult females 3 to 5 mm long, flattened and elongate, conforming to the narrow blades of the grass host. Females in later stages completely concealed within a long cottony white ovisac.

Biology: One North American species, *E. festucae* (Fonscolombe) has 2 generations per year and overwinters as eggs. For more information see Patch (1905), Tiensuu (1951) and Williams and Kosztarab (1972).

Similar Species: Scales in the genera *Luzulaspis*, *Eriococcus* and some grass infesting mealybugs, which form long ovisacs on grasses, may be similar.

Hosts: Restricted to grasses.

Economic Importance: None in the United States, except for substantial losses to a hay crop in Maine in 1904 (Williams and Kosztarab, 1972).

Distribution: An *Eriopeltis* was collected along Tualata Creek, west of Sage, Riverside County in 1963. Other specimens have been collected at Montgomery Pass, Esmeralda County, Nevada, and it is assumed that this scale probably occurs in the adjoining Inyo-Mono County area of California. Elsewhere in North America *Eriopeltis* species are known from Nevada, Montana, Colorado, Nebraska, the Eastern United States and Canada.

Diagnosis: The large truncated setae will immediately separate these scales from other soft scales in California. Specimens from western North America cannot be placed to species although evidence suggests that California specimens may be *E. festucae*. See previous discussion of the genus *Eriopeltis*.

SOFT SCALES OF CALIFORNIA

GENUS *ERIOPELTIS*

- Patch, E. M., 1905: Maine Agric. Exp. Stn. Bull.121:169-180.
- Tiensuu, L., 1951: Ann. Entomol. Fenn. 17:3-10.
- Williams, M. L., and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.
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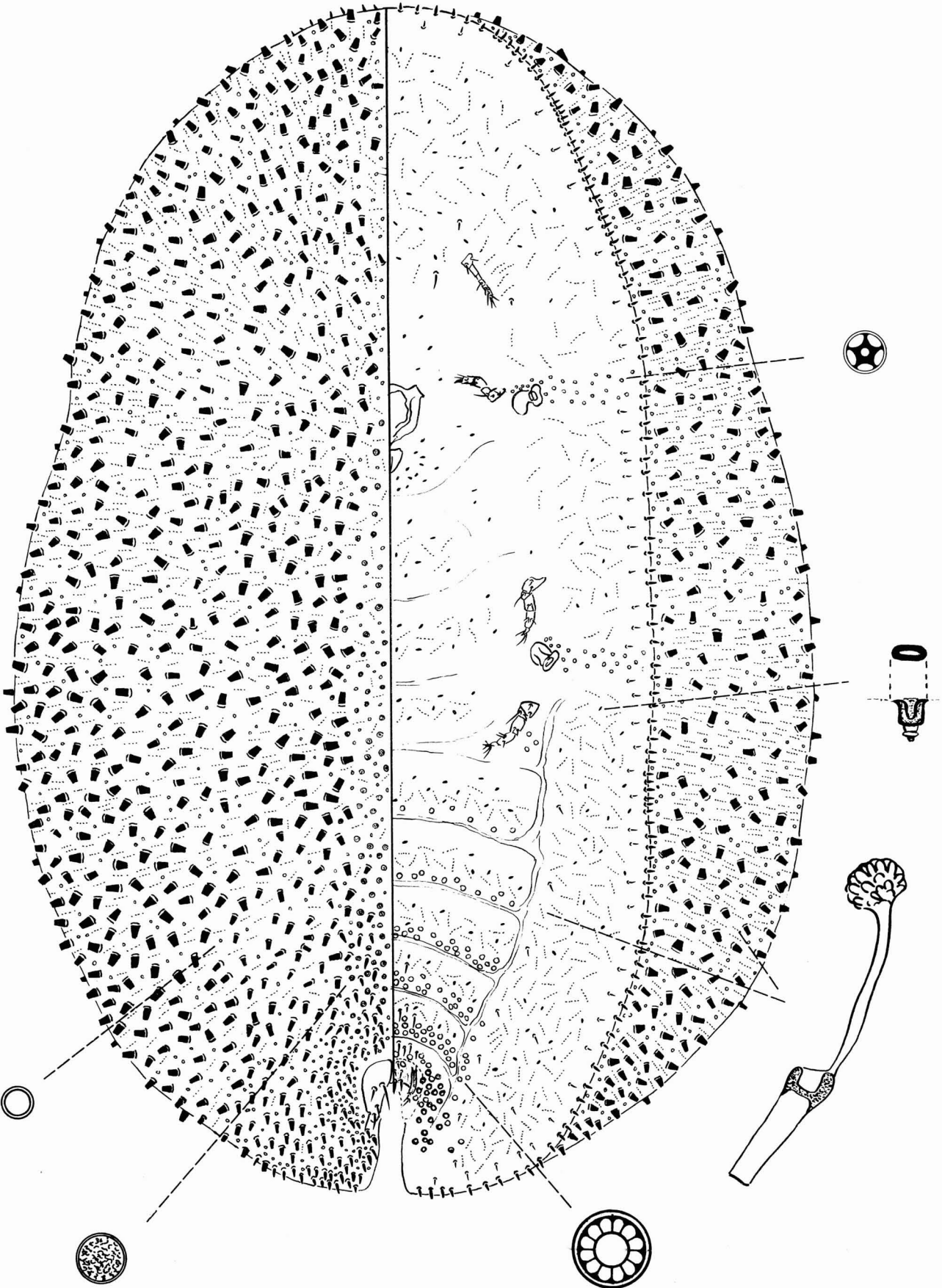


Fig. 11: *Eriopeltis festucae* (Fonscolombe).

Genus *Eucalymnatus* Cockerell, 1901 The tessellated scales

The genus is characterized by ovoid or pyriform flat species with the dorsal derm divided into irregular sclerotized plates. Nymphs and very young adult females, however, have a membranous, undivided dorsal derm and are quite similar to species in the genera *Coccus* and *Mesolecanium*. The genus is apparently native to South America where about 15 species are known; one species is cosmopolitan.

Eucalymnatus tessellatus (Signoret), 1873 tessellated scale (ESA approved)

Fig.12, Color Plate 40

Other Common Names:

palm scale.

Synonymy:

Lecanium tessellatum Signoret,

Coccus tessellatus (Signoret),

Lecanium perforatum Newstead,

Eucalymnatus perforatus (Newstead).

Field Characteristics: Adult females 2 to 5 mm long, pyriform to oval (often asymmetrical), flat in profile and reddish to dark brown. Readily recognized by the variable-shaped dorsal polygonal plates (tessellations) formed by sclerotized areas in the dorsal derm. There is usually a raised median dorsal keel or carina.

Biology: Poorly known. It apparently has more than 1 generation per year and is parthenogenetic and ovoviviparous. For more information see Essig (1915).

Similar Species: Nigra scale has smaller, polygonal (cell-like) reticulations and lacks the dorsal median keel. Immature specimens and young females of tessellated scale are not distinguishable in the field from some soft scales in the genera *Coccus*, *Protopulvinaria* and *Kilifia*.

Hosts: Polyphagous but prefers palms. For a complete host list see Merrill (1953) and Dekle (1973).

Economic Importance: Dekle (1973) lists this species as an occasional pest in greenhouses in Florida. Has never developed large popula-

tions in California.

Distribution: This species was once widely distributed but rarely collected in Southern California. However, populations have apparently died out, and the last California collection was in 1965 in Santa Barbara. A cosmopolitan species common in Florida and Hawaii; the genus is apparently native to South America, where other closely related species occur.

Diagnosis: Readily recognized by the unique dorsal polygonal plates. Young, untessellated adult females resemble *Coccus longulus*, but differ by lacking the subdiscal setae on the anal opercula and by having apico-lateral setae on the opercula. For more information see Gill et al. (1977). A similar, apparently undescribed species with large dorsal polygonal plates is known from Mid Hills, San Bernardino County on *Yucca brevifolia*.

Dekle, G. W., 1973: Fla. Dept. Agric. Entomol. Circ. 138:1-2.

Essig, E. O., 1915: Calif. Dept. Agric. Mon. Bull. Suppl. 4(4):1-541.

Gill, R. J., S. Nakahara and M. L. Williams, 1977: Calif. Dep. Agric. Occas. Pap. Entomol. 24:1-44.

Merrill, G. B., 1953: Fla. State Plant Board Bull. 1:1-143.

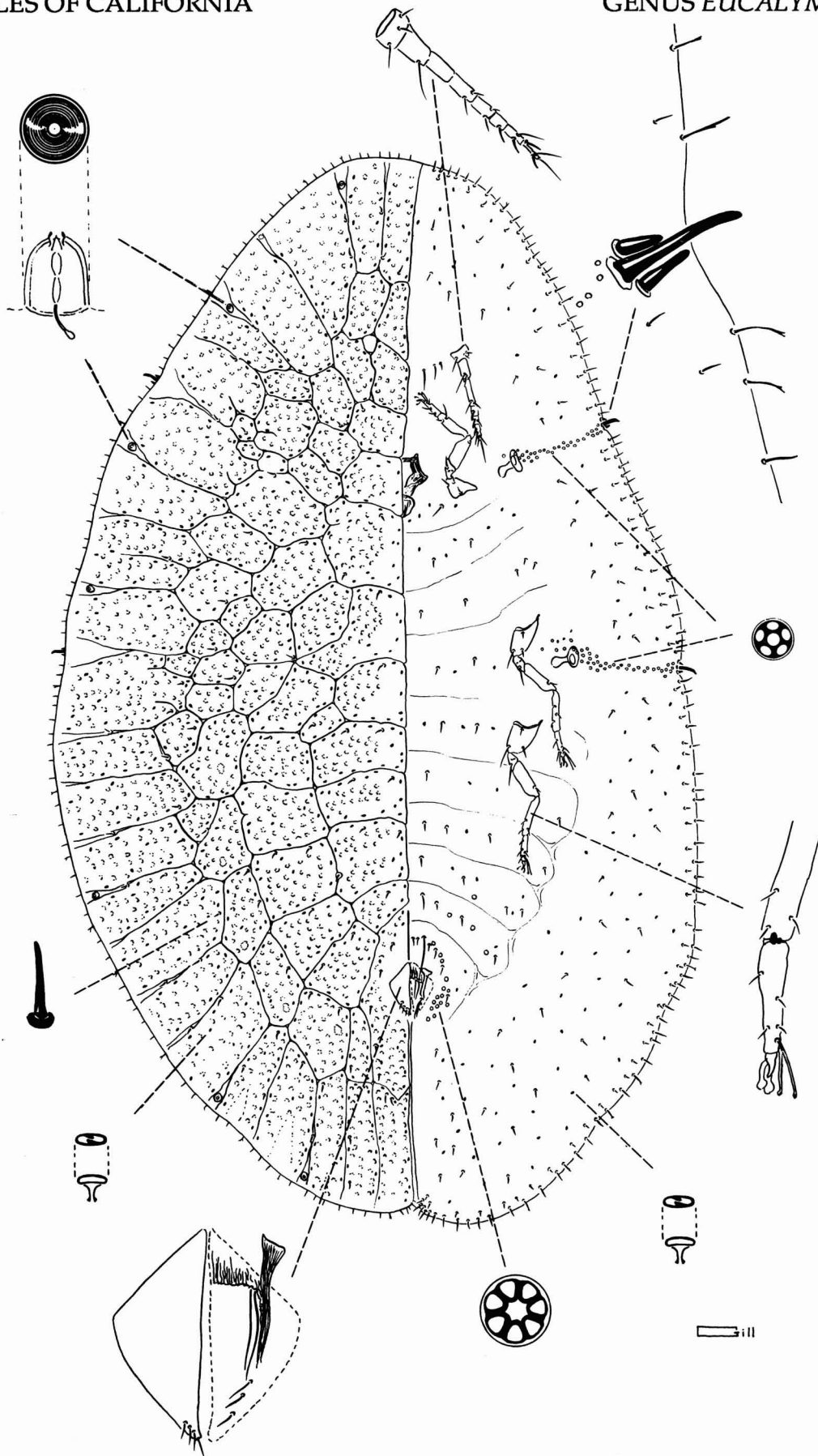


Fig. 12: *Eucalymnatus tessellatus* (Signoret).

Genus *Eulecanium* Cockerell, 1893 The Spherical Scales

The genus is characterized by moderately convex to nearly spherical species. Young adults are often brightly colored but become much darker with advancing maturity. Morphologically, there are two types of scales in this genus. One type has a continuous marginal band of closely set, spine-like setae. The other has marginal spine-like setae laterally and long filamentous setae apically and posteriorly. The last stage nymphs are also of two types, one with many closely set marginal setae, the other with fewer more widely set marginal setae. About 36 species are known world-wide.

Key to the California Species of *Eulecanium*

- 1 Marginal setae of two types, spine-like laterally and filamentous anteriorly and posteriorly; spiracular setae greatly differentiated from marginal setae; anal opercula surrounded by a striated dermal area. 2
- Marginal setae of one type, spine-like throughout; spiracular setae poorly differentiated from marginal setae, usually slightly smaller; striated dermal area absent. 3
- 2(1) Two spiracular setae in each spiracular depression; few thoracic multilocular pores; anal ring setae absent. *kunoense*
- Three spiracular setae in each spiracular depression; many thoracic multilocular pores; anal ring setae present. *tiliae*
- 3(1) Spiracular depressions each with 3 spiracular setae separated by 2 larger setae the same size as marginal setae; anal fold with 4-6 fringe setae. *caryae*
- Spiracular depressions each with only 3 setae; usually with more than 6 fringe setae. 4
- 4(3) Few multilocular pores on thorax; few dorsal tubular ducts; living adults black with rows of large white spots. *cerasorum*
- Many multilocular pores on thorax; many dorsal tubular ducts; living adults covered with mealy, white wax. *excrescens*

Eulecanium caryae (Fitch), 1857 large hickory lecanium

Fig. 13

Other Common Names:
hickory lecanium,
Chico almond lecanium.

Synonymy:
Lecanium caryae Fitch,
Lecanium cockerelli Hunter.

Field Characteristics: Probably the largest soft scale in California, reaching 10 to 15 mm in length; oval and flat or slightly convex

depending on the host. Young adult females are yellow-brown and are covered with dense mealy white wax; older females become dark shiny brown.

Biology: One generation per year in the eastern United States. For more information see Williams and Kosztarab (1972).

Similar Species: Adult females of frosted scale, excrescent scale and this species are not

readily separated in the field. Nymphs of this species are similar to those of calico scale and excrescent scale. However, calico scale nymphs have one less row of wax plates than this species (Mackie, 1936).

Hosts: Polyphagous on deciduous hosts. California collections are from almond. For a more complete list see Williams and Kosztarab (1972).

Economic Importance: None. According to Williams and Kosztarab (1972), it is usually kept under control by natural enemies. Mackie (1936) reported heavy parasitization in California.

Distribution: Widespread in the midwestern and eastern United States. In California col-

lected only at Chico, Butte County. It is the Chico almond lecanium of Mackie (1936). Has not been collected in California since 1936.

Diagnosis: Similar morphologically to *Eulecanium cerasorum* and *E. excrescens*. It has fewer multilocular disc pores and fewer fringe setae (4-6) than either of these 2 species. Also, the 3 spiracular setae are separated usually by 2 seta as long as the marginal setae.

Mackie, D. B., 1936: Calif. Dept. Agric. Mon. Bull. 25(4):476-477.

Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.

Eulecanium cerasorum (Cockerell)
calico scale (ESA approved)

Fig.14, Color Plates 22, 41, 42

Other Common Names:

cherry scale.

Synonymy:

Lecanium cerasorum Cockerell.

Field Characteristics: Adult females hemispherical, 6 to 9 mm in diameter. Living adult females dark brown or black with 4 rows of yellow or white spots on the dorsum. Small amounts of white woolly wax secreted from the areas of the white or yellow spots. Immature forms flat, dark brown and covered with angular transparent wax plates. Adults live only a few weeks. After death the dorsum gradually becomes lighter and the yellow spots become darker and difficult to distinguish.

Biology: One generation per year. Crawlers settle on the foliage or young twigs of the host in late spring and develop into second-stage nymphs during the summer months. Late stage nymphs pass the winter on the stems. Females reach maturity in late April or May. For more information see Madsen and Barnes (1959), and Michelbacher and Ortega (1958).

Similar Species: The dorsal calico pattern of

living adult females distinguishes this species from all other California soft scales. Dead female scales resemble other "Lecanium" type soft scales, although the faint calico spots are still visible as much as a year later. Nymphs have wax plates similar to those of other scales in the genus *Eulecanium*, and are not distinguishable in the field.

Hosts: Found on many species of deciduous trees. In California prefers *Liquidambar*. Occasionally attacks fruit and nut trees such as walnuts, apricots and plums.

Economic Importance: A serious pest of liquidambar street trees in Sacramento, where it often requires treatment. This scale has occasionally developed large populations on commercial fruit trees, but it is not normally considered a commercial crop pest. Also a pest on deciduous ornamental trees in the eastern United States (Stimmel, 1986). For more information on the economic importance of this species see Michelbacher and Ortega (1958), and Madsen and Barnes (1959). For information on natural enemies see Michelbacher and Hitchcock (1957), and Bartlett

(1978).

Distribution: Restricted to the San Francisco Bay Area and the Sacramento and San Joaquin Valleys. Also occurs in several eastern states. Probably native to the Orient; apparently introduced into the Bay Area prior to 1930.

Diagnosis: The color pattern of the adult female should readily distinguish this species. Resembles *Eulecanium excrescens* and *E. caryae*, but can be distinguished by its relatively fewer number of dorsal tubular ducts along with differences in placement of the dorsal discoidal pores and ventral minute bilocular pores. According to Michael Williams of Auburn University (pers. comm.), the species commonly considered as calico scale in the United States does not agree morpho-

logically with the type specimen of *cerasorum*. Therefore, the scientific name of calico scale must be changed eventually. See also Ferris (1920).

Bartlett, B. R., in C. P. Clausen, Ed., 1978: U.S. Dep. Agric. Handb. 480:1-545.

Ferris, G. F., 1920: Stanford Univ. Publ., Univ. Ser. Biol. Sci. 1:1-57.

Madsen, H. F. and M. M. Barnes, 1959: Calif. Agric. Exp. Stn. Circ. 478:1-40.

Michelbacher, A. E. and S. Hitchcock, 1957: Pan-Pac. Entomol. 33:15.

Michelbacher, A. E. and J. C. Ortega, 1958: Calif. Agric. Exp. Stn. Bull. 764: 1-87.

Stimmel, J. F., 1986: Pennsylv. Dept. Agr. Entomol. Circ. No.105, in Reg. Hort. 12(2): 13-14.

Eulecanium excrescens (Ferris), 1920
excrescent scale

Fig.15, Color Plates 43, 44

Synonymy:

Lecanium excrescens Ferris.

Field Characteristics: A large, convex, oval or round species, often 8 to 10 mm in length or diameter. Total length and convexity vary with the size of the host twig; the scale is usually shorter and more convex on smaller diameter twigs. Young adult females brown, sometimes with yellow mottling, covered with a white mealy wax secretion similar to that of frosted scale. Nymphs brown and yellow, covered with transparent white wax platelets as are the nymphs of the other *Eulecanium* species.

Biology: Apparently has 1 generation per year.

Similar Species: Frosted scale, *P. pruinosum*, is similar but smaller and less convex. Very similar to and probably not distinguishable from *E. caryae* in the field. Nymphs are not distinguishable from other *Eulecanium* species.

Hosts: Most deciduous orchard trees and many deciduous ornamental trees. For a complete host list, see Essig (1958).

Economic Importance: None.

Distribution: Rare. Infrequently found from Merced and Alameda Counties north to Humboldt County. Also occurs in Oregon, Connecticut, New York and Pennsylvania. Apparently introduced from the Orient where other similar species occur.

Diagnosis: Similar to *E. caryae*, but differs in having many more multilocular pores and 7 to 10 fringe setae. Differs from *E. cerasorum* by having more multilocular disk pores and more dorsal discoidal pores. The multilocular pores of *E. excrescens* have a slit-like center, whereas, *E. cerasorum* and *E. caryae* have circular centers.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., N. Y. 1050 pp.

Eulecanium kunoense (Kuwana), 1907

Kuno scale

Fig.16, Color Plates 34-36, 53

Synonymy:*Lecanium kunoensis* Kuwana,*Lecanium insignicola* (Craw), (misidentification).

Field Characteristics: Adult females, almost spherical, 3 to 4 mm in diameter, resembling rows of spheres (B-Bs) glued to the stems of the host. One of the most useful identification characteristics of this species is the broad internal "lip" of the body margin which occurs where the adult female scale attaches to the host. This lip is best seen by removing the females from the host and examining the venter. During most of the year females are a dark, shiny, chestnut brown, with numerous darker depressed spots. For a short time in spring before egg-laying begins, adult females are yellowish with 7 to 8 transverse black bands or partially coalescing black blotches and a diffuse median longitudinal stripe of red or orange. Nymphs flat, yellow or brown, covered with large angular wax plates and with a fringe of marginal wax. Males prevalent, with cover or test of transparent crystalline wax, 2.0 mm long, and divided into 7 plates by bands of curled strands of white wax.

Biology: One generation per year in California. Overwinters in March through early May. Crawlers migrate to the leaves, nymphs develop on the leaves during summer. Nymphs return to the twigs before leaf drop in the fall. For more information see, Husseiny and Madsen (1962), and McKenzie (1951).

Similar Species: Distinguished from other soft scale insects in the field because of the broad ventral internal lip of the adult female. Most similar to calico scale, *Eulecanium cerasorum*. Immature stages cannot be separated from other scales in the genus *Eulecanium*.

Hosts: Prefers pyracantha and plum, but also infests walnut and most fruit trees in the rose family. For a complete host list see Husseiny and Madsen (1962).

Economic Importance: A minor pest of dooryard ornamentals. Not a pest of commercial crops in California although it has the potential to become one. Populations can enlarge quickly and produce copious amounts of honey-dew. For information on the economic importance of this species see McKenzie (1951) and Husseiny and Madsen (1962). Attempts at biological control of this species have not been particularly successful. For information on natural enemies see Clausen (1932), Koehler and Hamilton (1978), and Husseiny and Madsen (1962).

Distribution: Found only in Santa Clara, Alameda, Contra Costa, Lake, Napa, Butte and Sacramento Counties. Introduced from the Orient. According to Essig (1941), has probably been in California at least since 1896.

Diagnosis: Field characteristics are enough to readily distinguish this species. Distinct morphologically from all other North American soft scales except *Eulecanium tiliae*. Both species have marginal setae which are spine-like along the lateral margins and bristle-like on the anterior and posterior margins. Further, the anal opercula are surrounded by striated derm in older females. This scale differs from *E. tiliae* as follows: More marginal setae; fewer multilocular disc pores; many large dorsal discoidal pores; only 2 spiracular setae in each spiracular depression and lacks anal ring setae.

Clausen, C. P., 1932: Ann. Entomol. Soc. Am. 25:670-687.

Essig, E. O., 1941: J. Econ. Entomol. 34(4): 590.

Husseiny, M. M. and H. F. Madsen, 1962: Hilgardia 33(6):179-203.

Koehler, C. S. and W. D. Hamilton, 1978: Univ. Calif. Div. Agric. Sci. Leaflet. 21001. 2 pp.

McKenzie, H. L., 1951: Calif. Dept. Agric. Mon. Bull. 40(3):105-109.

Eulecanium tiliae (Linnaeus), 1758
thorn scale

Fig.17, Color Plates 25, 38, 39

Other Common Names:

brown scale,
nut scale,
brown gooseberry scale,
European fruit lecanium.

Synonymy:

Coccus tiliae Linnaeus,
Lecanium tiliae (L.),
Coccus coryli Linnaeus,
Lecanium coryli (L.).

For a complete list see Kawecki (1958).

Field Characteristics: Adult females 4 to 7 mm in diameter, convex to nearly hemispherical in profile. Young, living adult females mottled reddish, black and white with a distinctive series of white transverse bands on the dorsum becoming progressively shorter posteriorly. Older adults brownish, the mottled patterns faint or indistinguishable. Nymphs flattened, mottled red and brown.

Biology: One generation per year. Overwinters as late instar nymphs. Females mature in February and March in California. Early nymphal stages occur on the leaves, but nymphs return to the twigs in autumn. Males are common and apparently the species is obligatorily biparental. For more information see Kawecki (1958) and Kerr (1951).

Similar Species: Similar to Kuno scale in field appearance, but Kuno scale lacks the distinctive white dorsal pattern. Also similar to other scales of the "Lecanium" group, particularly if the scales are found late in the season.

Hosts: In California prefers dogwood (*Cornus*) and is polyphagous on other deciduous hosts. For a complete host list see Kawecki (1958) and Kerr (1951).

Economic Importance: Occasionally a pest of deciduous trees in Europe and has been a serious pest of maples in the Pacific Northwest. Not a pest in California; found only on nursery stock originally from Oregon and Washington, except for one collection in Grass Valley, Nevada County in 1984. Controlled by natural enemies in Europe (Kawecki, 1958). For information on natural enemies see Beirne (1984) and Rubin and Beirne (1975).

Distribution: Has been found only in several nurseries in the Bay Area and central California, and in a dooryard in Nevada County. Also occurs in the Pacific Northwest, Rhode Island and in Europe.

Diagnosis: Distinguished by spine-like lateral marginal setae and filamentous anterior and posterior marginal setae, and by the striated area surrounding the anal plates. It is similar to *kunoense* but differs from that species by having a well-developed anal ring with setae; three setae in each spiracular depression and few filamentous marginal setae.

Beirne, B. P., 1984: J. Entomol. Soc. Brit. Columbia 81:28.

Glendenning, R., 1925: Proc. Entomol. Soc. Brit. Columbia 22:21-26.

Kawecki, Z., 1958b: Pol. Pismo Entomol. 27(4):39-69.

Kerr, T. W., 1951: J. Econ. Entomol. 44(2) 234-240.

Rubin, A. and B. P. Beirne, 1975: Can. Entomol. 107:337-342.

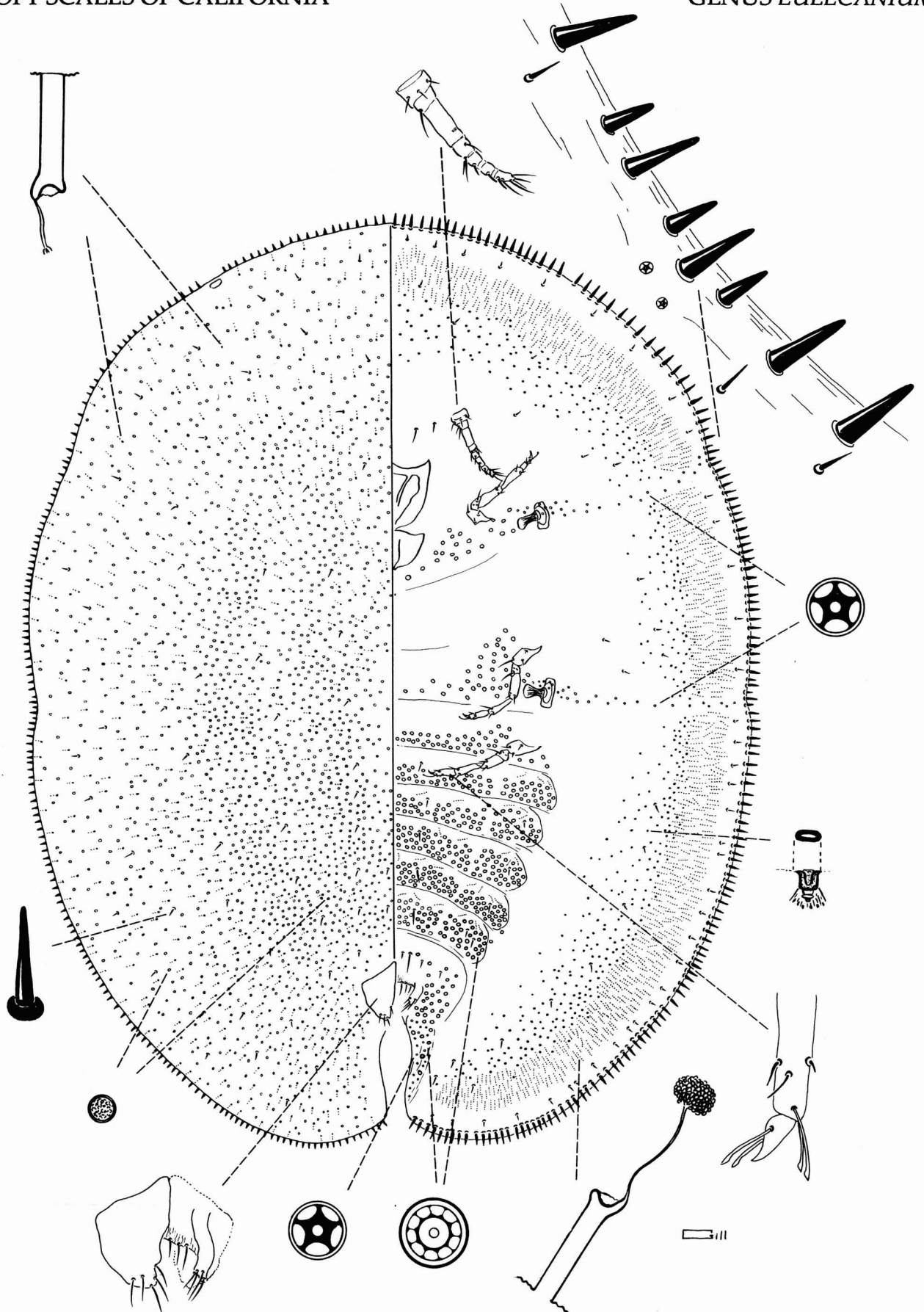


Fig. 13: *Eulecanium caryae* (Fitch).

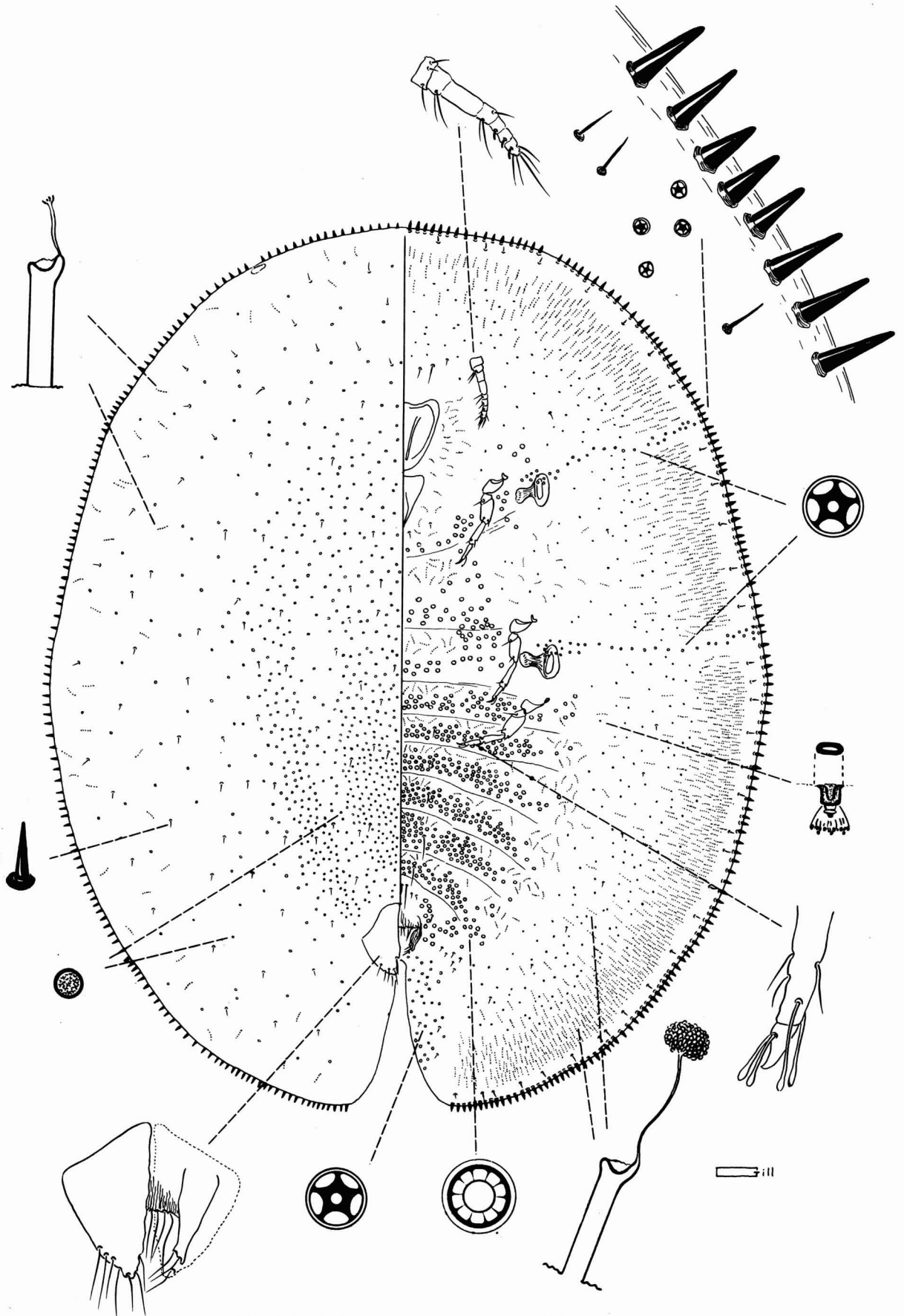


Fig. 14: *Eulecanium cerasorum* (Cockerell).

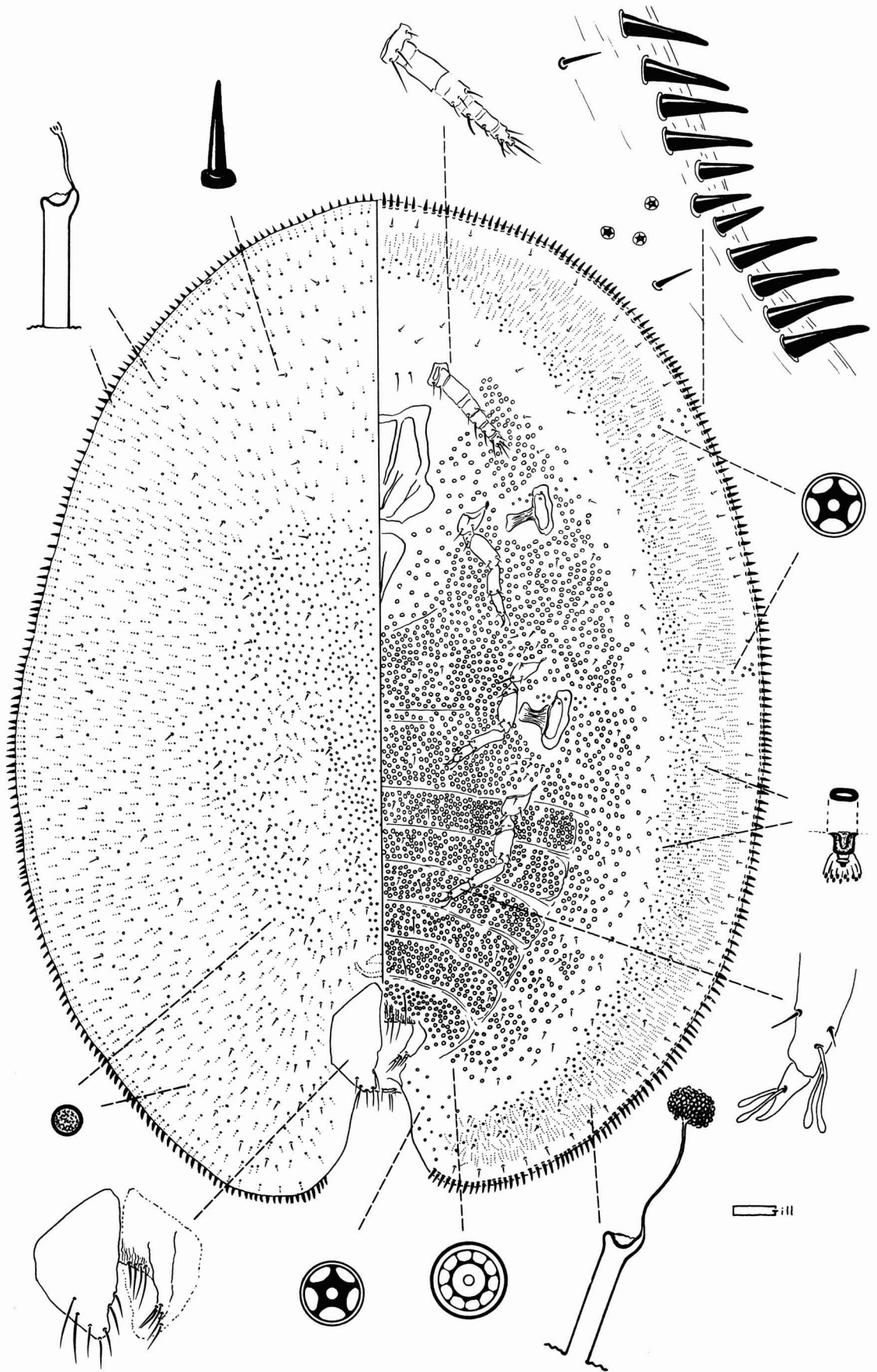


Fig. 15: *Eulecanium excrescens* (Ferris).

Genus "*Lecanium*" Burmeister, 1835

According to Opinion 1303 of the International Commission on Zoological Nomenclature (Melville, 1985), *Lecanium* is an invalid name and can no longer be used in publication. The official wording of Article 4 of Opinion 1303 is as follows: "The generic name *Lecanium* Burmeister, 1835 (a junior objective synonym of *Coccus* Linnaeus, 1758) is hereby placed on the Official Index of Rejected and Invalid Generic Names in Zoology with the Name Number 2155."

The generic name *Lecanium* had been used by American scientists for many years and therefore the name is well known to field entomologists in California. *Lecanium* was treated as a junior objective synonym of *Coccus* Linnaeus by Fernald (1903), but was not accepted by Sanders (1909). Since that time, North American authors have continued using *Lecanium* even though European authors accepted its junior status. Borchsenius (1957) changed the concept of "*Lecanium*" by dividing it into 4 genera: *Palaeolecanium*, *Parthenolecanium*, *Nemolecanium* and *Eulecanium*. In order to conform, Nakahara (1981) assigned North American *Lecanium* to the following genera: *Eulecanium*, *Mesolecanium*, *Parthenolecanium* and *Sphaerolecanium*. The 10 species in California previously assigned to *Lecanium* have been placed in the genera *Eulecanium* and *Parthenolecanium*.

Although these scales are placed here in their proper genera, they may be referred to collectively as "lecaniums" or as the "lecanium group" in this handbook.

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- | | |
|---|--|
| Borchsenius, N. S., 1957: Akad. Nauk. Zool. Inst. (n.s. 66) 9:1-493. | 42(2):139-141. |
| Fernald, M. E., 1903: A catalogue of the Coccidae of the World. Mass. Agr. Expt. Stn. Spec. Bull. 88:1-360. | Nakahara, S., 1981: Proc. Entomol. Soc. Wash. 83(2):283-286. |
| Melville, R. V., 1985: Bull. Zool. Nom. | Sanders, J. G., 1909: J. Econ. Entomol. 2:428-448. |
-

Genus *Luzulaspis* Cockerell, 1902
The Sedge Scales

This genus is part of the soft scale tribe Eriopeltini, composed of 9 genera of mostly Palearctic grass and sedge feeders. There are 4 *Luzulaspis* species known from North America: 1 from Alaska, 1 from Georgia and 2 from California. A key to the North American species will be found in Koteja and Howell (1979). A key to the Eriopeltini and a list of the 16 world species of *Luzulaspis* will be found in Koteja (1978, 1979).

The genus is characterized by having 2 nearly identical setae in each spiracular depression and numerous dorsal and ventral tubular ducts. The 2 California species are known only from the type localities. They are similar morphologically, but are geographically isolated.

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- Koteja, J., 1978: Pol. Pismo Entomol. 48:311-327. Koteja, J. and J. C. Howell, 1979: Ann. Entomol. Soc. Am. 72(3):334-342.
Koteja, J., 1979: Pol. Pismo Entomol. 49:585-638.

KEY TO THE CALIFORNIA SPECIES OF *LUZULASPIS*

1. Marginal setae slightly bent, sharply pointed, usually larger anteriorly and posteriorly than laterally; interantennal setae and ventral abdominal setae 60-120 μ long. *caricis*
Marginal setae straight, bluntly pointed, subequal around entire margin; interantennal and ventral abdominal setae less than 60 μ long. *minima*

***Luzulaspis caricis* (Ehrhorn), 1902**
alpine sedge scale

Fig. 18

Synonymy:

Exaeretopus caricis Ehrhorn.

Field Characteristics: Adult females 1.5 to 2.0 mm long, elongate oval, flattened, shiny salmon pink. During egg laying, a dense mass of white wax is produced over the entire body which coalesces with the long white ovisac; the combined length reaches 4 to 5 mm. According to Ehrhorn (1902), females leave the host and attach themselves to the undersides of rocks where the ovisacs are formed. Crawlers apparently hatch in the spring. Presuma-

bly 1 generation per year. For more data see Ehrhorn (1902).

Similar Species: *Luzulaspis minima* is probably similar to this species in the field. Certain of the woolly-sac scales in the genus *Eriococcus* and cottony grass scales in the genus *Eriopeltis* resemble this species.

Hosts: Known only from grass, *Trisetum subspicatum*, and a sedge, *Carex breweri*.

Economic Importance: None.

Distribution: Known only from the original

collection on Mt. Shasta above timberline between 9,000 and 10,000 feet elevation.

Diagnosis: Has slightly bent, sharply pointed marginal setae and ventral abdominal setae 60-120 mm long. *L. minima* has straight, bluntly pointed marginal setae and ventral abdominal setae less than 60 mm long.

Ehrhorn, E. M., 1902: Can. Entomol. 34:193-194.

Koteja, J. and J. O. Howell, 1979: Ann. Entomol. Soc. Am. 72(3): 334-342.

***Luzulaspis minima* Koteja and Howell, 1979**
 lesser sedge scale

Fig. 19

Field Characteristics: Adult females 2.0 to 2.5 mm long. Other information unknown. Presumably the same as *Luzulaspis caricis*.

Biology: Unknown.

Similar Species: *Luzulaspis caricis* and other species in the genus *Luzulaspis* as well as scales in the genera *Eriopeltis* and *Eriococcus*.

Hosts: *Carex*.

Distribution: Known only from the type collection at Eagle Lake, Mineral King, Tulare County, above 10,000 feet elevation.

Diagnosis: The marginal setae are subequal in this species and all setae are generally shorter than in *L. caricis*.

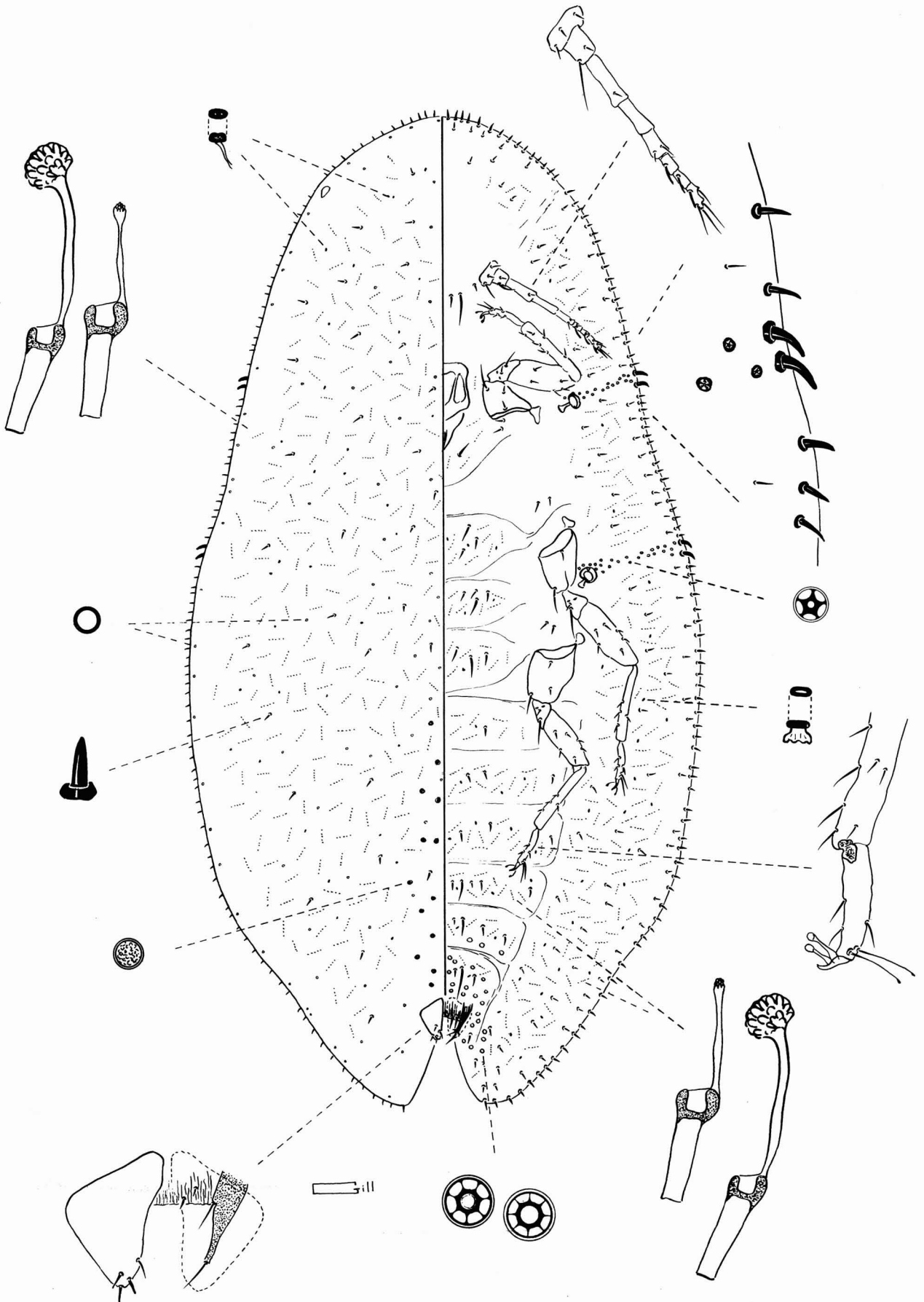


Fig. 18: *Luzulaspis caricis* (Ehrhorn).

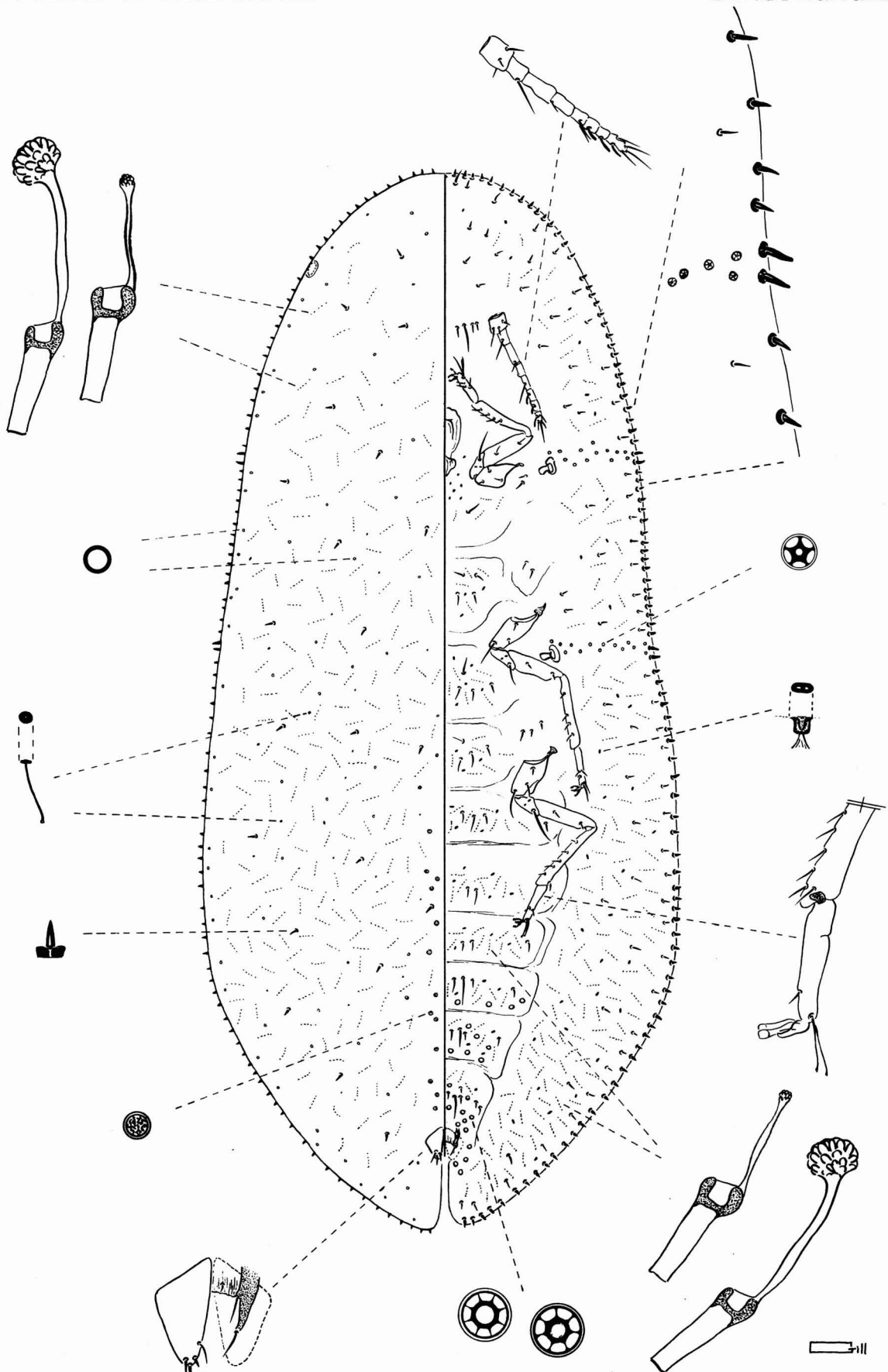


Fig. 19: *Luzulaspis minima* Koteja and Howell.

Genus *Metapulvinaria* Nakahara and Gill, 1985 The Desert Thorn Scales

The genus is characterized by the absence of dorsal setae, by having 6 anal ring setae, 1 pair of prevulvar setae, spine-like, blunt marginal setae and slender claw digitules.

One species is currently assigned to the genus. It occurs in California and other southwestern desert localities. The genus is reviewed by Nakahara and Gill (1985) along with the genus *Philephedra*, to which it is probably related.

Nakahara, S. and R. J. Gill, 1985: Entomography 3:1-42.

Metapulvinaria lycii (Cockerell), 1895 lycium soft scale

Fig. 20, Color Plates 56, 57

Synonymy:

Lichtensia lycii Cockerell,
Ctenochiton lycii (Cockerell),
Filippia lycii (Cockerell).

Field Characteristics: Adult females 3 to 6 mm long. oval and fairly convex. Color yellow or tan, mottled with dark brown or black, closely resembling the color of host twigs. Older adult females secrete a white, leathery, waxy cover over the entire body.

Biology: Unknown, probably 1 yearly generation. Males are present (Cockerell, 1895).

Similar Species: None on the preferred host.

Hosts: Prefers desert thorn, (*Lycium*). Also known from *Solanum* and *Hibiscus*.

Economic Importance: None.

Distribution: In California known only from Cameron, Kern County, but probably occurs

in other desert locations where *Lycium* occurs. Also occurs in Arizona, New Mexico, Texas and Baja California, Mexico.

Diagnosis: Similar to *Philephedra* but differs by lacking a wooly ovisac and by having 6 anal ring setae, 1 pair of prevulvar setae and the spine-like marginal setae blunt. *Philephedra* species produce long wooly ovisacs and have 10 anal ring setae, 3 pairs of prevulvar setae and pointed marginal setae. *M. lycii* also resembles certain *Pulvinaria* species but lacks the dorsal setae and 3 pairs of prevulvar setae found in that genus.

Cockerell, T. D. A., 1895: Psyche 7:254-255.

Nakahara, S. and R. J. Gill, 1985: Entomography 3:1-42.

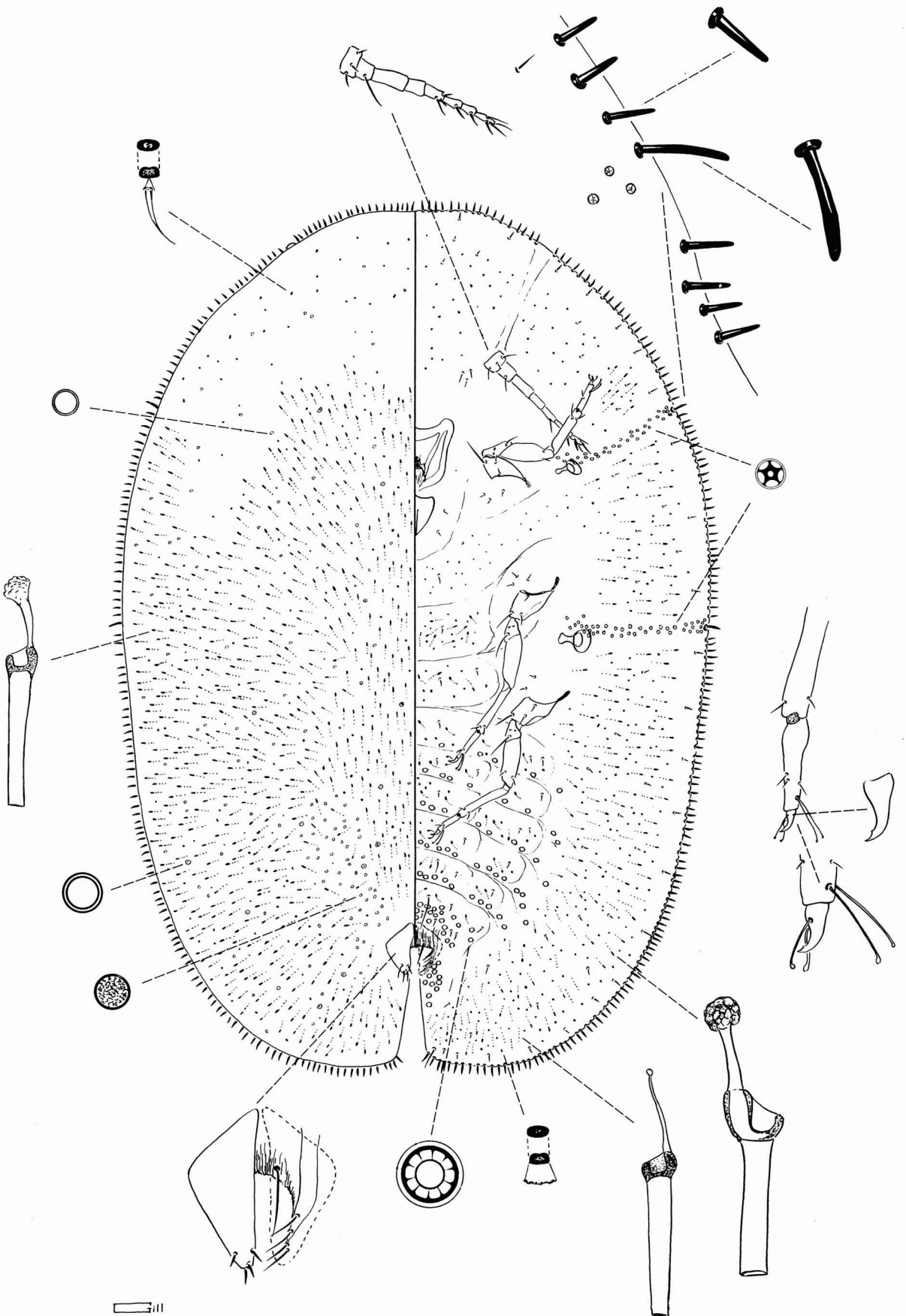


Fig. 20: *Metapulvinaria lycii* (Cockerell).

Genus *Parasaissetia* Takahashi, 1955 The Nigra Scales

This genus contains 1 species in California that is characterized by a dark, heavily sclerotized dorsal surface divided into a multitude of polygonal reticulations. The reticulations and the lack of a dorsal "H" pattern will separate this species from the black scales (*Saissetia*).

Morphologically, this genus is recognized by the ventral submarginal duct band, cylindrical, capitate dorsal setae, absence of tibio-tarsal articulatory schlerosis and by the polygonal reticulations or cell-like oval clear spots on the dorsum. *Parasaissetia nigra* is a cosmopolitan species and 4 other species are known from Africa.

Parasaissetia nigra (Nietner), 1861 nigra scale (ESA approved)

Fig. 21, Color Plate 49

Other Common Names: At least 12 common names have been used for this species in various parts of the world. For a list of these see Smith (1940b).

Synonymy:

Lecanium nigrum Nietner,
Saissetia nigra (Nietner),
L. depressum Targioni-Tozzetti,
L. sideroxylum Kuwana,
S. cuneiformis Leonardi,
L. signatum Newstead,
S. perseae Brain,
L. crassum Green.

Field Characteristics: Adult females 3.0 to 4.0 mm long. Shape and color of adults varies with type of host and location on host. Young adult females translucent yellow, occasionally with brown or red mottling, becoming shiny and dark brown to purple-black with age. Females usually elongate oval and flat to rounded and convex depending on type of host. Elongate individuals usually found on twigs, and rounded ones on leaves. Dorsum of older, darkened females smooth, without "H" pattern, polygonally reticulated, and often with a single series of staggered, squarish white wax plates around the margin along

with 5 longitudinal dorsal rows of smaller wax plates. Immature forms yellowish, flat and indistinguishable from other soft scales. Male puparia are not known.

Biology: One and a partial second generation per year out-of-doors in California (Smith, 1944); up to 6 generations per year in greenhouses in Israel (Ben -Dov, 1978). In California, nymphs usually migrate from leaves to twigs and overwinter as second or third stage nymphs. Females reproduce parthenogenetically; males unknown. Eggs laid over a very long period, from May until February. For a thorough study on the biology of this species, see Smith (1944) and Marin and Cisneros (1979).

Similar Species: Some members of the "black scale" group are similar but nigra scale lacks the dorsal "H" pattern and is further differentiated by the unique dorsal reticulate (net-like) pattern on the dorsum. Tessellated scale is also similar, but the dorsal reticulations are much larger. Nymphs and young membranous adult females are difficult to distinguish from some other soft scales, particularly brown soft scale. Certain *Mesolecanium* species known from tropical America are also

similar.

Hosts: In California, most often seen on ornamental *Ficus* (indoors) and on ivy (*Hedera*). Formerly common on *Citrus*. Known from at least 160 species of plants. For a complete host list see Smith (1944).

Economic Importance: Formerly a moderate pest of ornamental plants and a minor pest of citrus in Santa Barbara and Ventura Counties and other coastal areas of California. Presently not an economic pest. Apparently restricted by temperature extremes, low humidity, and by natural enemies such as parasites and disease. For more information on the economic importance of this species, see Smith (1944), Ebeling (1959), and Marin and Cisneros (1979). For information on biological control, see Smith (1944), Flanders (1959), and Bartlett (1978).

Distribution: Found generally throughout the State on indoor ornamentals such as *Ficus* and most commonly found out of doors in the San Francisco Bay Area. Generally rare. Common out-of-doors in Texas, Florida, Hawaii and most tropical areas of the world. Found indoors practically worldwide. Apparently Afro-Asian in origin and was first found in California at San Francisco in 1906. The history of nigra scale in California is recounted by Smith (1940a).

Diagnosis: Characteristic reticulated dorsal derm pattern and lack of "H" shaped ridges distinguish nigra scale from other species of California soft scales. Cylindrical dorsal setae and absence of tibio-tarsal articulation aid in the identification of young membranous adult females that normally lack the reticulated pattern. Some morphological characters variable, particularly the amount of fimbriation of marginal setae. For additional information on this variation see Ben-Dov (1978).

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- Bartlett, B. R., in C. P. Clausen Ed. 1978: U.S. Dept. Agric. Handb. 480:1-545.
- Ben-Dov, Y., 1978: *Phytoparasitica* 6(3):115-127.
- Ebeling, W., 1959: *Subtropical Fruit Pests*. Univ. Calif. Div. Agric. Sci. Bull., Los Angeles. 436 pp.
- Flanders, S. E., 1959: *J. Econ. Entomol.* 52(4):596-600.
- Marin, R. L. and F. H. V. Cisneros, 1979: *Rev. Peru. Entomol.* 22(1): 103-110.
- Smith, R. H., 1940a: *Calif. Dept. Agric. Mon. Bull.* 29:102-105.
- Smith, R. H., 1940b: *Calif. Dept. Agric. Mon. Bull.* 29:125-127.
- Smith, R. H., 1944: *Hilgardia* 16(5):225-288.

Genus *Parthenolecanium* Sulc, 1908
The Lecanium Scales

The genus is characterized by moderately convex, drab colored forms. Morphologically, the genus is recognized by the ventral, submarginal tubular duct band, relatively few tubular ducts on median areas of venter, non-articulating tibio-tarsal joints (except *P. persicae*) widely set, blunt or pointed spine-like marginal setae and dorsal spine-like setae. This group is found principally in the Holarctic region. Approximately 15 species are assigned to the genus.

Species within this genus are variable morphologically with regards to host-related physical characteristics. Moreover, many of the type specimens are lost or are in such poor condition that they cannot be studied adequately. As a result, the genus is presently not totally understood. The taxonomic status of some California forms near *P. corni* is in doubt and requires much further study and clarification.

KEY TO CALIFORNIA SPECIES OF *PARTHENOLECANIUM*

- 1 Submarginal duct tubercles (2-ring ducts) usually absent. 2
 Submarginal duct tubercles usually present. 3
- 2(1) Median dorsal tubular ducts large, plentiful; marginal setae number about 40 anteriorly between anterior spiracular depressions; apparently restricted to oaks and related plants in the Fagaceae. *quercifex*
 Median dorsal tubular ducts absent; marginal setae number about 20 anteriorly between anterior spiracular depressions; apparently restricted to conifers. *fletcheri*
- 3(1) Inner ductlet of ventral tubular ducts in submarginal duct band shortened, enlarged; with up to 16 pairs of dorsal submarginal duct tubercles; with hair-like or bristle-like marginal setae. *persicae*
 Inner ductlet of ventral tubular ducts in submarginal duct band thin, elongate; with 13 or fewer pairs of dorsal submarginal duct tubercles; with stout, straight, spine-like marginal setae. 4
- 4(3) With numerous, easily discernible dorsal tubular ducts situated all over dorsum including anal lobe area. *pruinatum*
 With few or no dorsal tubular ducts. *corni*

***Parthenolecanium corni* (Bouché), 1844**
European fruit lecanium (ESA approved)

Fig. 22, Color Plates 26-28

Other Common Names:

- brown apricot scale,
- brown scale,
- brown fruit scale,
- New York plum scale,
- brown elm scale.

Synonymy:

- Lecanium corni* Bouché,
- Lecanium canadense* (Cockerell),
- Lecanium adenostomae* Kuwana,
- Lecanium crawii* Ehrhorn.

For additional synonymies consult Sanders

(1909), Kawecki (1958) and Nakahara (1981).

Field Characteristics: Adult females 5 to 7 mm long; shape and coloration extremely variable depending on host plant and age of the scale. Dead females (the most commonly encountered form of this scale) are chestnut-brown leathery shells that vary from slightly convex to pyramidal or hemispherical in profile. Ebeling (1938) published an excellent study on the effects of host plants on the profile shapes of this scale. Coloration of living stages varies with the time of year and part of the plant infested. Stages on leaves semi-transparent yellow-green; stages on twigs mottled yellow and brown. Young adult females before egg-laying begins and second or third instar nymphs occurring on twigs are well camouflaged and extremely difficult to detect. Males present but uncommon; females generally parthenogenetic. Immature male nymphs identical in color and shape to female nymphs. Pupal stages typical of other males of this family.

Biology: Normally 1 generation per year in California. From late April to June, females deposit up to 2,000 + eggs in the cavity formed beneath the body. Crawlers hatch from late May to July, then move to the leaves. On deciduous hosts, the nymphs leave the foliage before leaf fall and return to the twigs and branches where they spend the winter and develop into adults by the following spring. On evergreen hosts such as toyon, *Heteromeles arbutifolia*, the entire life cycle is completed on the leaves. There is a variety of this scale which has 2 generations per year, but it is not common. For more information, see Asquith (1949), Kawecki (1958) and Bailey (1964).

Similar Species: *Parthenolecanium pruinatum* is similar in the field, living adult females covered with white powdery wax, but dead and dried examples of the 2 species are indistinguishable. Other species of the "*Lecanium*" group are also similar. Hemispherical scale, *Saissetia coffeae*, is similar to this species in the field. However, *S. coffeae* is lighter brown; immature forms have an "H" pattern charac-

teristic of the black scale group; and it prefers evergreen indoor ornamentals. In *S. coffeae* old convex females are covered with minute light-colored dots which can be seen with a good hand lens or dissecting scope.

Hosts: Prefers deciduous hosts. In California, common on deciduous fruit and nut crops in the genus *Prunus*, on deciduous ornamental trees and on a few evergreen species such as toyon and *Ceanothus*. For more complete host lists see Essig (1958), Kawecki (1958), and McDaniel (1930).

Economic Importance: Although normally held below economic thresholds by natural enemies or normal pest control practices, this scale can rapidly develop large injurious populations, particularly on ornamentals. In California, a serious pest of deciduous orchards in coastal valleys or other areas where daily temperatures do not exceed 90°F when crawlers are hatching and moving to the leaves (Bailey 1964). Major injury due to honeydew and sooty mold on fruit, which lowers grade or makes it unmarketable. For more information on economic importance, see McDaniel (1930) and Madsen and McNelly (1961). Biological control organisms have been fairly successful on this species. For information on natural enemies, see DeBach (1939), Kawecki (1958), Bailey (1964), Williams and Kosztarab (1972), and Bartlett (1978).

Distribution: Throughout California. Widely distributed in continental U.S., Canada, Europe and USSR. Also known from Japan and Chile.

Diagnosis: The taxonomic status of this species is very poorly understood, due partly to the highly variable morphology. Much intergradation of characters occurs between members of the "*corni*" complex and further study is needed to clarify species limits. *P. corni* is recognized by having few, small, scattered dorsal tubular ducts and by having submarginal duct tubercles normally present. The number of submarginal duct tubercles will vary from 2 pairs to 11 or 12 pairs. The

SOFT SCALES OF CALIFORNIA

European *P. corni* normally has 9 or more pairs but in California 2 or 3 pairs is the most common number. There may actually be 2 or more species involved in California within the present concept of *P. corni*.

-
- Asquith, D., 1949: J. Econ. Entomol. 42(5):853.
Bailey, S. F., 1964: J. Econ. Entomol. 57(6):934-938.
Bartlett, B. R., in C. P. Clausen, Ed. 1978: U.S. Dept. Agric. Handb. 480:1-545.
DeBach, P., 1939: J. Econ. Entomol. 32(5):728-729.
Ebeling, W., 1938: Hilgardia 11(11):613-631.
Essig, E. O., 1958: Insects and Mites of Western

GENUS *PARTHENOLECANIUM*

- North America. The MacMillan Co., New York. 1050 pp.
Kawecki, Z., 1958: Ann. Zool. (Warsaw) 4(9):135-230.
Madsen, H. F. and L. B. McNelly, 1961: Calif. Agric. Exp. Stn. Bull. 783:1-40.
McDaniel, E. I., 1930: Mich. State Coll. Agric. Exp. Stn. Circ. Bull. 133:1-17.
Nakahara, S., 1981: Proc. Entomol. Soc. Wash. 83(2):283-286.
Sanders, J. G., 1909: J. Econ. Entomol. 2:428-448.
Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.

Parthenolecanium fletcheri (Cockerell), 1893 Fletcher scale (ESA approved)

Fig. 23, Color Plate 52

Other Common Names:

arborvitae soft scale.

Synonymy:

Lecanium fletcheri Cockerell,
Eulecanium fletcheri (Cockerell).

For a complete list of synonyms, see Kawecki (1954) and Dziejzicka (1968).

Field Characteristics: Adult females 2.0 to 5.0 mm long; flattened in early stages, hemispherical in older stages. Young adult females brown with median lengthwise yellowish stripe and yellowish border. Color changes to uniform brown as the adults become older.

Biology: One and a partial second generation per year in Europe (Dziejzicka, 1968). One generation per year in Pennsylvania (Stimmel, 1978). Overwinters as second or third instar nymphs. Females mature and lay eggs in spring. Males not known. All stages feed on stems and branches; branches must be held apart before infestation is noticeable.

Similar Species: Should not be confused with any other species on arborvitae and yew.

Hosts: Prefers Arborvitae, (*Thuja*) and yew (*Taxus*). Also recorded from cypress and

juniper.

Economic Importance: Uncommon in California; not a pest. A serious pest of yew in Pennsylvania (Stimmel, 1978) where it causes yellowing and premature drop of needles, and is a copious honeydew producer.

Distribution: In California, known from the San Francisco Bay Area, Sacramento and Siskiyou Counties. Very likely will be found in many other California counties. Also found in Oregon, Washington, the eastern states and in Europe.

Diagnosis: Differs from other members of the genus by lacking dorsal tubular ducts; by having fewer ventral tubular ducts and marginal setae; and by usually lacking submarginal duct tubercles.

Dziejzicka, A., 1968: Zool. Poloniae 18(1):125-165.

Kawecki, Z., 1954: Pol. Akad. Nauk. Inst. Zool., Ann. Zool. 16:9-23.

Stimmel, J. F., 1978: Pa. Dep. Agric. Reg. Hort. Entomol. Circ. 27. Vol. 4(1):15-16.

Parthenolecanium persicae (Fabricius), 1776
European peach scale (ESA approved)

Fig. 24, Color Plates 29, 30

Other Common Names:

peach scale,
grape-vine scale,
European fruit scale.

Synonymy:

Chermes persicae Fabricius,
Eulecanium persicae (Fabricius),
Lecanium magnoliarum Cockerell.

See Sanders (1909), Borchsenius (1957) and Nakahara (1981) for additional synonyms.

Field Characteristics: Adult females 2.0 to 9.0 mm long; flat to moderately convex depending on age. Coloration varies according to age, location on host and type of host. Young adult females generally yellowish with brown markings or brown mottling becoming uniformly brownish as egg-laying progresses. Many long, crystalline, hair-like wax rods protrude from the margins of each scale.

Biology: Poorly known. In Virginia, apparently has overlapping broods but exact number of generations unknown (Williams and Kosztarab, 1972). Overwinters as second stage nymphs. Usually parthenogenetic although males are known. For more information, see Williams and Kosztarab (1972).

Similar Species: Easily confused with European fruit lecanium and other scales in the "*Lecanium*" group. In young adult females the large number of long crystalline wax rods is usually distinctive.

Hosts: Polyphagous. In California, most fre-

quently found on *Daphne* and deciduous trees. For a complete host list, see Borchsenius (1957), Essig (1958), and Williams and Kosztarab (1972).

Economic Importance: In Virginia, may kill host plant if left uncontrolled (Williams and Kosztarab, 1972). Not a pest in California.

Distribution: Throughout California, rare. Also known from many eastern states, widespread in Europe.

Diagnosis: Distinguished from other members of the genus by having many submarginal duct tubercles; ventral submarginal tubular ducts with shortened and enlarged inner ductlet; tibio-tarsal joints with articulating scleroses; and bristle-like marginal setae.

Borchsenius, N. S., 1957: Akad. Nauk. Zool. Inst. (n.s. 66) 9:1-493.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Nakahara, S., 1981: Proc. Entomol. Soc. Wash. 83(2):283-286.

Sanders, J. G., 1909: J. Econ. Entomol. 2:428-448.

Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.

Parthenolecanium pruinosum (Coquillett), 1891
frosted scale

Fig. 25, Color Plate 54

Other Common Names:

prune scale.

Synonymy:

Lecanium pruinosum Coquillett,

Eulecanium pruinosum (Coquillett),

Lecanium robiniae Townsend,

Lecanium robiniarum Cockerell.

Biology: One generation per year. Crawlers hatch from late May through July and settle on

leaves or young twigs. Later instar nymphs migrate from the leaves to the twigs in fall. Winter is spent as second or third instar nymphs. For more information see Michelbacher (1955), Michelbacher and Ortega (1958) and Anonymous (1976).

Similar Species: Indistinguishable from *Parthenolecanium corni* if the powdery wax is absent. *Eulecanium excrescens* and *E. caryae* also produce powdery white wax on the dorsum; although much larger and less convex than *P. pruinosum* they are extremely difficult to distinguish in the field. However they are very rare in California (See comments under these two species). *Pulvinaria* species produce dorsal powdery wax but they also produce large white ovisacs.

Hosts: Prefers walnut; also feeds on many deciduous tree species including most of the pome and stone fruits. For a host list see Essig (1958).

Economic Importance: An occasional pest of walnuts although it is usually held below economic levels by the encyrtid parasite *Metaphycus californicus* (Howard) and several other parasitoids. Regarded as a pest of plum trees in Australia. Often undergoes cyclic population fluctuation and has developed large injurious populations due to pesticide induced reduction of natural enemies. Actual damage caused by this scale is difficult to assess. Large populations impair tree vigor; honeydew and sooty mold are problems when large populations occur. The above information on economic importance and biological control summarized from Michelbacher et al. (1946), Middlekauff et al. (1947), Bartlett and Ortega (1952), Michelbacher (1955), Michelbacher and Ortega (1958), Ebeling (1959) and Anonymous (1976). For information on natural enemies see Michelbacher and Swift (1954).

Distribution: Throughout California. Also known from several other western states, northwestern Mexico and Australia. Probably native to the highlands of Mexico (Sanders; 1909).

Diagnosis: Slide-mounted specimens are rec-

ognized by the 8 to 12 submarginal duct tubercles found on the dorsum, numerous dorsal tubular ducts which produce the powdery covering, normal type of tubular ducts in the ventral submarginal duct band, and dorsal tubular ducts along the anal cleft. Resembles *Parthenolecanium persicae* because of the numerous dorsal duct tubercles but that species has few dorsal tubular ducts and has ventral submarginal tubular ducts with a short swollen inner ductlet. Some species in the *Parthenolecanium corni* complex also have duct tubercles but they either lack or have fewer dorsal tubular ducts; and they lack ducts in the anal cleft area. Studies by A. E. Michelbacher and H. L. McKenzie (Michelbacher, personal communication) indicate that two distinct forms of soft scales forming a dorsal frosted wax covering have been found on walnuts in the Linden area of San Joaquin County (see Color Plate 93). One form produced such copious amounts of dorsal wax that the dorsal surface is completely obscured (Plate 93-right); the other form has much less wax and the dorsal surface and a darkened median keel are visible (Plate 93-left). There are minor morphological differences between these two forms but further study is necessary before this problem can be totally resolved.

Anonymous, 1976: N. S. Wales Dep. Agric. Entomol. Branch Insect Pest Bull. 121:1-2.

Bartlett, B. R. and J. C. Ortega, 1952: J. Econ. Entomol. 45(5):783-785.

Ebeling, W., 1959: Subtropical Fruit Pests, Univ. Calif. Div. Agric. Sci. Bull., Los Angeles. 436 pp.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Michelbacher, A. E., 1955: Pan-Pac. Entomol. 31(3):139-148.

- Michelbacher, A. E. and J. C. Ortega, 1958: Calif. Agric. Exp. Stn. Bull. 764:1-87.
 Michelbacher, A. E., C. Swanson and W. W. Middlekauf, 1946: J. Econ. Entomol. 39(6) 812-813.
 Michelbacher, A. E. and J. E. Swift, 1954: Calif.

- Agric. 8(4):9-10.
 Middlekauf, W. W., A. E. Michelbacher and C. Swanson, 1947: J. Econ. Entomol. 40(3):442-444.
 Sanders, J. G., 1909: J. Econ. Entomol. 2:428-448.

Parthenolecanium quercifex (Fitch), 1859
 oak lecanium (ESA approved)

Fig. 26, Color Plates 31-33

Synonymy:

- Lecanium quercifex* Fitch,
Lecanium quercitroneis Fitch,
Lecanium antennatum Signoret,
Lecanium pruinatum var. *kermoides*
 Tyrrell.

Field Characteristics: Adult females 4.0 to 6.0 mm long, convex in profile in late stages, with a broad lengthwise, yellow-brown or orange-median stripe. Median areas of thorax often covered with short curls of white wax. Color of late instar nymphs brownish, mottled with yellow.

Biology: Apparently has 1 generation per year (Brown and Eads, 1965).

Similar Species: European fruit lecanium, *P. corni*, is similar to *P. quercifex* but is not generally found on oak.

Hosts: Apparently restricted to plants in the Fagaceae, such as oak (*Quercus*), and chinquapin (*Chrysolepis*). Sanders (1909), found that this species will survive only on oaks and oak relatives.

Economic Importance: Considered serious pest of coast live oak, *Quercus agrifolia* (Brown and Eads, 1965). Occasionally develops large populations on this host which kill or weaken the twigs and branches, and which produce

large amounts of honeydew and sooty mold. Also a pest of oaks in the southern states (Sanders, 1909 and Schultz, 1985). For information on natural enemies see Schultz (1985).
Distribution: Throughout California at low elevations. Also known throughout most of the United States.

Diagnosis: Separated from other *Parthenolecanium* species by usually lacking dorsal submarginal duct tubercles, by having relatively large, easily discernible dorsal tubular ducts medially on the thorax and anterior abdomen, and by the shorter, thicker and more blunt marginal setae. The coloration of the living adult females and the preference for oaks is usually distinctive.

Brown, L. R. and C. O. Eads, 1965: Calif. Agric. Exp. Stn. Bull. 810:1-105.

Sanders, J. G., 1909: J. Econ. Entomol. 2:428-448.

Schultz, P. B., 1985: J. Arboriculture 11(6):182-184.

Turner, W. F., 1914: Ala. Agric. Exp. Stn. Ala. Polytech. Inst., Auburn, Circ. 28:105-110.

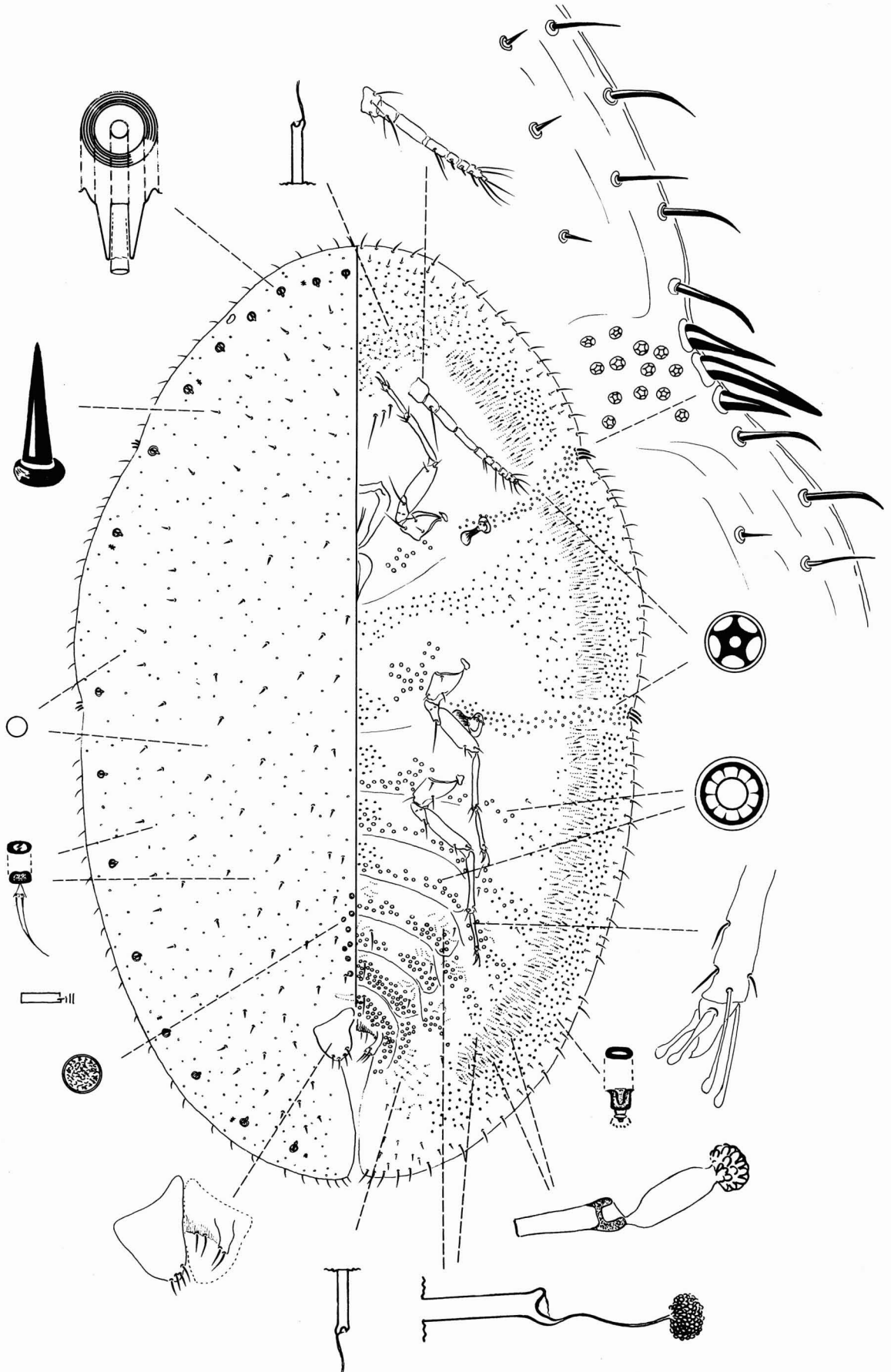


Fig. 24: *Parthenolecanium persicae* (Fabricius).

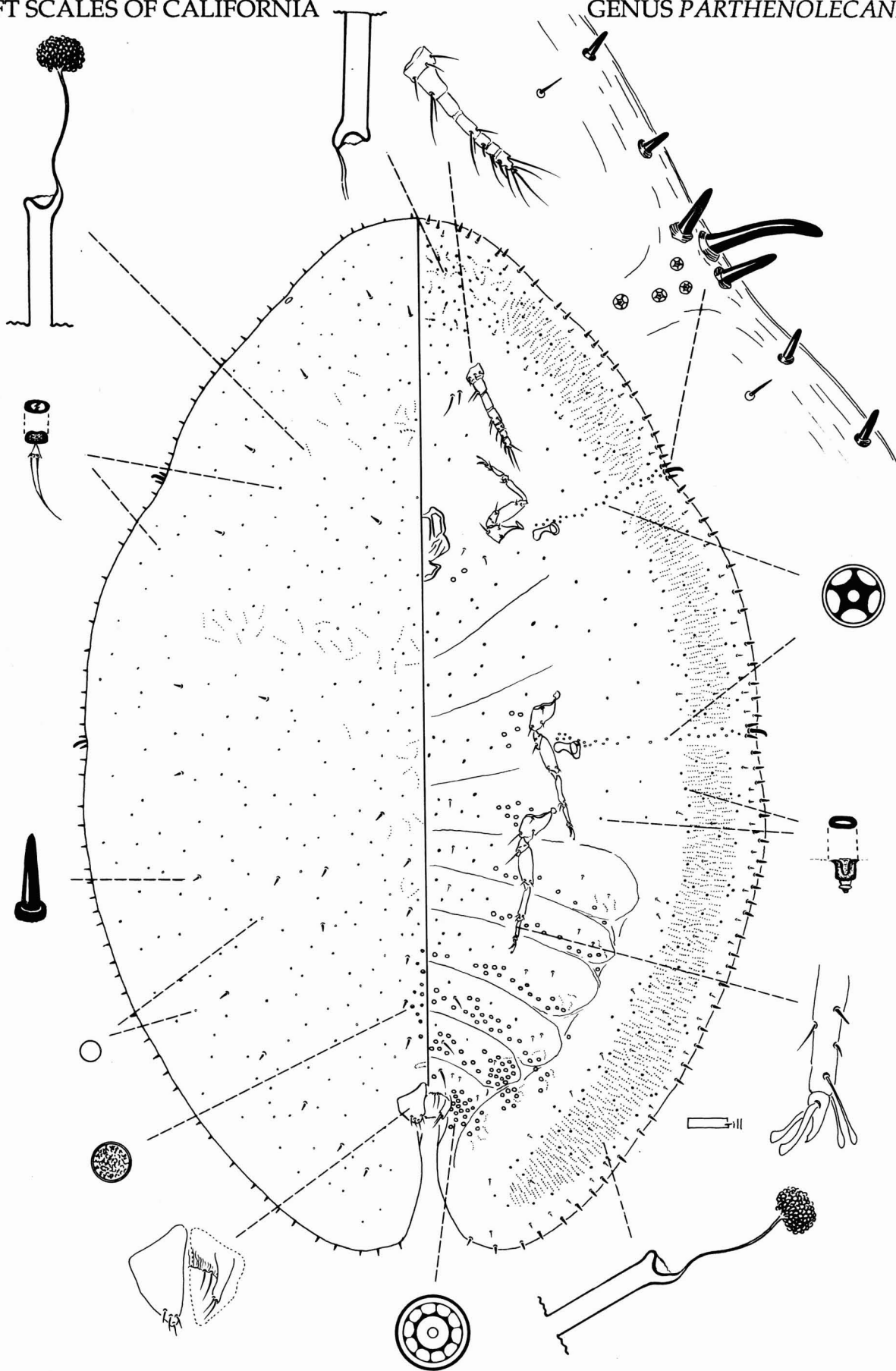


Fig. 26: *Parthenolecanium quercifex* (Fitch).

Genus *Philephedra* Cockerell, 1898
The False Pulvinaria Scales

The genus is characterized by the absence of dorsal setae; inverted duct tubercles dispersed over dorsum or absent; dorsal tubular ducts as numerous or more numerous than ventral tubular ducts; marginal setae stout, spine-like; legs well developed with tibio-tarsal articulation and scleroses. Adult females produce long white ovisacs and resemble species of *Pulvinaria* which also produce ovisacs.

Nine species are currently assigned to this genus. The type species, *P. ephedrae* (Cockerell), occurs in California.

The genus has been revised by Nakahara and Gill (1985).

Nakahara, S. and R. J. Gill, 1985: Entomography. 3:1-42.

***Philephedra ephedrae* (Cockerell), 1898**
ephedra scale

Fig. 27

Synonymy:

Pulvinaria ephedrae Cockerell.

Field Characteristics: Adult females 5 mm long, elongate, flat in profile; mottled pinkish and greenish with minute black dots. A conspicuous, pure white ovisac 10 to 20 mm long is produced. Nothing is known about the appearance of the other stages.

Biology: Unknown.

Similar Species: The *Pulvinaria* group of soft scales is similar but the ovisac is usually much broader than and not usually as long as in this species, and no *Pulvinaria* species are known from *Ephedra* in California. Similar to *Ceroplastodes acaciae* Cockerell from mesquite in Arizona and to other species in the genus *Ceroplastodes* from the southwestern U. S.

Hosts: Known only from Mormon tea, (*Ephedra*).

Distribution: Known in California only from

Lancaster, Los Angeles County, and Wrightwood, Victorville and Deep Creek Public Camp, San Bernardino County. Also known from the type locality at Mesilla Park, New Mexico and Nevada, Texas and Utah.

Economic Importance: None.

Diagnosis: The only California soft scale with closely set spine-like marginal setae, inverted dorsal duct tubercles and no dorsal setae. For more information, see Cockerell (1898), Ferris (1919), and Nakahara and Gill (1985).

Cockerell, T. D. A., 1898: Ann. Mag. Nat. Hist. ser. 7(2):24-27.

Ferris, G. F., 1919: A Contribution to the Knowledge of the Coccidae of Southwestern United States. Stanford Univ. Publ., Univ. Ser. 68 pp.

Nakahara, S. and R. J. Gill, 1985: Entomography 3:1-42.

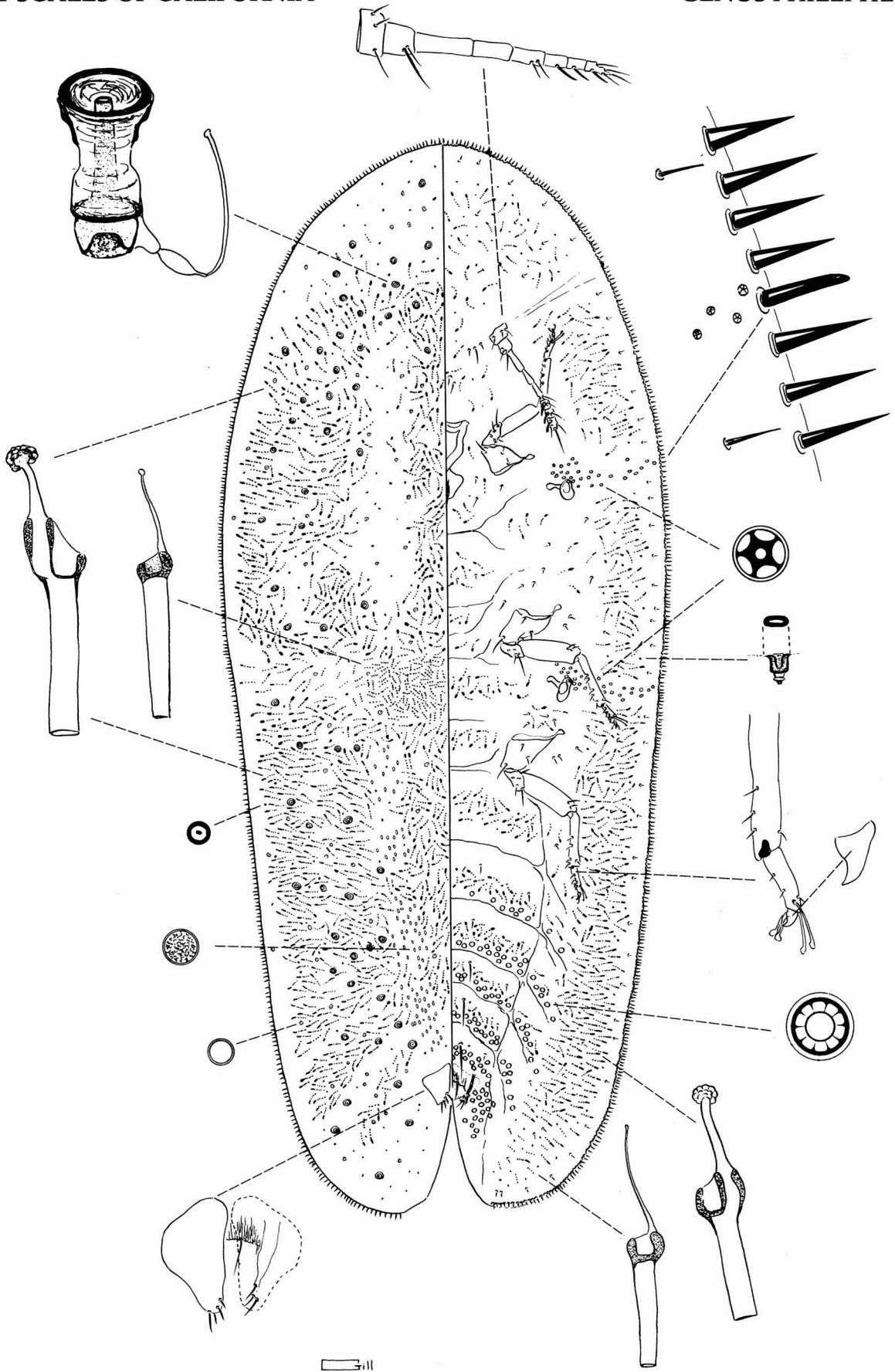


Fig. 27: *Philephedra ephedrae* (Cockerell).

Genus *Physokermes* Targioni-Tozzetti, 1868 The Conifer-bud Scales

This genus is characterized by a globular shape which resembles the developing buds of the coniferous host. Adult female conifer bud scales are recognized morphologically by the absence of anal opercula. Also, marginal and spiracular setae are absent in the adult females, and the dividing line between the dorsal and ventral surfaces is usually indistinguishable. The last stage nymphs of 3 Nearctic species discussed here have a closely set marginal row of spine-like setae which are absent from *P. hemicryphus*, an introduced European species.

There are 4 nominate species in California; 12 world-wide. An undetermined *Physokermes* sp. known from *Pinus monophylla* in Nevada and eastern California is suspected to be *P. coloradensis* Cockerell, which was described from *Pinus edulis* in Colorado. However, slide mounted type specimens are apparently nonexistent and the species cannot be recognized with the available description.

Adult females must be collected in spring if microscope slides are to be made. At other times of the year, tentative identifications can be made based on host and distribution within the State.

KEY TO CALIFORNIA SPECIES OF *PHYSOKERMES*

1. Anal lobe setae few in number, not extending along lateral margin; minute discoidal pores absent from dorsum medially, antennae reduced. *hemicryphus*
 Anal lobe setae extending along lateral margin; minute discoidal pores generally distributed over entire dorsum. 2
- 2(1) Multilocular pores extending from anterior spiracular depression onto dorsum *insignicola*
 Multilocular pores absent from dorsum. 3
- 3(2) Band of multilocular pores in anterior spiracular depression becoming wider toward body margin. *concolor*
 Anterior band of multilocular pores not becoming wider toward body margin. *taxifoliae*

Physokermes concolor Coleman, 1903 fir bud scale

Fig. 28, Color Plate 59

Field Characteristics: Adult females 3 to 6 mm in diameter, although several unmounted specimens in an advanced state of maturity from Fort Bidwell, Modoc County, on white fir, are 15 mm in diameter. Whether this large size is normal for *concolor* in advanced stages cannot be substantiated. Color

of adults yellow to brown, with variable transverse dark brown bands or mottlings and usually a brown dorsal abdominal stripe on the midline.

Biology: Currently unknown. Probably similar to that of Monterey pine scale.

Similar Species: Douglas fir scale, which dif-

fers in host preferences and distribution in the State.

Hosts: Although normally found on white fir, *Abies concolor*, specimens from *Pinus ponderosa* in Amador County are probably this species.

Economic Importance: None.

Distribution: Known from a number of loca-

tions in the Sierra Nevada and from Trinity County.

Diagnosis: Post-reproductive females recognized by host preference, distribution in the State; slide-mounted females by the anterior spiracular bands of multilocular pores that become very wide at the margin.

Physokermes hemicryphus (Dalman), 1825
spruce bud scale

Fig. 29, Color Plate 60

Synonymy:

Coccus hemicryphus Dalman,
Physokermes piceae Schrank
(misidentification).

NOTE: *Physokermes hemicryphus* has been misidentified for many years as *Physokermes piceae* Schrank. Specimens were first identified as *hemicryphus* by Williams and Kosztarab (1972) in Virginia using the diagnostic characters of Schmutterer (1956). It has been determined that all identifiable lots of *Physokermes* collected from spruce in the United States are *hemicryphus*.

Field Characteristics: Adult females nearly spherical, 2 to 5 mm in diameter and dark brown. Old adults usually found at the junction of first and second year wood, where they resemble undeveloped buds.

Biology: One generation per year (Schmutterer, 1956); overwinters as second instars (possible third instars as this reference to its biology lists only 3 instars rather than the usual 4 which are normally found in the Coccoidea). Adults mature in late May in California. Parthenogenetic. For more information, see Schmutterer (1956) and Fenton (1917).

Similar Species: Other *Physokermes* species are similar but hosts and distribution patterns will separate the species.

Hosts: In California, occurs on Colorado blue spruce, *Picea pungens*, Sitka spruce, *Picea sitchensis* and Norway spruce, *Picea abies*. In Europe, known from other spruce species and

reported on fir and pine.

Economic Importance: Normally attacks and kills the lower branches, causing the tree to develop an unhealthy appearance. Also produces large amounts of honeydew. Not a serious pest in California, probably because of the few host trees grown here.

Distribution: Restricted to urban areas around San Francisco Bay and to Humboldt, Del Norte and San Bernardino Counties. Also known from the northeastern United States; native to Europe.

Diagnosis: Post-reproductive females recognized by host preference. Slide-mounted adult females recognized by lack of mid dorsal discoidal pores and reduced numbers of anal lobe setae. Nymphs do not have the marginal row of spine-like setae found in North American species of *Physokermes*. For more information on separating *hemicryphus* from *piceae* see Schmutterer (1956) and Kozarzhevskaya and Reitzel (1975).

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- Fenton, F. A., 1917: Can. Entomol. 49:309-320.
Kozarzhevskaya, E. and J. Reitzel, 1975: The Scale Insects of Denmark. Statens Fors. Plantekultur, Copenhagen. 40 pp.
Schmutterer, H., 1956: Z. Angew. Entomol. 39:445-466.
Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.

Physokermes insignicola (Craw), 1894
Monterey pine scale

Fig. 30, Color Plates 61, 62

Synonymy:

Lecanium insignicola Craw.

Field Characteristics: Adult females nearly spherical, 2 to 6 mm in diameter, shiny, dark chestnut brown to black. Early stages and young adult females yellow-brown and fairly flat. Male puparia flat and elongate. Females feed on the stems between needle bases; male puparia are on needles. Heavy populations often almost totally obscured by honeydew and sooty mold.

Biology: One generation per year. Adults present in March and April, when each female lays up to 500 eggs in the cavity under their body. For more information, see Moulton (1907), Burke (1932), and Brown and Eads (1967).

Similar Species: Irregular pine scale, *Toumeyella pinicola*, is similar and often occurs on the same trees but is flatter and irregular in shape; whereas *P. insignicola* is nearly spherical and has a more uniform, darker coloration. An unidentified species of *Physokermes* on *Pinus monophylla* in the Inyo-Mono County area of California and from central Nevada is similar but lighter in color. Other *Physokermes* species are not usually found on pines.

Hosts: Restricted to Monterey and Bishop pines, *Pinus radiata* and *P. muricata*.

Economic Importance: Occasionally develops large populations causing minor debilitation and producing large amounts of honey-

dew and sooty mold. For more information, see Burke (1932), Brown and Eads (1967) and Furniss and Carolin (1977). For information on natural enemies, see Burke (1937).

Distribution: Apparently restricted to central coastal and southern California, although it has probably been moved to other areas on nursery stock.

Diagnosis: Post-reproductive females recognized by host preference and distribution. Morphologically, the only California species of *Physokermes* with multilocular disc pores in the anterior spiracular furrow extending onto the dorsum. Another *Physokermes*, on pinyon pine in Inyo County, has a few dorsal multilocular disc pores at the end of the anterior spiracular furrow like *insignicola*, but it also has a ventral, submarginal band of microtubular ducts which are absent in *insignicola*.

Brown, L. R. and C. O. Eads, 1967: Calif. Agric. Exp. Stn. Bull. 834:1-72.

Burke, H. E., 1932: Calif. Dep. Agric. Mon. Bull. 21:358-369.

Burke, H. E., 1937: 4th West Shade Tree Conf. Proc. 21-30, Santa Barbara, Calif. pg. 117.

Furniss, R. L. and V. M. Carolin, 1977: U.S. Dep. Agric. Misc. Publ. 1339:1-654.

Moulton, D., 1907: Proc. Davenport Acad. Sci. 12:1-26.

Physokermes taxifoliae Coleman, 1903
Douglas fir scale

Fig. 31, Color Plates 47, 55, 58

Field Characteristics: Adult females nearly spherical, 4 to 6 mm in diameter, yellow to light brown with occasional dark dorsal mottling. Older adults become darker.

Biology: Unknown, but probably similar to

that of *P. insignicola*.

Similar Species: Monterey pine scale and fir bud scale are similar, but have different hosts and distributional patterns.

Hosts: Apparently restricted to Douglas fir,

SOFT SCALES OF CALIFORNIA

Pseudotsuga menziesii.

Economic Importance: None.

Distribution: In California collected only in the San Francisco Bay Area. Common in Oregon (Schuh and Mote, 1948). Possibly collected on Douglas fir in Seattle, Washington and may occur along the western coast of the contiguous United States wherever Douglas fir is found.

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Diagnosis: Host and distribution will aid in recognizing this species. Separated morphologically from *P. insignicola* by the absence of dorsal, multilocular disc pores and from *P. concolor* by the narrow, anterior spiracular pore band.

Schuh, L. and D. C. Mote, 1948: Ore. State Coll. Stn. Bull. 449:1-164.

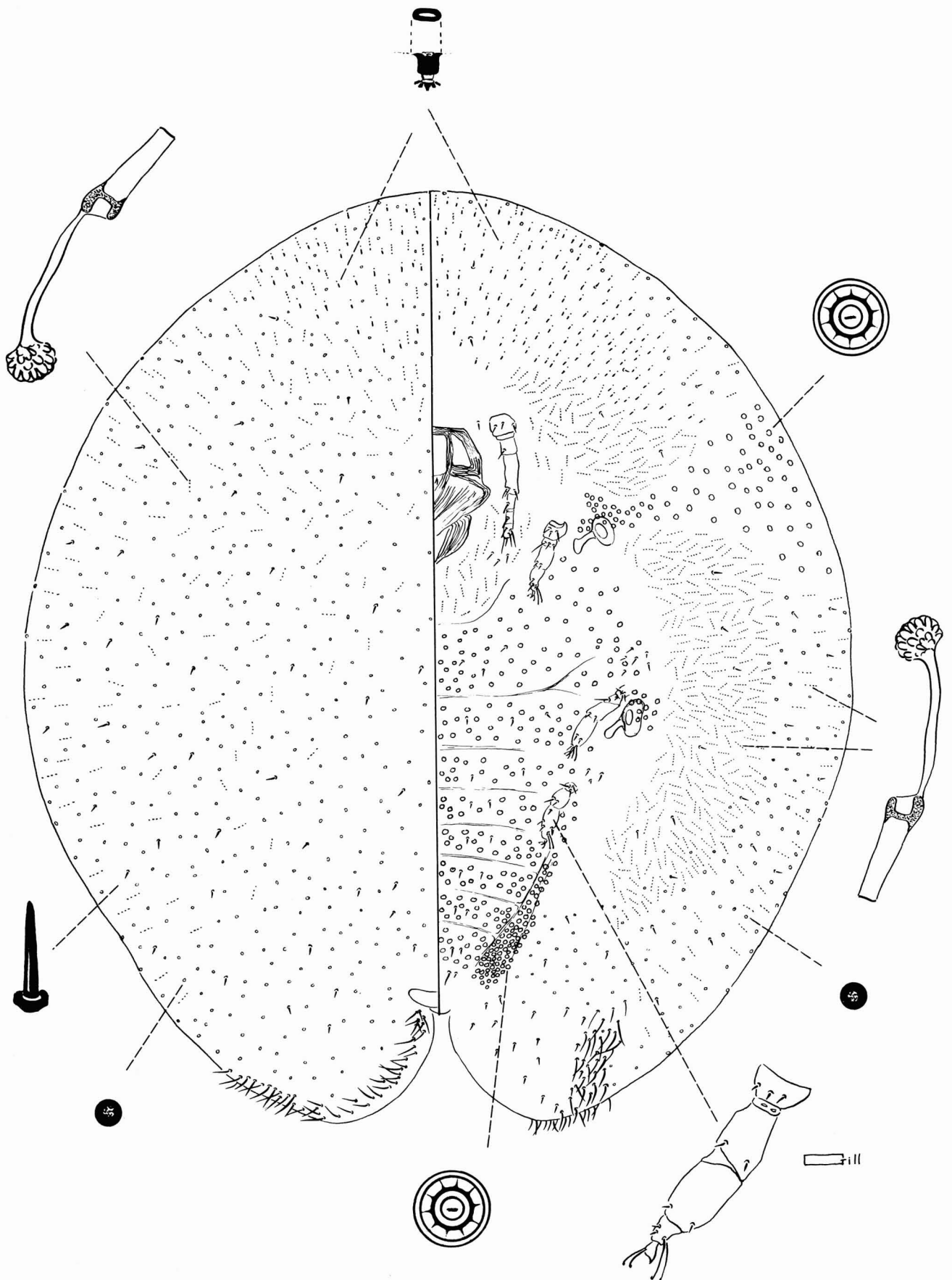


Fig. 28: *Physokermes concolor* Coleman.

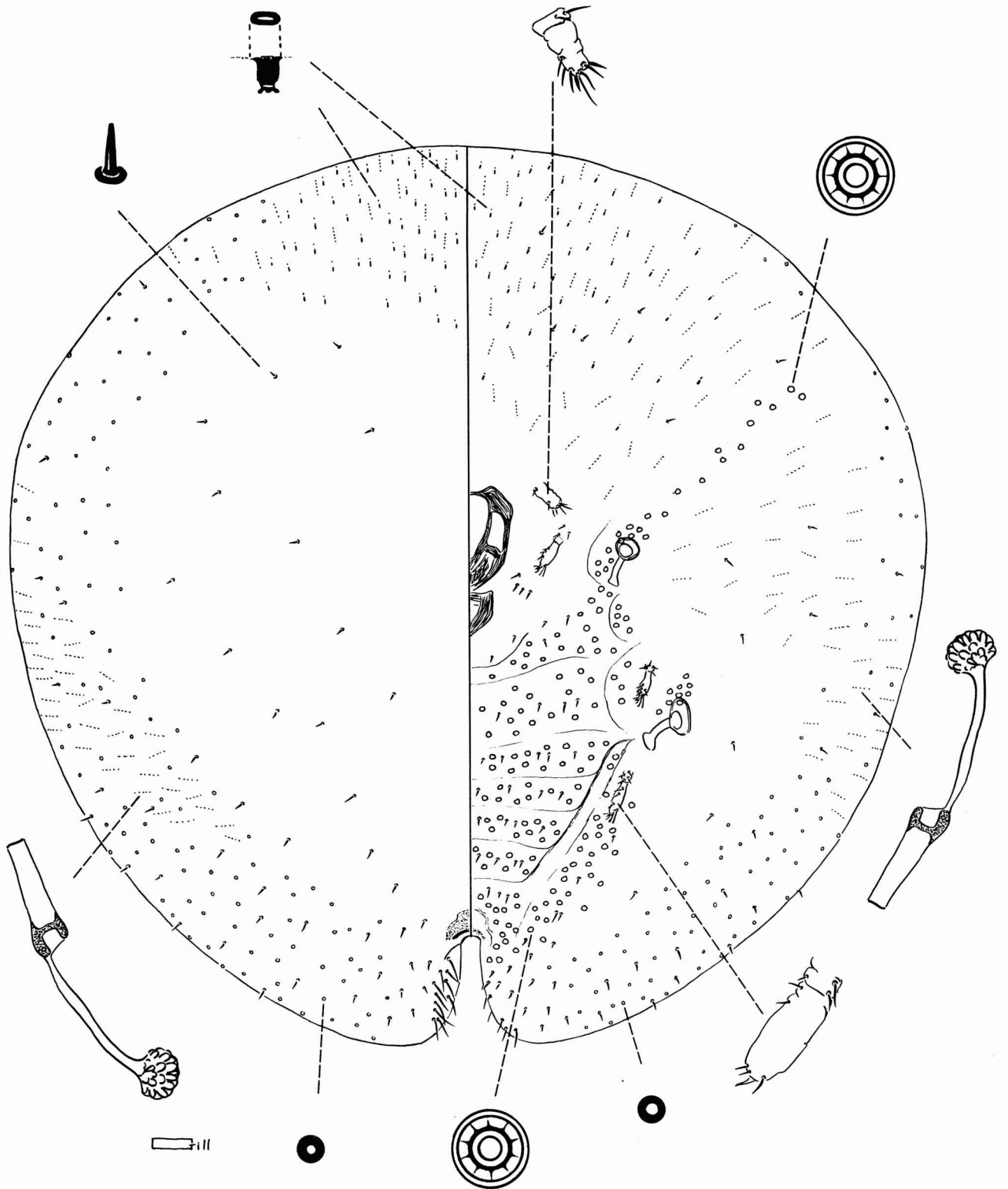


Fig. 29: *Physokermes hemicryphus* (Dalman).

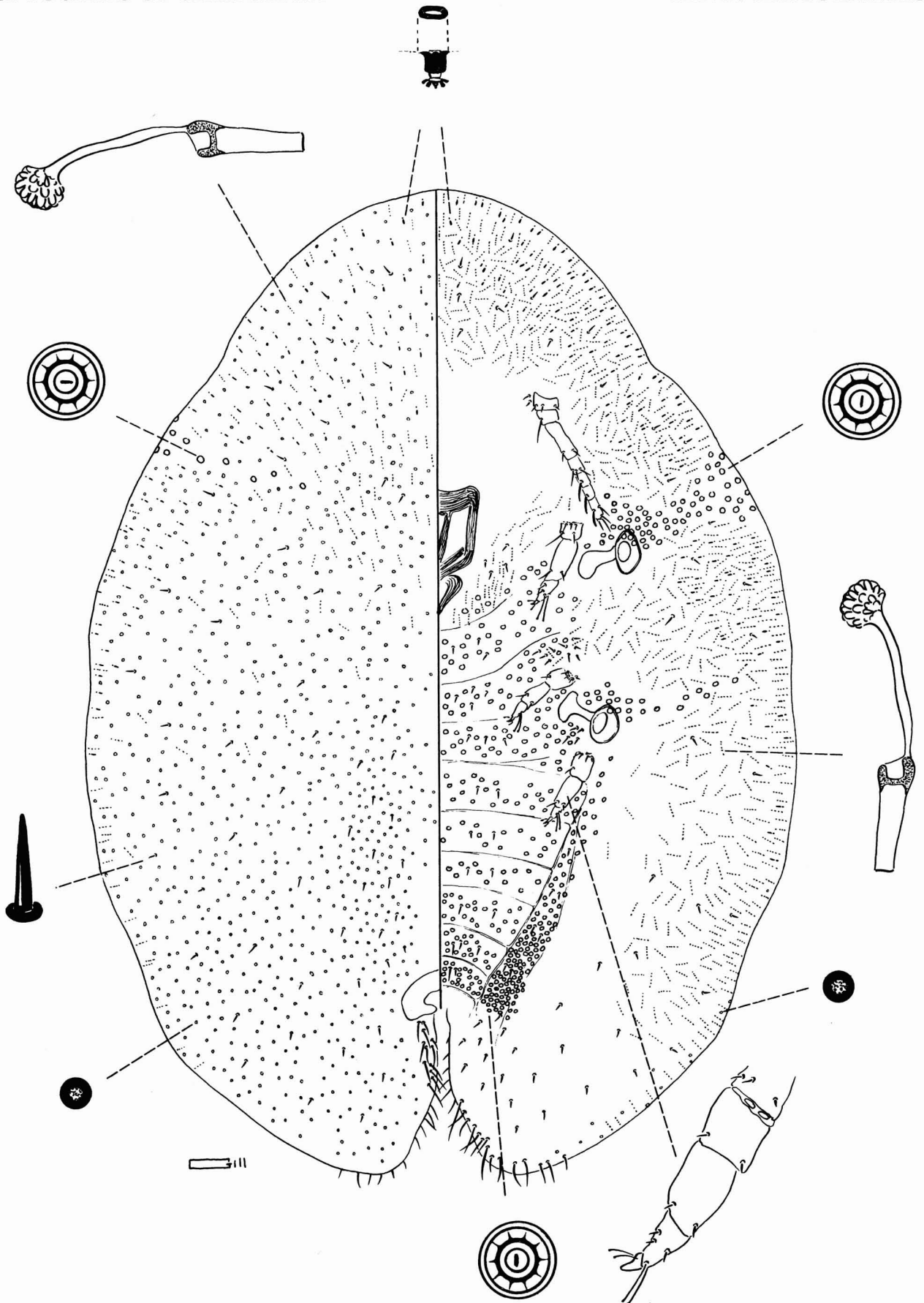


Fig. 30: *Physokermes insignicola* (Craw).

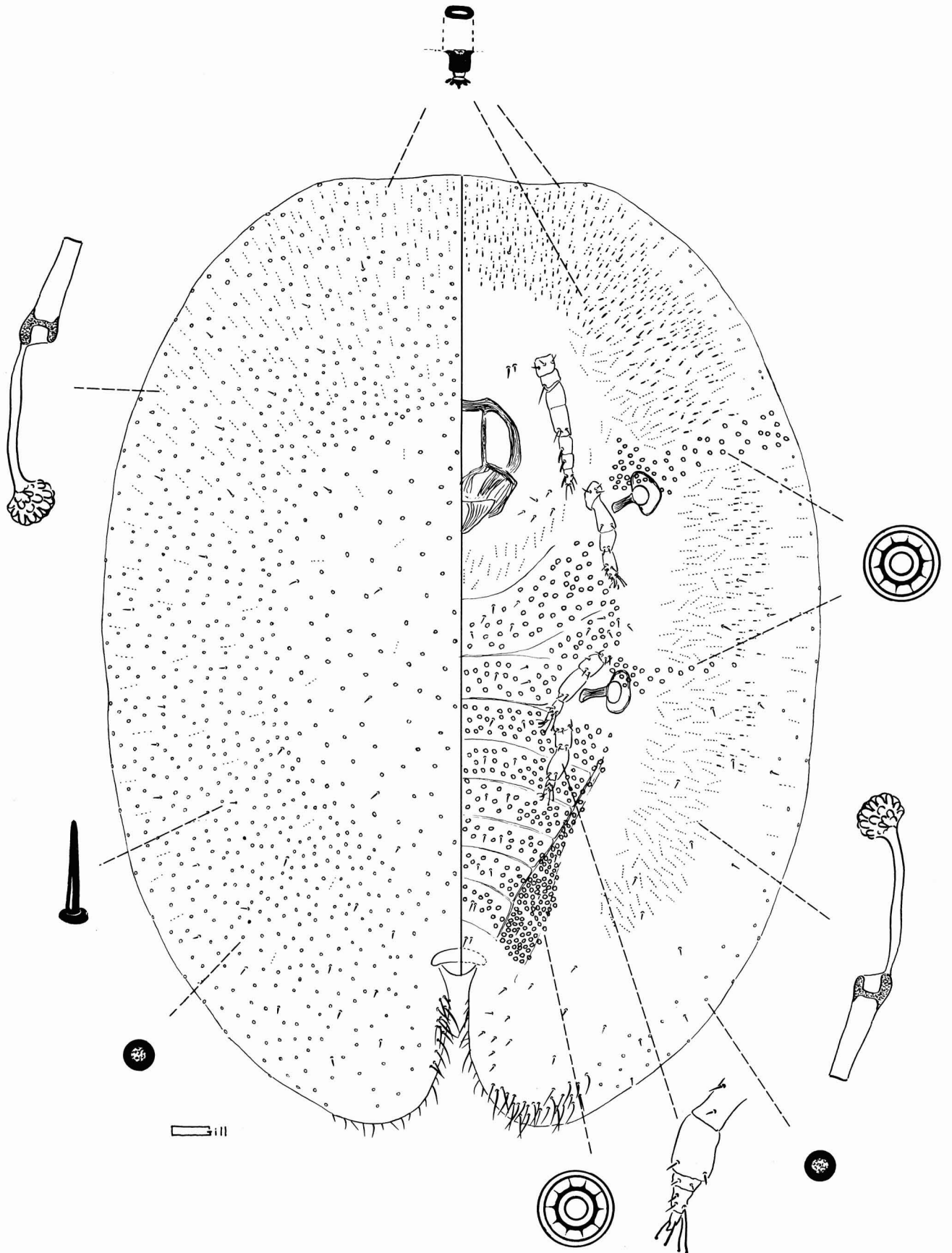


Fig. 31: *Physokermes taxifoliae* Coleman.

Genus *Protopulvinaria* Cockerell, 1894 The Pyriform Scales

Members of this genus are characterized by the presence of deltoid or pyriform shape, closely set fimbriated marginal setae, capitate dorsal setae elongated anal plates located near the middle of the dorsum, normal coxae and normal tubular ducts.

Protopulvinaria is similar morphologically to the genus *Kilifia*, which differs by having characteristically enlarged and mis-shapen mesothoracic and metathoracic coxae and by lacking ventral tubular ducts.

The genus is apparently Oriental in origin, as there are about six species known from Ceylon and Japan. Two species occur in the U.S.

Protopulvinaria pyriformis (Cockerell), 1894 pyriform scale (ESA approved)

Fig. 32, Color Plates 50, 63

Synonymy:

Pulvinaria pyriformis Cockerell,

Pulvinaria newsteadi Leonardi,

Protopulvinaria piriformis (Cockerell).

Field Characteristics: Adult females 2 to 4 mm long, very flat, deltoid or pyriform (pointed anteriorly and broadly rounded posteriorly), usually somewhat asymmetrical. Nymphs and young adults transparent yellowish; older adult females yellowish-brown with broad, reddish, mottled marginal bands. During egg laying, a short white ovisac is produced along the posterior margin. Very old individuals uniform brown. Anal opercula narrow, elongated, located centrally along the dorsal midline, appearing as a carina or ridge. This character is diagnostic for the only California species, although the neotropical species, *P. longivalvata* Green, also has the same characteristic.

Biology: Several overlapping generations per year. Overwinters as nymphs, adults produce several hundred eggs in spring. The entire life cycle is spent on the lower leaf surfaces. Males common, at least in Florida, according to Moznette (1922). For more information on

this species, see Moznette (1922).

Similar Species: Acuminate scale, *Kilifia acuminata* (Signoret), *Kilifia americana* Bendov, *Protopulvinaria longivalvata* Green and mango shield scale, *Protopulvinaria mangiferae* (Green) are similar but do not occur in California. Identification of this species should not be attempted in the field. Nymphs of pyriform scale may be confused with citrus whitefly, which is found on many of the same hosts.

Hosts: Polyphagous. In California, prefers gardenia, ivy and avocado. Has also been found on citrus. For a complete host list, see Merrill (1953).

Economic Importance: Occasionally a serious pest of avocados and certain ornamental plants in Florida. Sap removal, host debilitation, honeydew production and sooty mold are major economic effects. In California, not known to occur in commercial avocado orchards and, so far, has not been particularly serious in dooryard situations. The above information summarized in part from Moznette (1922), Merrill (1953) and Ebeling (1959). For information on natural enemies, see Williams and Kosztarab (1972).

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Distribution: Restricted to San Diego and Los Angeles counties. Also found out-of-doors from South Carolina to Texas, the Caribbean Islands, Mexico and Central and South America.

Diagnosis: The extremely elongated, centralized opercula separate this species from other soft scales including species in the genus *Kili-fia* and from *Protopulvinaria mangiferae* (Green). Nearly identical to *P. longivalvata* Green but in *longivalvata* the marginal setae are smaller and the dorsal setae are barely discernible. The dorsum of both species is

GENUS *PROTOPULVINARIA*

usually sclerotized submarginally, but the middle areas remain membranous.

Ebeling, W., 1959: Subtropical fruit pests. Univ. Calif. Div. Agric. Sci. Bull., Los Angeles. 436 pp.

Merrill, G. B., 1953: Fla. State Plant Board Bull. 1:1-143.

Moznette, G. F., 1922: U.S. Dep. Agric. Farmer's Bull. 1261:1-31.

Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74:1-215.

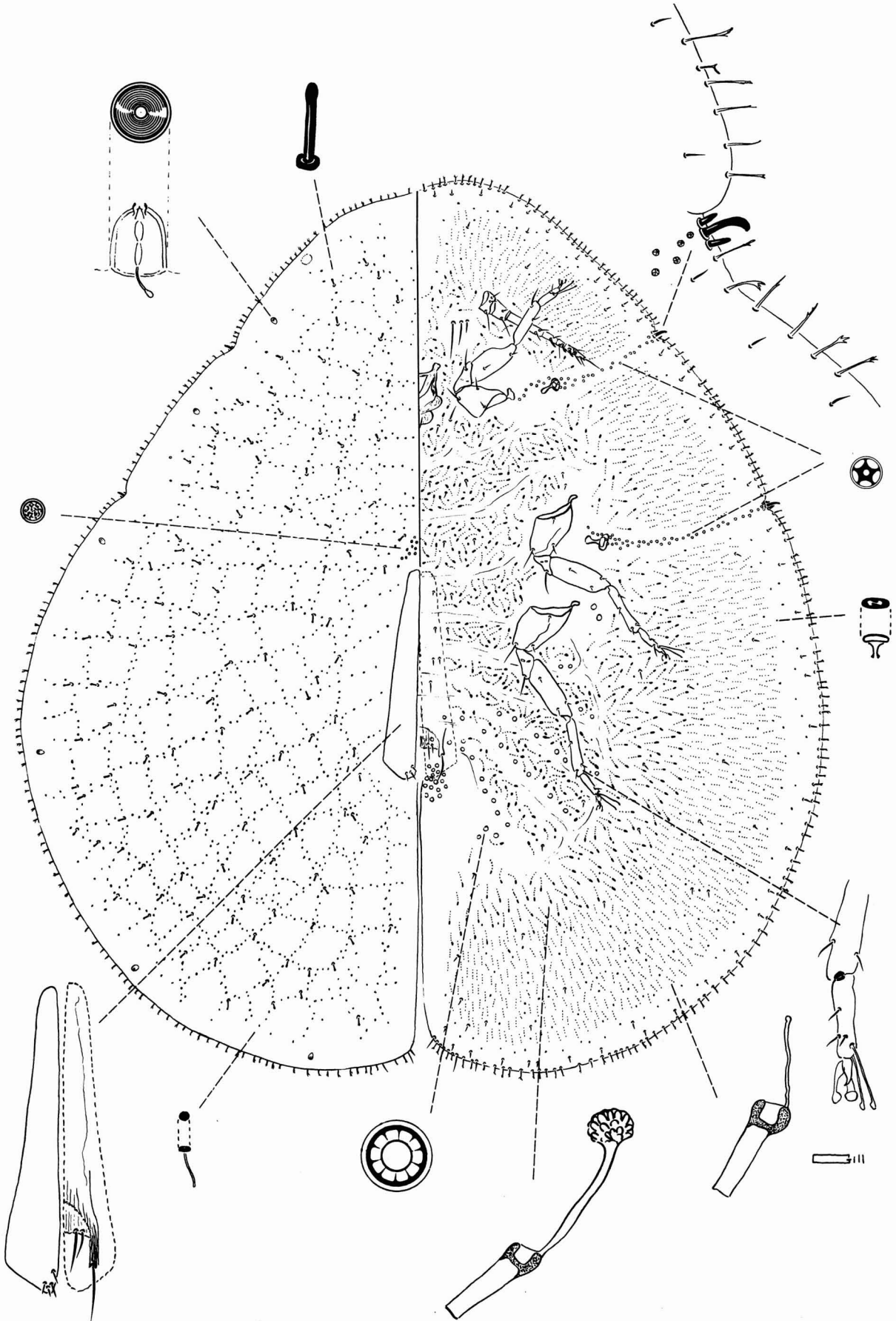


Fig. 32: *Protopulvinaria pyriformis* (Cockerell).

Genus *Pulvinaria* Targioni-Tozzetti, 1866 The Cushion Bearers

All species characterized in part by the elongate white ovisac (cushion) produced behind the body and composed of wax of varying consistencies. The ovisac does not completely enclose the female body as is the case in *Luzulaspis*, *Eriopeltis* and *Philephedra*. The ovisac is occasionally shallowly grooved lengthwise, but is never uniformly and deeply grooved or fluted like the ovisac of cottony cushion scale. As the ovisac is produced, the female becomes flattened, shriveled and usually is pushed forward and upward so that she is resting at a 45° angle or more to the host surface. Eventually the scale body may become detached from the ovisac after oviposition is complete.

The genus is recognized morphologically by the presence of the ventral submarginal tubular duct band, many tubular ducts in median area of venter, and the freely articulating tibio-tarsal joints. A major revisionary work of the genus for North America was done by Steinweden (1946).

Borchsenius (1952, 1953, 1957) divided the genus *Pulvinaria* into several genera, and assigned five species that occur in California to the following genera: *Eupulvinaria citricola*, *Eupulvinaria hydrangeae*, *Chloropulvinaria floccifera*, *Pulvinariella mesembryanthemi* (See DeLotto, 1979) and *Pulvinaria vitis*. If Borchsenius' concepts are followed, the remaining California species should be placed in one of the aforementioned genera except for *innumerabilis* which probably belongs in *Neopulvinaria*, and *bigeloviae* which belongs in another genus. However, Borchsenius' concepts are not generally accepted by American Coccidologists because the generic concepts are based partly on field characteristics and because the morphological characters intergrade between the genera when the group is studied on a world basis. Moreover, species such as *delottoi* do not fit satisfactorily in any of the current genera with restricted concepts. For these reasons, the species are left in *Pulvinaria* for the purpose of this handbook. Under the Borchsenius concept, 41 nominate species are assigned to *Pulvinaria*, 2 to *Acanthopulvinaria*, 9 to *Chloropulvinaria*, 3 to *Pulvinariella* and 34 to *Rhizopulvinaria*.

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- | | |
|--|---|
| Borchsenius, N. S., 1952: Akad. Nauk. Zool. Inst. Trudy. USSR 12: 269-316. | Inst. (n.s. 66) 9:1-493. |
| Borchsenius, N. S., 1953: Entomol. Obozr. 33:281-290. | DeLotto, G., 1979: J. Entomol. Soc. South Afr. 42(2):245-256. |
| Borchsenius, N. S., 1957: Akad. Nauk. Zool. | Steinweden, J. B., 1946: Microentomol. 11(1):1-28. |

KEY TO CALIFORNIA SPECIES OF *PULVINARIA*

- 1 Spiracular setae not differentiated from marginal setae; on native Compositae in Great Basin habitats. *bigeloviae*
- Spiracular setae differentiated; on other hosts in different areas of California. 2

- 2(1) Marginal setae long, stout, thick throughout their length, spine-like or curved, apices blunt or slightly knobbed. 3
- Marginal setae hair-like or bristle-like, not thick throughout their length, apices acute, bifid or variously fringed. 5

- 3(2) Lateral spiracular setae subequal in length with marginal setae; ventral submarginal tubular duct band extending anteriorly only to anterior spiracular furrow. *innumerabilis*
 Lateral spiracular setae less than 1/2 the length of marginal setae; ventral submarginal tubular duct band extending anteriorly onto head. 4
- 4(3) Marginal setae straight, apices blunt; 9-12 preopercular pores anterior to anal plates *delottoi*
 Marginal setae curved, apices blunt or slightly knobbed; about 50 preopercular pores anterior to anal plates. *mesembryanthemi*
- 5(2) Posterior ventral abdominal multilocular pores predominantly with 6-8 loculi. 7
 Posterior abdominal multilocular pores predominantly with 10 loculi. 6
- 6(5) Dorsal setae slender, may be curved; claw with denticle; ventral submarginal tubular duct band absent from anterior part of head; with 3 subapical setae on anal plates. *vitis*
 Dorsal setae stout, straight, spine-like; claw without denticle; ventral, submarginal tubular duct band continuous anteriorly around head. *rhois*
- 7(5) Submarginal duct tubercles absent; ventral submarginal tubular duct band continuous anteriorly around head. 8
 Submarginal duct tubercles present; ventral submarginal tubular duct band extending anteriorly only to posterior spiracular furrow. 9
- 8(7) Each anal plate with a subdiscal seta; long setae between antennae without bulbous expansion near apex; some marginal setae bifid or fimbriate apically. . . *hydrangeae*
 Each anal plate without subdiscal seta; 1 or 2 long setae between antennae usually with bulbous expansions; all marginal setae with acute apices. *citricola*
- 9(7) Short dorsal tubular ducts present; with 10-20 preopercular pores anterior to anal plates; on many hosts. *floccifera*
 Dorsal tubular ducts usually absent; with 60-80 preopercular pores; on orchids. . *phiaiae*

Pulvinaria bigeloviae Cockerell, 1893
 cottony sagebrush scale

Fig. 33, Color Plates 80, 81

Other Common Names:
 bigelovia scale.

Field Characteristics: Adult females 3 to 7 mm long, oval to circular and fairly convex. Color greenish or yellowish with a diffuse red mottle, becoming darker with age. Ovisac white, rough, somewhat fluted and 5 to 10 mm long.

Biology: Unknown but probably has one yearly generation. Found on the stems, crowns and roots of the host.

Similar Species: None. Host plants and distribution should separate this species from all others.

Hosts: Apparently restricted to the Compositae including *Chrysothamnus (Bigelovia)*, *Hapl-*

SOFT SCALES OF CALIFORNIA

opappas, *Hymenoclea* and *Franseria*.

Economic Importance: None.

Distribution: Native to the Great Basin regions of California, Oregon, Idaho and to New Mexico, Utah and Colorado. Probably occurs in Arizona, Nevada and eastern Washington.

GENUS *PULVINARIA*

Diagnosis: The only *Pulvinaria* which lacks differentiated spiracular setae. The relationship of this species to *Pulvinaria plucheae* as mentioned by Steinweden (1946) is unknown.

Steinweden, J. B., 1946: Microentomol. 11(1):1-28.

Pulvinaria citricola Kuwana, 1914 cottony citrus scale

Fig. 34

Field Characteristics: Adult females 2 to 5 mm long, ovoid to circular and flat. Color yellow to light brown. The ovisac is white and about 5 to 10 mm long.

Biology: One generation per year. For more biological information see Williams and Kosztarab (1972).

Similar Species: Most scales in the genus *Pulvinaria* are similar. It is impossible to accurately identify this species in the field.

Hosts: Has been found on *Citrus* and several other hosts. The only recorded California host is persimmon (*Diospyros kaki*).

Economic Importance: None.

Distribution: Collected in 1939 and 1940 at El Monte, Los Angeles County, but has not been collected since then in California. Also occurs in Maryland, Virginia, Florida and in Japan.

Diagnosis: Possesses bristle-like, simple marginal setae, lacks submarginal duct tubercles, and subdiscal opercular setae. Usually has a bulbous expansion near the apex of one or more interantennal setae.

Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. and State Univ. Res. Div. Bull. 74:1-215.

Pulvinaria delottoi Gill, 1979 DeLotto iceplant scale

Fig. 35, Color Plates 86-88

Field Characteristics: Adult females 2 to 5 mm long, oval to circular, moderately convex. Female stages green, usually matching color of the host. When oviposition begins, females secrete a sparse, dorsal covering of white powdery wax and a convex irregular white ovisac which is about as long as the body when complete. At this time the females develop a reddish or brownish color along the margin.

Biology: One generation per year; ovisacs present from January through May. Males unknown. For more information see Donaldson et al. (1978), Moore et al. (1979) and

Washburn and Frankie (1985).

Similar Species: Iceplant scale, *P. mesembryanthemi*, is similar in the field. However, *delottoi* is duller in color and is usually found on the lower parts of the host, while *mesembryanthemi* is bright green and usually found on the upper parts of the host.

Hosts: Prefers iceplant (*Carpobrotus edulis*) but has been found on other plants in the Aizoaceae and Crassulaceae.

Economic Importance: Along with *P. mesembryanthemi*, has been a serious pest of iceplant in California. For more information see Donaldson et al. (1978), Moore et al. (1979) and

Gill (1979). As reported by Tassan et al. (1982), a joint biological control program conducted by the University of California and the California Department of Transportation has resulted in good economic control of this species and *P. mesembryanthemi*.

Distribution: Restricted to Alameda, Monterey, Santa Clara, and Santa Cruz Counties. Elsewhere known only from southern Africa where it is probably native.

Diagnosis: Similar to iceplant scale but the marginal setae are thicker and straight instead of bent. The marginal setae of *P. innumerabilis* are similar but the medial spiracular setae are nearly twice as long as the marginal setae in *innumerabilis* and subequal in *delottoi*. For more information see Gill (1979). Several

species on iceplant in Africa are also similar, especially morphologically; for comparisons see comments under *P. mesembryanthemi*.

-
- Donaldson, D. R., W. S. Moore, C. S. Koehler and J. L. Joos, 1978: Calif. Agric. 32(10):4, 7.
 Gill, R. J., 1979: Pan-Pac. Entomol. 55(4):241-250.
 Moore, W. S., C. S. Koehler, J. L. Joos, D. R. Donaldson, D. V. Cassidy and R. J. Gill, 1979: Univ. Calif. Div. Agric. Sci. Leaflet 21084: 1-7.
 Tassan, R. L., K. S. Hagen and D. V. Cassidy, 1982: Calif. Agric. 36(9-10):16-17.
 Washburn, J. O. and G. W. Frankie, 1985: Hilgardia 53(2): 1-27.

Pulvinaria floccifera (Westwood), 1870
 cottony camellia scale

Fig. 36, Color Plates 48, 76, 79

Other Common Names:

camellia pulvinaria scale.

Synonymy:

Coccus flocciferus Westwood,
Pulvinaria camelliae Signoret,
Pulvinaria floccosa (Westwood),
Chloropulvinaria floccifera (Westwood).

Field Characteristics: Adult females 2 to 5 mm long, oval, fairly flat. Young adult females brown, usually with a yellow stripe. Ovisac white, fairly flat, 4 to 9 mm long.

Biology: One generation per year. Crawlers settle on the leaves; later instars return to the twigs where they mature. For more information on biology see Williams and Kosztarab (1972).

Similar Species: This species generally cannot be identified in the field except by host preference.

Hosts: Polyphagous. Most commonly found on camellia, pittosporum and holly. Occasionally found on *Citrus*. For a complete host list see Steinweden (1946), Merrill (1953) and

Williams and Kosztarab (1972).

Economic Importance: None.

Distribution: Probably occurs statewide but most common in the San Francisco Bay Region. Generally distributed in the United States; also occurs in Africa, Europe and Asia.

Diagnosis: This species has submarginal duct tubercles, less than 40 fringed marginal setae and 6-7 loculi in the multilocular pores. It is most similar to *P. phariae*, which has been considered as a synonym, but differs in having fewer fringed marginal setae and fewer preopercular pores.

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- Borchsenius, N. S., 1957: Akad. Nauk. Zool. Inst. (n.s.66)9:1-493.
 Merrill, G. B., 1953: Fla. State Plant Board Bull. 1: 1-143.
 Steinweden, J. B., 1946: Microentomol. 11(1): 1-28.
 Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74: 1-215.

Pulvinaria hydrangeae Steinweden, 1946
cottony hydrangea scale

Fig. 37

Synonymy:

Eupulvinaria hydrangeae (Steinweden).

Field Characteristics: Adult females 3 to 5 mm long, ovoid to circular, fairly flat. Color yellow or brown, becoming darker with age. Ovisac white, broadly and shallowly grooved, convex, about 10 mm long.

Biology: One generation per year. Overwinters as third stage nymphs on twigs where maturation and egg laying takes place in spring. Crawlers return to the leaves for initial development. For more information see Canard (1965) and Williams and Kosztarab (1972).

Similar Species: Other *Pulvinaria* species are similar and cannot be differentiated in the field. Cottony camellia scale is most likely found in the same habitat as this species, but it is smaller and has a less convex ovisac.

Hosts: Prefers hydrangea but is occasionally found on other hosts such as cherry. For a complete host list see Steinweden (1946) and Canard (1965).

Economic Importance: None.

Distribution: Rare; restricted primarily to

urban area around San Francisco Bay. Has also been found in Los Angeles and Sacramento counties. Also known from the East Coast of the United States, Japan, Australia, and Europe.

Diagnosis: This species has less than half of the marginal setae fringed, has a subdiscal seta and 3 subapical setae on the anal operculum, and lacks submarginal duct tubercles. It is similar to *floccifera* which has submarginal duct tubercles. Another similar relative, *citricola*, lacks subdiscal setae on the anal opercula, has simple marginal setae and usually a bulbous expansion on one or more of the interantennal setae.

Canard, M., 1965: Ann. Entomol. Soc. Fr. (n. s.) 1(2):411-419.

Steinweden, J. B., 1946: Microentomol. 11(1): 1-28.

Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. and State Univ. Res. Div. Bull. 74:1-215.

Pulvinaria innumerabilis (Rathvon), 1854
cottony maple scale (ESA approved)

Fig. 38, Color Plates 73-75

Synonymy:

Coccus innumerabilis Rathvon,

Lecanium acericorticis Fitch,

Pulvinaria tinsleyi King,

Pulvinaria vitis (Linnaeus).

(misidentification).

Field Characteristics: Adult females 3 to 10 mm long, ovoid to circular, flat. Young adults mottled grey or yellow and brown, becoming dark leathery brown with age. Ovisac white, convex, broad, 5 to 10 mm long; often the

female body is tilted at an angle from the twig and the anterior part of the ovisac.

Biology: One generation per year. Adult females mature in September, mated females overwinter on the twigs. Oviposition and ovisac formation begins in May and June. For more information see Phillips (1962) and Williams and Kosztarab (1972). Several other authors including Putnam (1880) and Johnson (1906) have supposedly worked on the biology of this species, but some confusion re-

mains as to which species they studied.

Similar Species: Cannot be separated from several other *Pulvinaria* species in the field except for its relatively large size. Has long been confused with the cottony maple-leaf scale, *Pulvinaria acericola* (Walsh and Riley), but that species normally forms ovisacs on the leaves, while *P. innumerabilis* normally forms ovisacs on the twigs.

Hosts: Polyphagous. Commonly found on grapes in California. For complete host lists see Merrill (1953), Phillips (1962) and Williams & Kosztarab (1972).

Economic Importance: None, although this species has apparently caused some injury to commercial grapes in San Joaquin County (see comments under *P. vitis*). There have been occasional outbreaks in the peach growing areas of Ontario, Canada. For more information see Phillips (1962) and Williams & Kosztarab (1972).

Distribution: Occurs statewide but most

common in the northern counties and in the San Joaquin Valley on grapes. Also occurs throughout the United States and in many parts of Canada.

Diagnosis: Recognized immediately by the large spine-like marginal setae. The only other California species with spine-like setae is *P. delottoi*, which has much shorter spiracular setae and is restricted to iceplant and succulents.

Johnson, S. A., 1906: Colo. Agric. Coll. Agric. Exp. Stn. Bull. 116: 1-16.

Merrill, G. B., 1953: Fla. State Plant Board Bull. 1: 1-143.

Phillips, J. H. H., 1962: Can. Entomol. 94(5):497-502.

Putnam, J. D., 1880: Davenport Acad. Sci. Proc. 2 (1879-1880) 2: 293-347.

Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74: 1-215.

Pulvinaria mesembryanthemi (Vallot), 1829
iceplant scale

Fig. 39, Color Plates 82-85

Synonymy:

Coccus mesembryanthemi Vallot,

Calypticus mesembryanthemi Perinquey.

This species is the type of the genus *Pulvinariella* Borchsenius (1953) (see comments under "Genus *Pulvinaria*").

Field Characteristics: Adult females 2 to 5 mm long, oval to circular, moderately convex. Color of all female stages bright green, usually matching host color. When oviposition starts, females secrete a sparse dorsal covering of white mealy wax and a convex, white ovisac, which is almost as long as the body when complete. At this time female adults develop a reddish to brownish margin. According to Field Entomologists, when large numbers of these scales form ovisacs, the host plant appears as if it were covered with popcorn.

Biology: Two yearly generations in northern

California. Ovisacs present from late April to late July and from September through February in northern California. Multiple generations occur in southern California. Male puparia commonly present in all generations. For more information see Quintana (1956), Donaldson et al. (1978), Moore et al. (1979), Washburn and Frankie (1985) and Washburn et al. (1985).

Similar Species: Nearly identical to DeLotto iceplant scale in the field, but *delottoi* is duller green and more commonly found on the lower parts of the host. May also be confused with cottony cushion scale (Margarodidae) and with other scales in the genus *Pulvinaria*.

Hosts: Restricted to iceplant (Aizoaceae). Preferred host is *Carpobrotus* (*Mesembryanthemum*) *edulis*.

Economic Importance: Can kill large patches

of iceplant, which is used to hold the soil on steep hillsides, particularly road cuts. As reported by Tassan et al. (1982), a joint biological control program conducted by the University of California and the California Department of Transportation has resulted in good economical control of this species and *P. delottoi*. For more information on the economic importance and control of this species see Brain (1920), Quintana (1956), Donaldson et al. (1978), Moore et al. (1979) and Gill (1979).

Distribution: Practically state-wide. Prevalent along the coast from Sonoma County to San Diego. Most common in the east bay region. Also found inland in Sacramento, Glenn, Solano, Yolo, San Joaquin, Fresno, Kern, Merced, Calaveras, Orange and San Bernardino counties. Occurs in southern Africa, the Mediterranean region, Australia and Argentina. Apparently native to southern Africa.

Diagnosis: Morphologically distinct because of the stout, blunt, slightly curved marginal setae. DeLotto iceplant scale is similar but the stouter, straight and pointed marginal setae should immediately separate the species. *Pulvinariella hemiacantha* DeLotto and *Mesembryanthemi*

bryna fasciata DeLotto from Africa are very similar to *P. mesembryanthemi* and they occur on the same hosts. They can be separated immediately because *P. hemiacantha* lacks the posterior set of spiracular setae and *M. fasciata* lacks spiracular setae altogether.

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- Borchsenius, N. S., 1953: Entomol. Obozr. 33:281-290.
 Brain, C. K., 1920: Bull. Entomol. Res. 11:1-40.
 Donaldson, D. R., W. S. Moore, C. S. Koehler and J. L. Joos, 1978: Calif. Agric. 32(10):4, 7.
 Gill, R. J., 1979: Pan-Pac. Entomol. 55(4):241-250.
 Moore, W. S., C. S. Koehler, J. L. Joos, D. R. Donaldson, D. V. Cassidy and R. J. Gill, 1979: Univ. Calif. Div. Agric. Sci. Leaflet 21804: 1-7.
 Quintana, F. J., 1956: Rev. Fac. Agron., Univ. Nac. La Plata 32(1): 75-110.
 Tassan, R. L., K. S. Hagen and D. V. Cassidy, 1982: Calif. Agric. 36(9-10): 16-17.
 Washburn, J. O. and G. W. Frankie, 1985: Hilgardia 53(2): 1-27.
 Washburn, J. O., G. W. Frankie and J. K. Grace 1985: Environ. Entomol. 14(6):755-761.

***Pulvinaria phaiae* Lull, 1899**
 cottony orchid scale

Fig. 40

Field Characteristics: Adult females 3 mm long, oval, flat. Color light yellowish green, matching color of host leaves. During oviposition females become covered with a sparse, white, flocculent wax, and secrete a long (up to 8 mm), white, slightly fluted and curved ovisac. The ovisac may have streaks of brown coloration, particularly on the midline.

Biology: Little known; males common. See Lull (1899).

Similar Species: Other *Pulvinaria* scales are similar and field identification should not be attempted. Brown soft scale and hemispherical scale are common on orchids and resemble this species before ovisac formation.

Hosts: Restricted to orchids. In California has been found on *Phalaenopsis* and *Odontoglossum*.

Economic Importance: Distorts leaves of host and occasionally kills plants. Too rare and apparently too susceptible to pesticides to be a serious pest. For more information see Lull (1899).

Distribution: Found in several nurseries in Alameda and Marin counties between 1938 and 1940, but has not been collected in California since then. Has also been found in Massachusetts and New York. Possibly native to Japan (Lull, 1899).

Diagnosis: The presence of submarginal duct

tubercles and many fimbriated marginal setae separate this species from all other North American *Pulvinaria* except for *psidii* Maskell and *urbicola* Cockerell. *Pulvinaria psidii* has 10 loculi in the multilocular pores, while *phaiae* and *urbicola* have 6-7. *Pulvinaria urbicola* has only 7-20 preopercular pores, while *phaiae* has 60-80. The most similar California species, *P. floccifera*, differs by having fewer fringed mar-

ginal setae and preopercular pores.

Pulvinaria rhois Ehrhorn, 1898
fruit tree pulvinaria

Fig. 41

Other Common Names:

cottony fruit scale,
cottony poison oak scale,
cottony peach scale.

Synonymy:

Pulvinaria amygdali Cockerell
(misidentification).

Field Characteristics: Adult females 3 to 5 mm long, ovoid to circular, flat. Color of all female stages prior to ovisac formation yellowish with a brown mottle. After ovisac formation, females reddish or brownish with a sparse covering of powdery white wax. Ovisac white, slightly grooved or fluted and up to 5 mm long.

Biology: One generation per year; overwinters as immatures on the twigs. Ovisacs formed in April and May. Scales feed on the leaves, bark and fruit. For more information see Essig (1958) under *P. amygdali*.

Similar Species: Most *Pulvinaria* species are similar. *Pulvinaria vitis*, found on the same group of hosts, cannot be separated from this species in the field.

Hosts: Collected most commonly on poison oak, *Rhus diversiloba*, but also found on peach, plum, apple and currant (*Ribes*).

Economic Importance: None; has never de-

veloped populations large enough to cause injury. Populations are sporadic and seldom collected.

Distribution: Rare. Has been found from Los Angeles to Siskiyou counties but is most common in the San Francisco Bay region and in the lower Sacramento Valley. May be generally distributed in the United States but identification problems preclude the exact limits of its range. Probably a native North American species.

Diagnosis: Has multilocular pores with usually 10 loculi, submarginal duct tubercles and few or no fimbriated marginal setae. Most similar to *P. vitis* in California and to the cottony maple-leaf scale, *P. acericola* (Walsh & Riley) in the eastern U.S. by having straight, spine-like dorsal setae, only 2 subapical setae on each operculum and large numbers of ventral submarginal tubular ducts on the anterior of the head. Differs from *P. acericola* in having 100-150 preopercular pores, while *acericola* has only 10-50.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Pulvinaria vitis (Linnaeus), 1758
cottony vine scale

Fig. 42, Color Plates 77, 78

Other Common Names:

cottony grape scale,
cottony maple scale,
vine scale.

Synonymy:

Coccus vitis Linnaeus,
Coccus betulae Linnaeus,
Lecanium vitis (Linnaeus),
Pulvinaria amygdali Cockerell
(misidentification),
Pulvinaria innumerabilis Rathvon
(misidentification in part),
P. occidentalis Cockerell
and its synonyms,
Pulvinaria betulae (Linnaeus).

P. coulteri Cockerell and *P. ehrhorni* King may be synonyms of this species [see comments by Phillips (1955, 1963) and Steinweden (1946)].

Field Characteristics: Adult females 3 to 7 mm long, ovoid to circular, flat. Color of young adults yellow with a variable brown mottle, becoming darker with age. Ovisac white, somewhat convex, 5 to 10 mm long.

Biology: One generation per year, overwinters as immatures on twigs and branches of host. Females parthenogenetic. Males unknown. All aspects of the biology of this species have been thoroughly studied by Phillips (1962, 1963).

Similar Species: Fruit tree pulvinaria and cottony maple scale are similar and cannot be separated in the field.

Hosts: Prefers peach, plum, grape, cherry, willow, poplar and currant. For a complete host list see Essig (1958) and Phillips (1963).

Economic Importance: Has never caused economic injury in California. Stafford and Doutt (1974) list the cottony maple scale, *P. vitis*, as a

minor pest of grapes in Lodi, San Joaquin County. However, there is confusion regarding the exact species that they referred to. All available specimens on grape from the Lodi area are the cottony maple scale, *P. innumerabilis*, not *P. vitis*. *P. vitis* has, however, caused economic losses to peach orchards in Ontario, Canada. For more information on the economic importance of this species and on natural enemies see Phillips (1963).

Distribution: Presently restricted to the San Francisco Bay region, the lower Sacramento Valley and Modoc County. Also known throughout the western United States, New York and Canada. Native and widespread in Europe; was probably introduced into the United States prior to 1897.

Diagnosis: Has submarginal duct tubercles and few or no fimbriated marginal setae. Readily separated from the similar *P. rhois* and *P. acericola* (Walsh & Riley) by having slender, curved dorsal setae, 3 subapical setae on each operculum and few or no ventral submarginal tubular ducts on the head.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Phillips, J. H. H., 1955: Can. Entomol. 87(6):245.

Phillips, J. H. H., 1962: Can. Entomol. 94(5):497-502.

Phillips, J. H. H., 1963: Can. Entomol. 95(4):372-407.

Stafford, E. M. and R. L. Doutt, 1974: Calif. Agric. Exp. Stn. Circ. 566: 1-75.

Steinweden, J. B., 1946: Microentomol. 11(1):1-28.

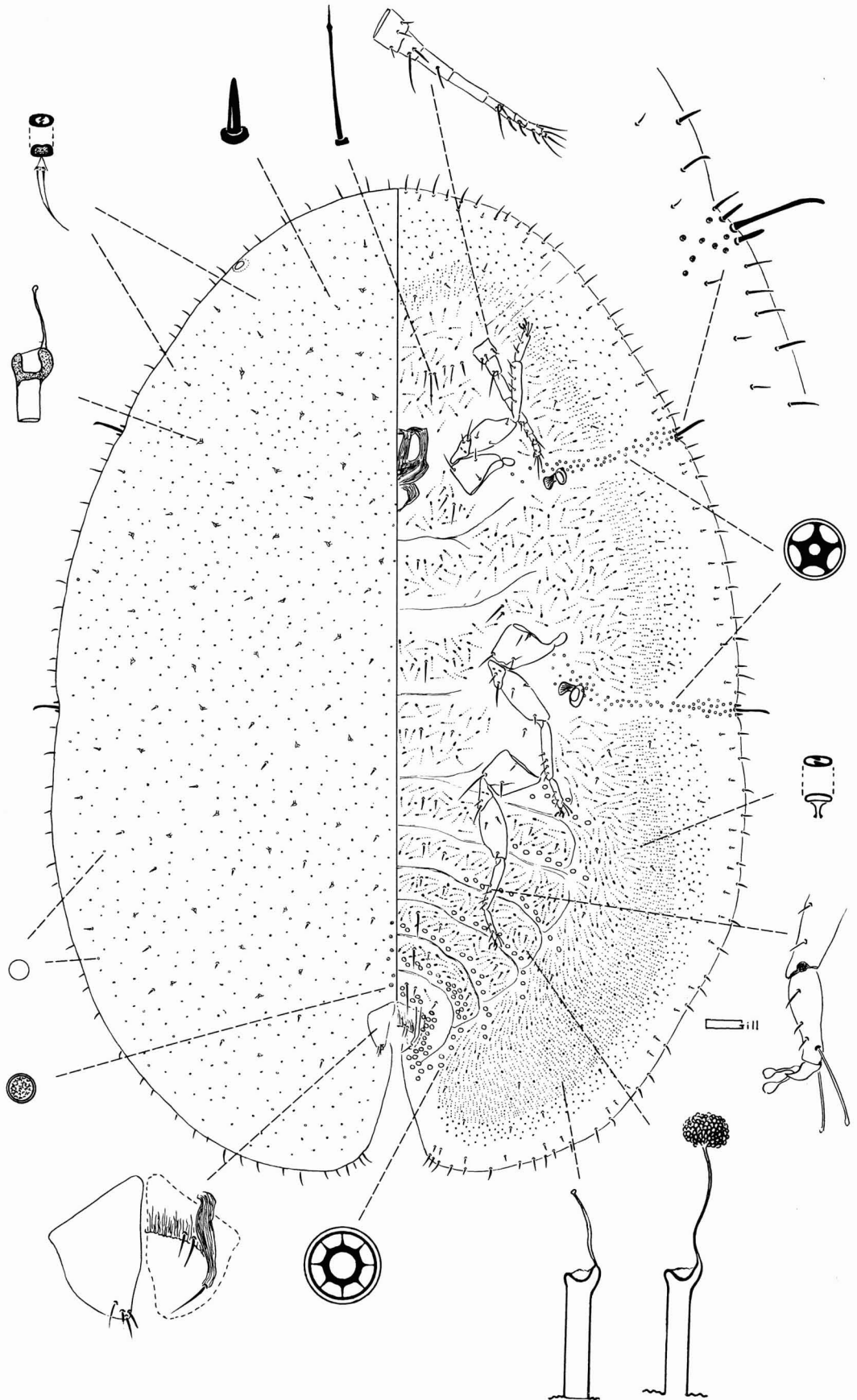


Fig. 34: *Pulvinaria citricola* Kuwana.

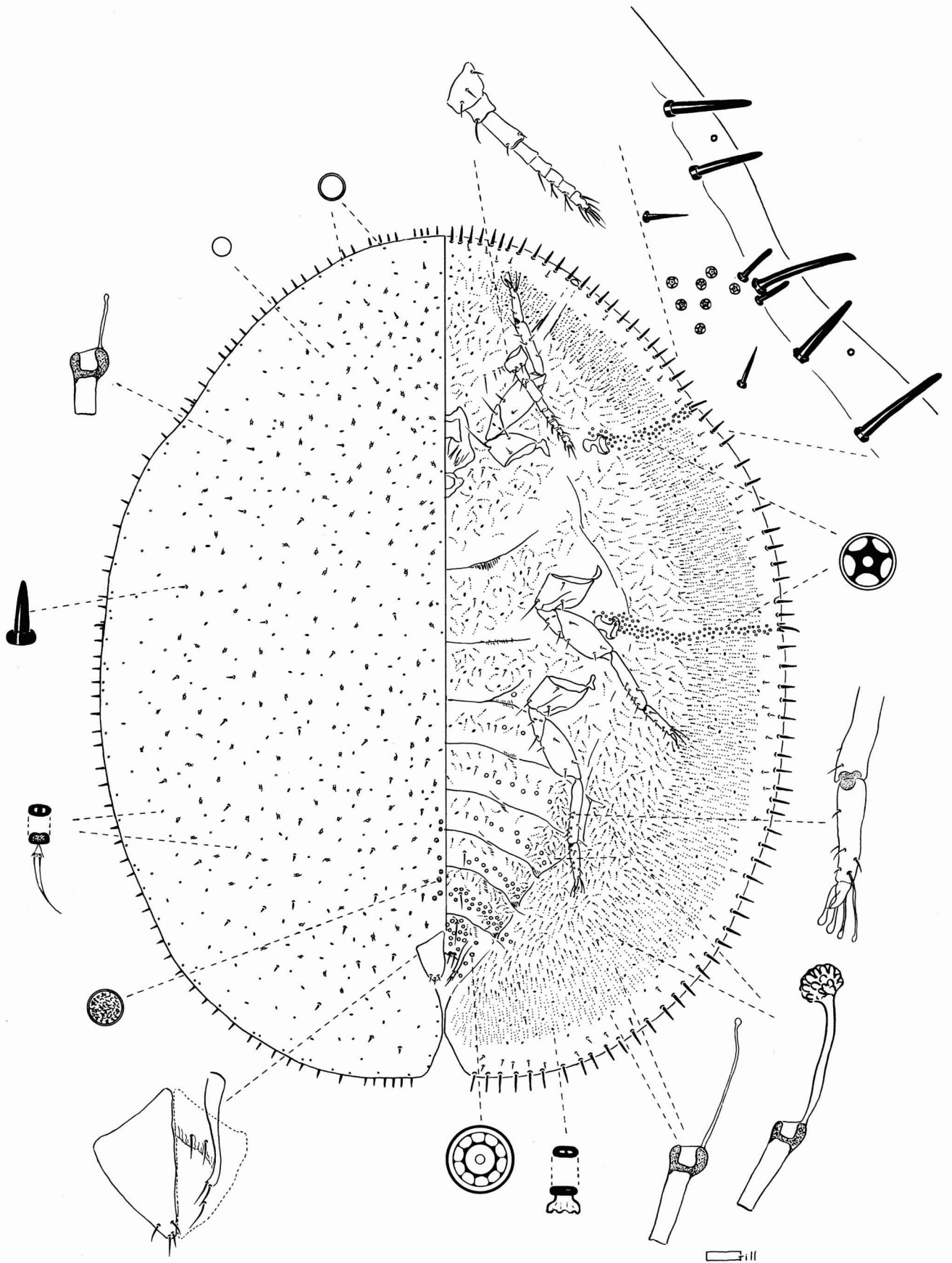


Fig. 35: *Pulvinaria delottoi* Gill.

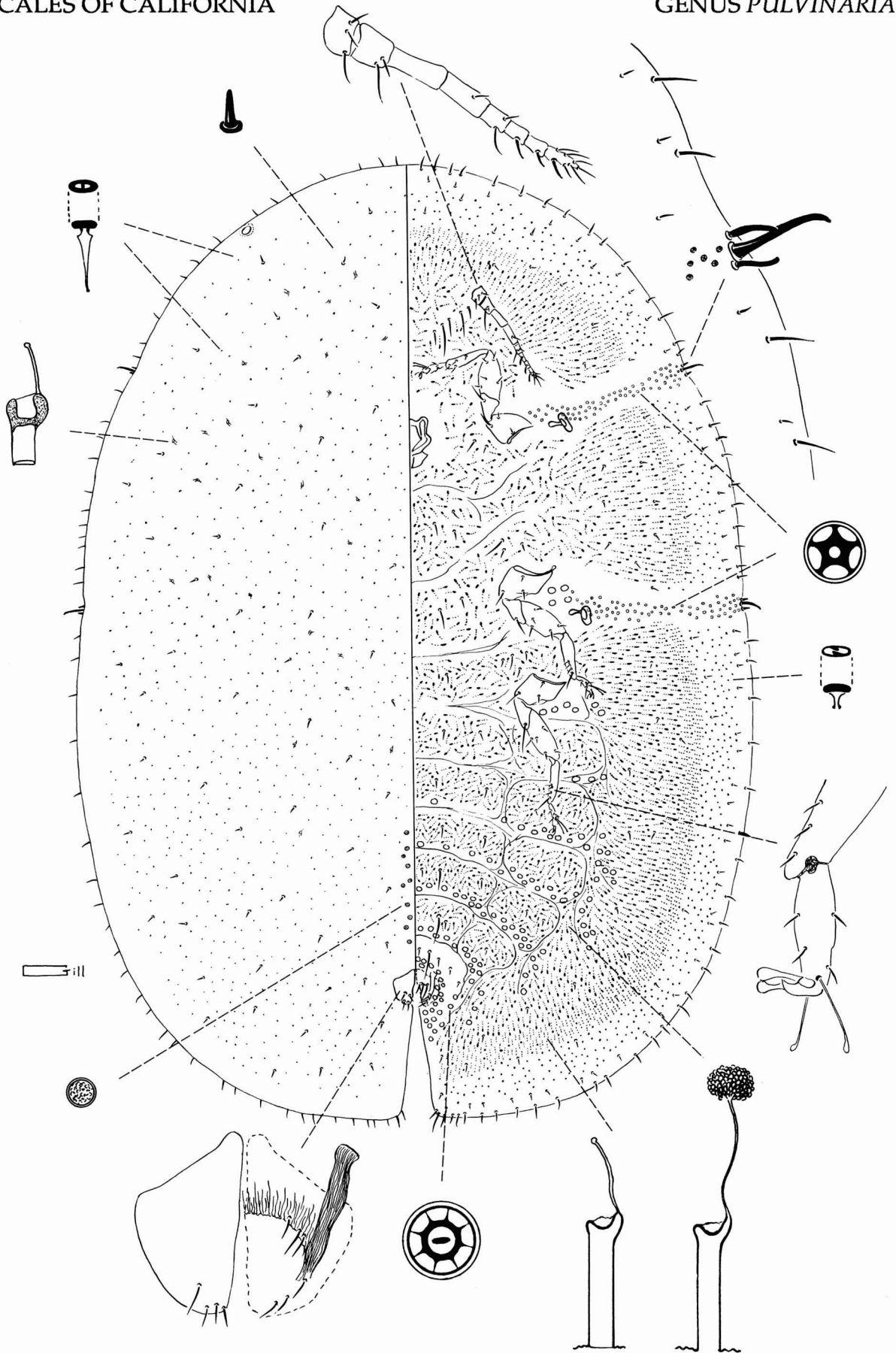


Fig. 37: *Pulvinaria hydrangeae* Steinweden.

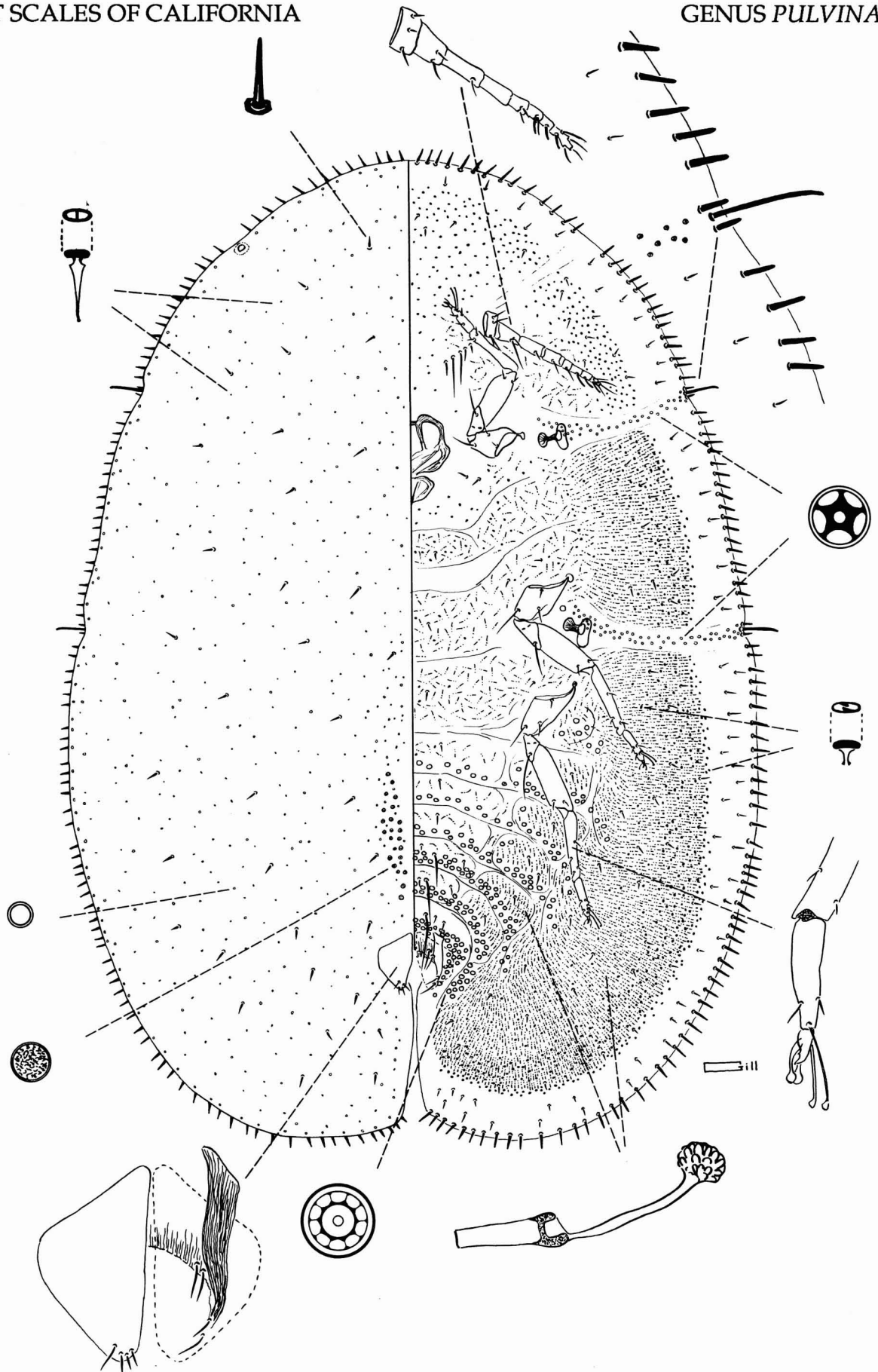


Fig. 38: *Pulvinaria innumerabilis* (Rathvon).

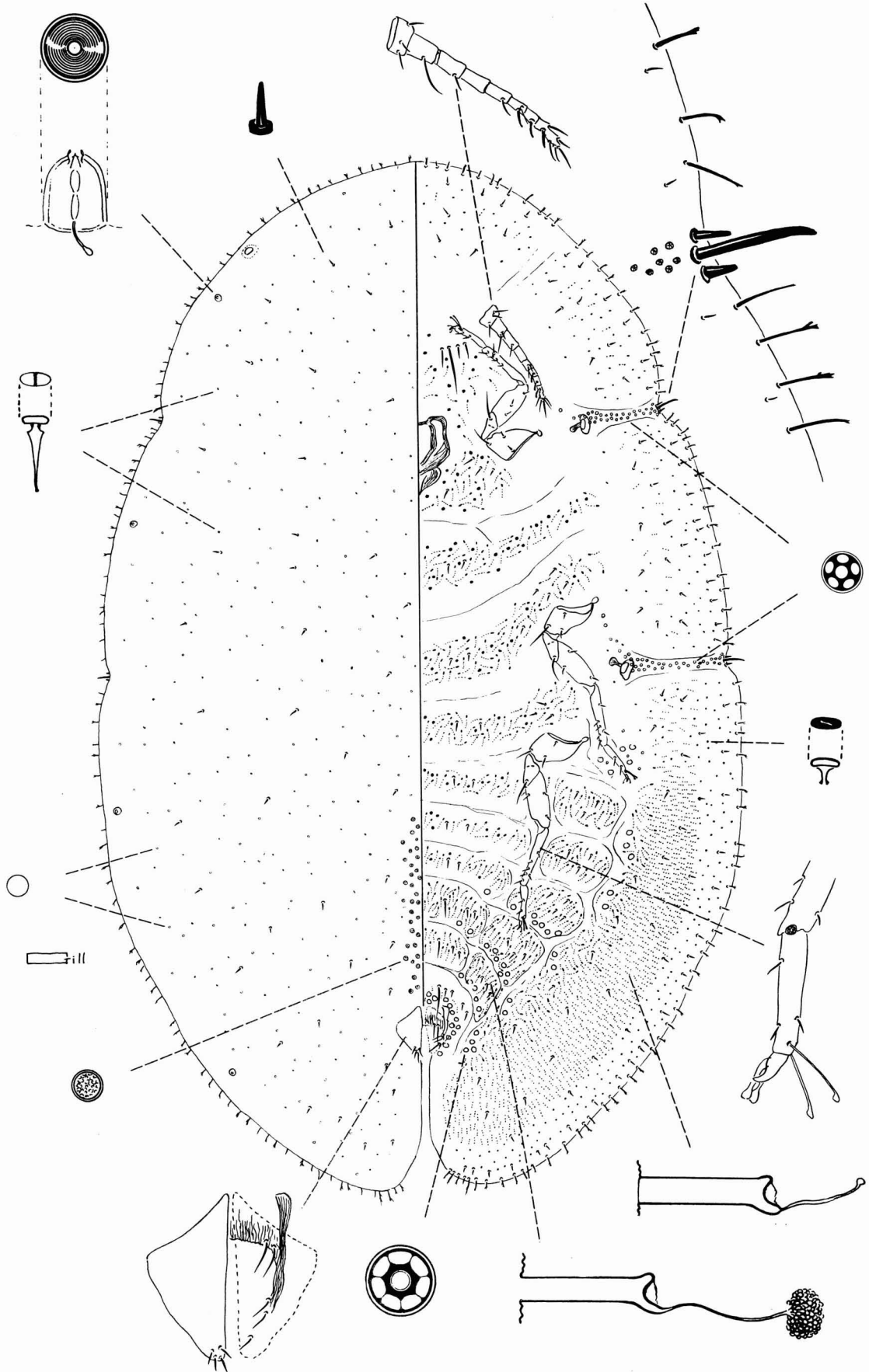


Fig. 40: *Pulvinaria phariae* Lull.

Genus *Saissetia* Deplanche, 1859
The Black Scales

Species in this genus are characterized by the convex (hemispherical) shape of fully mature adults and the distinctive "H" pattern of the nymphs and adults, formed by narrow raised ridges (carinae). Morphologically the genus is recognized by the large discal (central) seta on each operculum, cell-like areas dorsally, conical or spine-like dorsal setae, and ventral submarginal tubular duct bands.

The genus is generally considered native to Africa, where many species occur, although two species are presently known only from the Western Hemisphere, the Pacific Islands and the Far East. The genus contains 60 nominate species.

KEY TO THE CALIFORNIA SPECIES OF *SAISSETIA*

- 1 Ventral tubular duct band composed of 2 kinds of ducts, one with inner ductlets as wide or wider than the outer duct, and one with filamentous or thin inner ductlets. *coffea*
Ventral tubular duct band composed entirely of ducts with filamentous inner ductlets. 2
- 2 With 40-60 marginal setae around the anterior margin of head between the anterior spiracular depressions. *miranda*
With less than 30 marginal setae between the anterior spiracular depressions. *oleae*

***Saissetia coffea* (Walker), 1852**
hemispherical scale (ESA approved)

Fig. 43, Color Plates 51, 70, 71

Synonymy:

- Lecanium coffea* Walker,
- Coccus coffea* (Walker)
- Lecanium hemisphaerica* (Targioni-Tozzetti),
- Saissetia hemisphaerica* (Targioni-Tozzetti).

For a complete list of synonyms see Sanders (1909) and Brain (1920).

Field Characteristics: Adult females 2 to 4 mm long, older adult females become convex dorsally and flattened ventrally near the attachment with the host, thus resembling a hemisphere. Color of adults shiny tan to light brown with many evenly-spaced light dots over most of dorsal surface. Nymphs and young adult females much flatter than older adults and light yellow or pink with some

darker mottling. Characteristic "H" pattern of the "black scale" group noticeable in nymphs and young adults, but disappears as adults become convex. Dorsal surface completely smooth in fully mature individuals.

Biology: Metcalf and Flint (1951) list two generations per year although there may be more or fewer generations depending on environmental factors. All stages of development have been observed on the host at the same time so that there is an overlapping of broods. When the females become convex, a cavity is formed under the body which serves as an egg incubation chamber that may be filled with up to 1000 eggs. Males unknown; females parthenogenetic. For more information, see Alayo and Blahutiak (1981).

Similar Species: Adult female hemispherical

scales resemble "black scale" species but are much lighter in color and lack an "H" pattern. Also resembles the "Lecanium" group of soft scales but again is lighter in color and is seldom found on deciduous trees, the favored hosts of the "Lecaniums." "Lecaniums" also lack light colored dots on dorsal surfaces. Hemispherical scale resembles brown soft scale, particularly in early stages of development, but has the distinctive "H" pattern in these stages, while brown soft scale does not. **Hosts:** Polyphagous. Prefers evergreen ornamentals, house plants and particularly ferns and cycads. Occasionally found on citrus. For a more complete host list see Essig (1958).

Economic Importance: A serious pest of indoor ornamental plants, particularly Boston fern. Not a problem outdoors due to natural enemies, many of which are also natural enemies of black scale. For more information on economic importance see Quayle (1938). For more information on biological control see Ferris (1948) and Bartlett (1978).

Distribution: Throughout California on indoor plants. Survives outdoors in the southern coastal counties. Cosmopolitan; probably native to Africa.

Diagnosis: Field characteristics should im-

mediately separate this species from any others. Morphologically, the large discal (central) seta on each anal plate along with the swollen inner ductlet of the tubular ducts in the ventral submarginal duct bands will distinguish this species.

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***Saissetia miranda* (Cockerell & Parrott), 1899**
Mexican black scale (ESA approved)

Fig. 44, Color Plates 65, 66

Synonymy:

Lecanium oleae mirandum Cockerell & Parrott,

Saissetia oleae miranda (Cockerell & Parrott),

Saissetia oleae (Bernard) (misidentification in part).

Field Characteristics: Adult females 1 to 6 mm long, circular, moderately to strongly convex. Old adult females dark brown to black, young adults and nymphs yellow or yellow-grey. Dorsal, raised "H" pattern present in all stages.

Biology: Poorly known. It is not known if males occur.

Similar Species: Black scale, *Saissetia oleae* and Caribbean black scale, *Saissetia neglecta* Delotto are identical in the field.

Hosts: Prefers oleander (*Nerium*) and *Ficus*, especially commercial fig (*Ficus carica*) and fiddle-leaf fig (*Ficus lyrata*). Has also been found on *Citrus* in Texas but not in California. For a complete host list see Dean & Hart (1972).

Economic Importance: Has reached large population levels in Southern Texas, but there

are no published accounts of it causing any injury. For information on natural enemies see Bartlett (1960) and Dean and Hart (1972).

Distribution: In California, found outdoors only in Imperial County. Elsewhere in California it has been found in a number of nurseries on ornamental *Ficus*. It occurs in greenhouses in many states; outdoors in Texas, Florida, Mexico, Hawaii, Caribbean Islands, Central and South America and some Pacific Islands.

Diagnosis: This scale has been confused with the common black scale *Saissetia oleae*, for many years. Most of the United States records of black scale outside of California prior to

1969 are either this species or *Saissetia neglecta* DeLotto. Synonymized with *S. oleae* for a long time but reinstated to specific rank by DeLotto (1969). Separated from the other *Saissetia* species by the 40-60 marginal setae anterior to the spiracular setae, and by the tubular ducts with thin inner ductlets in the ventral duct band.

Bartlett, B. R., 1960: Ann. Entomol. Soc. Am. 53: 583-585.

Dean, H. A. and W. C. Hart, 1972: Ann. Entomol. Soc. Am. 65(2): 478-481.

DeLotto, G., 1969: J. Entomol. Soc. South Africa 32:413-422.

Saissetia oleae (Olivier), 1791
black scale (ESA approved)

Fig. 45, Color Plates 46, 64, 67, 68

Other Common Names:

Mediterranean black scale,
olive soft scale,
olive scale.

Synonymy:

Coccus oleae Olivier,
Lecanium oleae (Bernard),
Coccus oleae (Bernard),
Saissetia oleae (Bernard).

For a complete list of synonyms see Sanders (1909).

Field Characteristics: Adult females 2 to 5 mm long, hemispherical. Young adult females round, and fairly flat. Immatures oval. Older adults dark brown or black. Younger adult females and nymphs yellow or grey, roughened or granular in appearance. All stages with "H" pattern on dorsum which aids in field recognition. After the last molt, the scales enter the "rubber stage" in which the epidermis becomes thicker and harder, and changes from tan to a dark mottled grey. By late rubber stage and before egg laying begins, female scales become leathery, dark brown to black and hemispherical in outline. Eggs vary in color from white to reddish-

orange depending on maturity. The crawlers are less than 1/2 mm long, flat, oval and light brown.

Biology: Usually one generation per year in California although two generations occur in some coastal counties and three generations are reported in other countries. Egg laying occurs primarily from April to July in Southern California, but may extend into August and September. Each female lays up to 2000 eggs under her body. Eggs are incubated under the body of the female for 20-30 days before hatching into crawlers. The crawlers move actively for a day or so before they settle into a more or less fixed position on the leaves, fruit or green twigs. Nymphs develop, enlarge and molt twice before reaching maturity. Sometime before the last molt, nymphs leave their original positions on the leaves and fruit and move to permanent locations on older twigs and branches before normal leaf or fruit drop occurs, particularly on deciduous trees. Generally parthenogenetic; males are known but rare. Above information on the biology of this species summarized from

Quayle (1911, 1932), Quayle and Rust (1911), Bodenheimer (1951), Essig (1958), Ebeling (1959), Argyriou (1963), Bartlett (1978), Podoler et al (1979a, 1979b) and Mendel et al (1982, 1984).

Similar Species: Mexican black scale, *Saissetia miranda*, and Caribbean black scale, *Saissetia neglecta* Delotto, cannot be separated from black scale in the field. However, host plants and distribution will be of some help in distinguishing *S. oleae* from *S. miranda*. Hemispherical scale is similar to black scale but is lighter in color and lacks the dorsal "H" pattern in older adults. Nigra scale is similar but is usually less convex and lacks the dorsal "H" pattern.

Hosts: Polyphagous. Prefers citrus, olive and oleander in California. For a complete host list see Essig (1958).

Economic Importance: Considered the most injurious soft scale in California. Considered the most important pest of citrus prior to 1940, but oil sprays and effective natural enemies have reduced its importance. Has recently become a serious pest of olives in the San Joaquin Valley (Sibbett et al. 1976). Black scale is still of minor concern in inland areas because the major parasite, *Metaphycus helvolus* (Compere), is adversely affected by cold weather. Black scale outbreaks often occur when ants are not controlled. The ants protect the scale from natural enemies. The scales extract large quantities of sap which results in general host debilitation. The scales also excrete honeydew which collects on the upper surfaces of the leaves, twigs and fruit where it becomes a medium for sooty mold fungi. Fruit covered with sooty mold must be more carefully washed (or culled) during packing and is more susceptible to rot. A covering of sooty mold on the leaves may interfere with photosynthesis. The above information on the economic importance of this species summarized from Quayle (1911a, 1932), Quayle and Rust (1911), Bodenheimer (1951), Essig (1958), Ebeling (1959), Madsen and McNelly (1961), Argyriou (1963), Avidov and Harpaz

(1969) and Bartlett (1978). For information on natural enemies see Quayle (1911a, 1932), Quayle and Rust (1911), Smith and Compere (1928), Compere (1940), Ebeling (1959), Sibbett et al., (1979), Bartlett (1978), Viggiani (1978) and Mendel et al (1984).

Distribution: Throughout California at low elevations. Immature stages are adversely affected by high temperature and low humidity, so its distribution is restricted in the desert valleys of southern California. Uncommon in most other states but common in many other citrus growing areas of the world, particularly the Mediterranean region and South Africa. Apparently native to Africa. Has been in California since 1880.

Diagnosis: The taxonomy of black scale species in the U.S. was clarified by DeLotto (1969, 1971a and 1971b). The discal seta on the operculum and the presence of 15-30 blunt or only slightly frayed marginal setae between the anterior spiracular clefts differentiate this species from other California soft scales and other *Saissetia* species.

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SOFT SCALES OF CALIFORNIA

GENUS *SAISSETIA*

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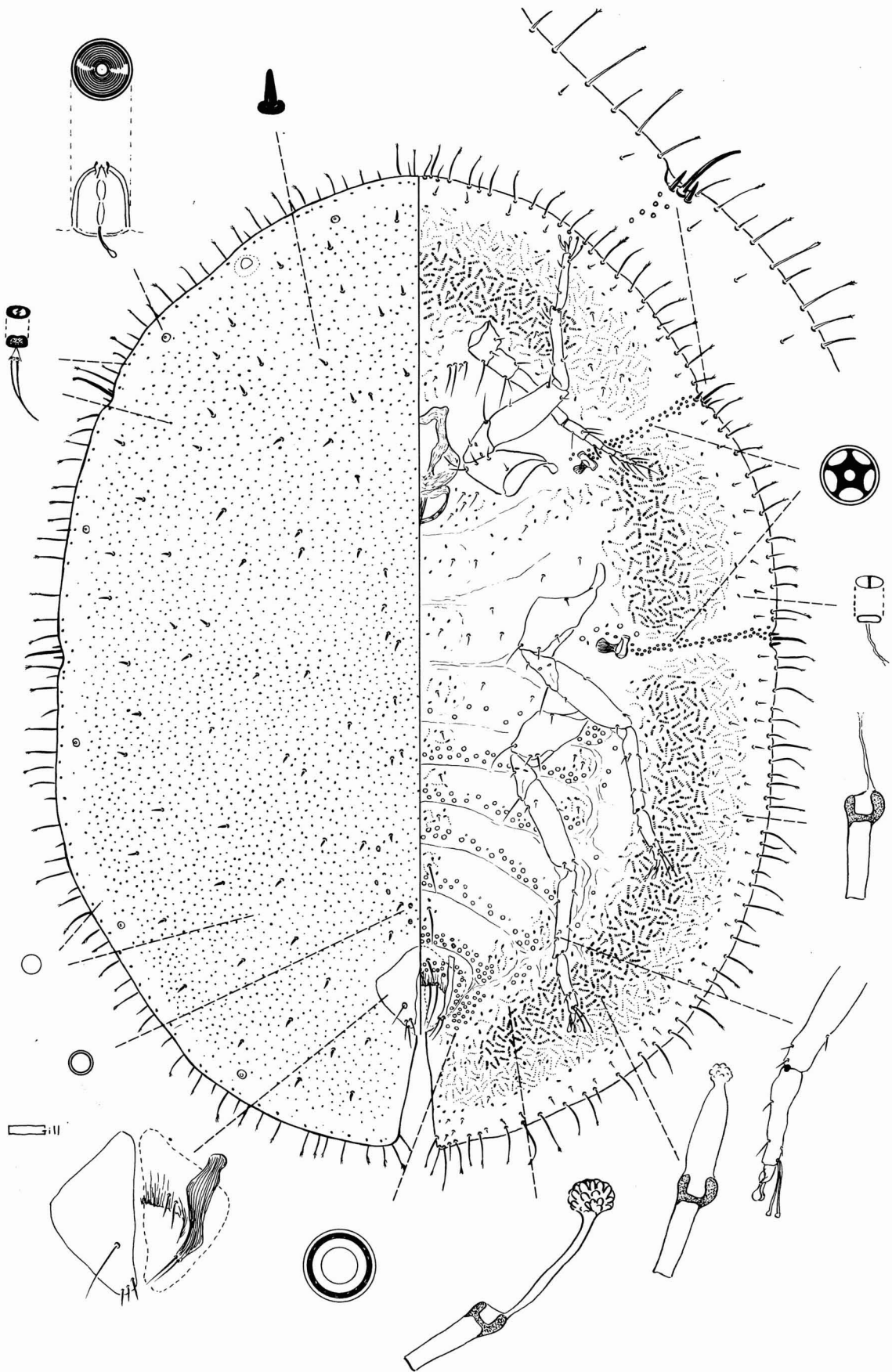


Fig. 43: *Saissetia coffeae* (Walker).

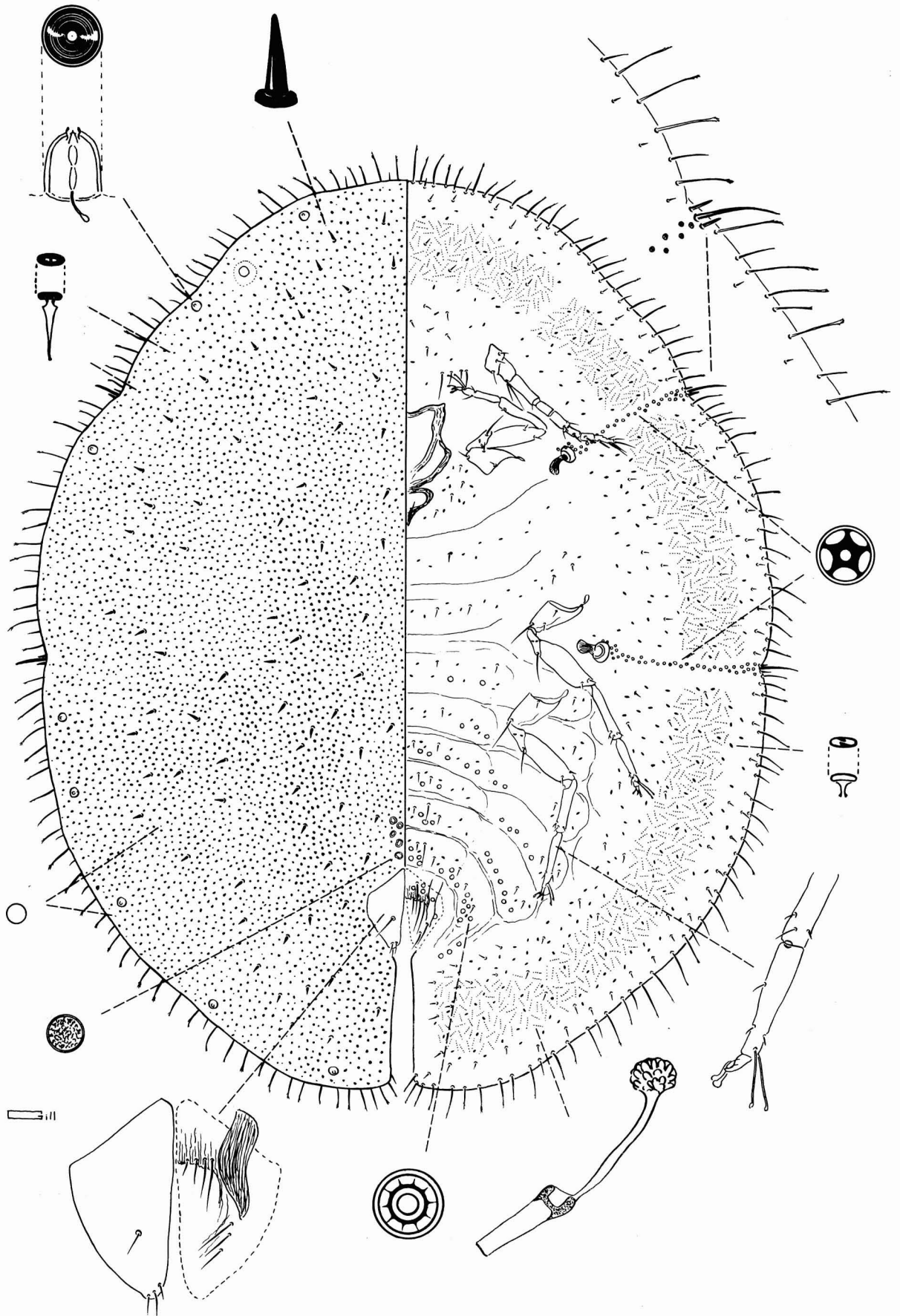


Fig. 44: *Saissetia miranda* (Cockerell & Parrott).

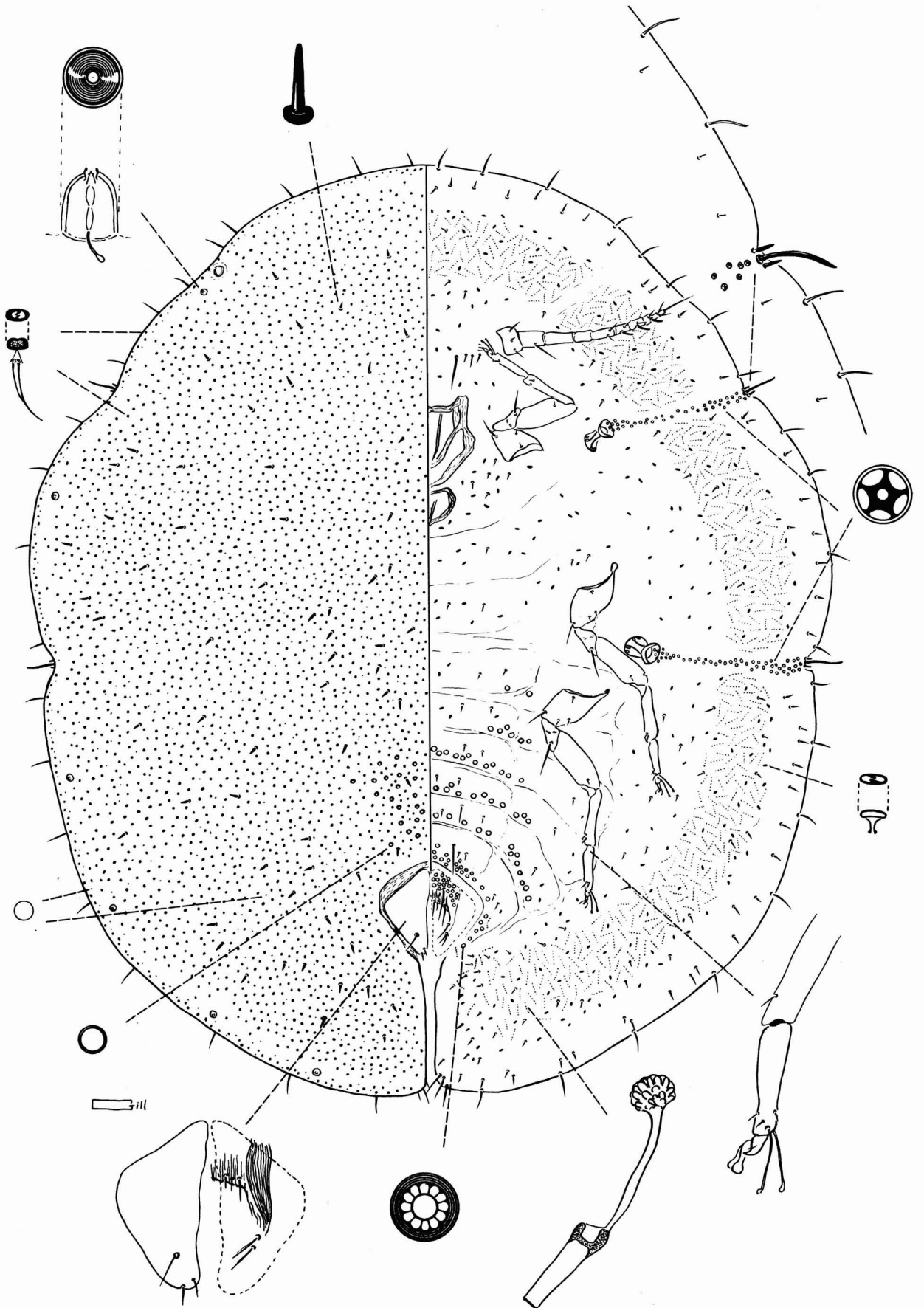


Fig. 45: *Saissetia oleae* (Olivier).

Genus *Toumeyella* Cockerell, 1895
The Tortoise Scales

These scales are large, strongly convex and often irregularly shaped because of elongate dorsal depressions. Most species in the United States are restricted to pines, but several are known from other hosts.

These scales are recognized morphologically by the reduced appendages, reduced or absent spiracular setae, normally 5-10 oculi multilocular pores on the abdomen and many apical setae on the opercula.

Most species are native to the New World, although some African forms, which are probably not congeneric, have been placed in this genus. Probably 9 nominate species actually belong in the genus.

KEY TO THE CALIFORNIA SPECIES OF *TOUMEYELLA*.

1. Occurring on conifers; 5-7 apical setae on each anal plate. *pinicola*
 Occurring on deciduous trees; 3-4 apical setae on each anal plate. *liriodendri*

***Toumeyella liriodendri* (Gmelin), 1789**
tuliptree scale (ESA approved)

Fig. 46, Color Plates 89, 90

Other Common Names:

tulip soft scale.

Synonymy:

- Coccus liriodendri* Gmelin,
- Lecanium liriodendri* (Gmelin),
- Eulecanium liriodendri* (Gmelin),
- Lecanium tulipiferae* Cook.

Field Characteristics: Adult females large, 4 to 10 mm long, very convex (hemispherical). Dorsal surface irregular with many depressions, particularly along the sides. Adults very colorful, generally grey or brown with pink, red, orange or green suffusions and irregular black spots. Older individuals more uniformly brown. Male puparia 2 to 3 mm long, flat and broadly oval. First instar and early second instar nymphs about 1 mm long, oval and chocolate brown. Nymphs are extremely difficult to see. Large colonies of this scale commonly have a distinctive, strong, musky odor.

Biology: One generation per year. Overwinters as small, second instar nymphs. Adults produce crawlers from August through November. Apparently biparental and ovoviparous. For more information see Donley and Burns (1965), Burns and Donley (1970) and Williams and Kosztarab (1972).

Similar Species: Adult females often confused with European fruit lecanium and calico scale. Color pattern is useful in separating these "Lecanium" scales from tuliptree scale. Also, tuliptree scale remains alive throughout summer, while the "Lecanium" group of scales are dead and dried out by late June. Females of tuliptree scale are ovoviviparous and do not form a cavity beneath the body nor do they incubate large numbers of eggs like the "Lecanium" scales. Magnolia scale, *Neolecanium cornuparvum* (Thro) is also similar to tuliptree scale and is a pest of *Magnolia* in the eastern states.

Hosts: Prefers tuliptree (yellow poplar), *Liriodendron tulipifera* and deciduous magnolias such as *Magnolia soulangeana*. Also attacks other plants in the genera *Magnolia*, *Michelia*, *Gardenia*, *Gordonia*, *Cephalanthus*, *Tilia* and *Juglans*, although its record on *Juglans* has been questioned.

Economic Importance: A serious pest of tuliptree in the east, particularly where tuliptree is grown commercially. Infested tulip trees in Sonoma and San Jose were severely injured before eradication of the scale. An extremely prolific species; females may produce up to 3,500 young and populations build to high levels rapidly. Scales cluster in large numbers on the limbs of the host, causing an unsightly wart-like appearance. Produces large amounts of honeydew and resulting sooty-mold; large populations will kill the host, particularly in the case of tuliptree. For more information on the economic importance of this species see Merrill (1953), Donley and Burns (1965) and Burns and Donley (1970). For information on natural enemies see Donley and Burns (1965), Burns and Donley (1970) and Williams and Kosztarab (1972).

Distribution: Currently under eradication in San Jose, Santa Clara and San Leandro, Alameda Counties. Previously it has been found in a number of locations in Santa Clara,

Alameda and Sonoma counties and in nurseries in other counties. Elsewhere it is found in the Midwest and in most states east of the Mississippi River. Native to eastern North America but described originally from Europe, apparently from introduced tuliptrees. **Diagnosis:** This is the only *Toumeyella* in California that is not found on pines. Morphologically recognized by having 3 spiracular setae and 3 dorsal anal plate setae. Magnolia scale, *Neolecanium cornuparvum* (Thro) which occurs in the eastern U.S., and tulip tree scale are quite similar morphologically but the dorsal surface of magnolia scale is uniformly covered with moderate sized 8-shaped pores and the ventral multilocular (5-loculi) pores are restricted to the posterior abdominal segments. *T. liriodendri* lacks large 8-shaped pores and has multilocular pores on most anterior abdominal segments.

Burns, D. P. and D. E. Donley, 1970: Ann. Entomol. Soc. Am. 63(1): 228-235.

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Williams, M. L. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div. Bull. 74: 1-215.

Toumeyella pinicola Ferris, 1920
irregular pine scale

Fig. 47, Color Plates 69, 72

Field Characteristics: Adult females 3 to 7 mm long, nearly round and moderately convex; the shape may be quite irregular or asymmetrical since the scales must often grow around the needle bases. Dorsal surface also normally irregular. Color mottled yellow-grey and brown, with some pinkish or orange suffused areas on the mid dorsal areas and a dark brown circular area around the anal plates. Older individuals become dark

brown. Females normally found on the stems of one-year-old growth. Immature males elongate, usually found on the needles.

Biology: One generation per year. According to Kattoulas and Koehler (1965), scales overwinter as mated, immature females; maturation and egg laying occurs in the spring and males emerge in August to mate with immature females. However, close observation of slide mounted specimens in the CDFA collec-

tion indicates that adult females mature in August, at the same time that adult males emerge and that the scales actually overwinter in the adult female stage. Crawlers may be active from February through May depending on climate and location. For more information see Kattoulas & Koehler (1965), Koehler et al. (1965), Brown & Eads (1967) and Furniss & Carolin (1977).

Similar Species: Monterey pine scale is similar but is more spherical, less irregular and darker. There are a number of pine infesting *Toumeyella* species known from the eastern states which cannot be separated from this species in the field. The pine tortoise scale, *Toumeyella parvicornis* (Cockerell) is quite similar to irregular pine scale and causes considerable injury to pines on the East Coast. There is also a similar undescribed species of *Toumeyella* known from four-needled pinyon, *Pinus quadrifolia*, in the desert areas of San Diego and Riverside counties and from one-needled pinyon, *Pinus monophylla*, in Inyo and Kern Counties.

Hosts: Restricted to pines. Found most commonly on Monterey pine, but found also on Bishop, knob cone, lodgepole, aleppo, Canary Island, Italian stone and mugo pines.

Economic Importance: Considered to be the most serious soft scale pest of pines in California. Severely weakens the trees, kills branches and sometimes kills young trees. Much honeydew and sooty mold is produced. For more on the economic importance of this scale see Burke (1932), Kattoulas and Koehler (1965), Koehler et al. (1965), Brown and Eads (1967) and Furniss and Carolin (1977). For information on natural enemies see Burke (1932).

Distribution: Common along, and usually restricted to the central coast and Southern

California, although the species has been moved to favorable inland locations on nursery stock. Ferris (1920) states that the species was introduced since it had never been noticed prior to 1920 on Monterey pines in their native habitat. Although the species has never been collected outside of California, Ferris may be correct in his assumption, particularly since there do not appear to be effective natural enemies present in California.

Diagnosis: This is the only conifer infesting *Toumeyella* species in California with three well differentiated, subequal spiracular setae and 5-7 apical setae on each anal plate. One or 2 other species of *Toumeyella*, possibly undescribed, also occur on pines in California. They differ from *T. pinicola* by having fewer apical setae on each anal operculum, fewer multilocular pores in the spiracular furrows and thickened, lanceolate dorsal body setae. A key to the eastern species of *Toumeyella* occurring on pines will be found in Williams and Kosztarab (1972).

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 Burke, H. E., 1932: Calif. Dep. Agric. Mon. Bull. 21: 358-369.
 Ferris, G. F., 1920: Stanford Univ. Publ. Univ., Ser., Biol. Sci. 1(1): 1-57.
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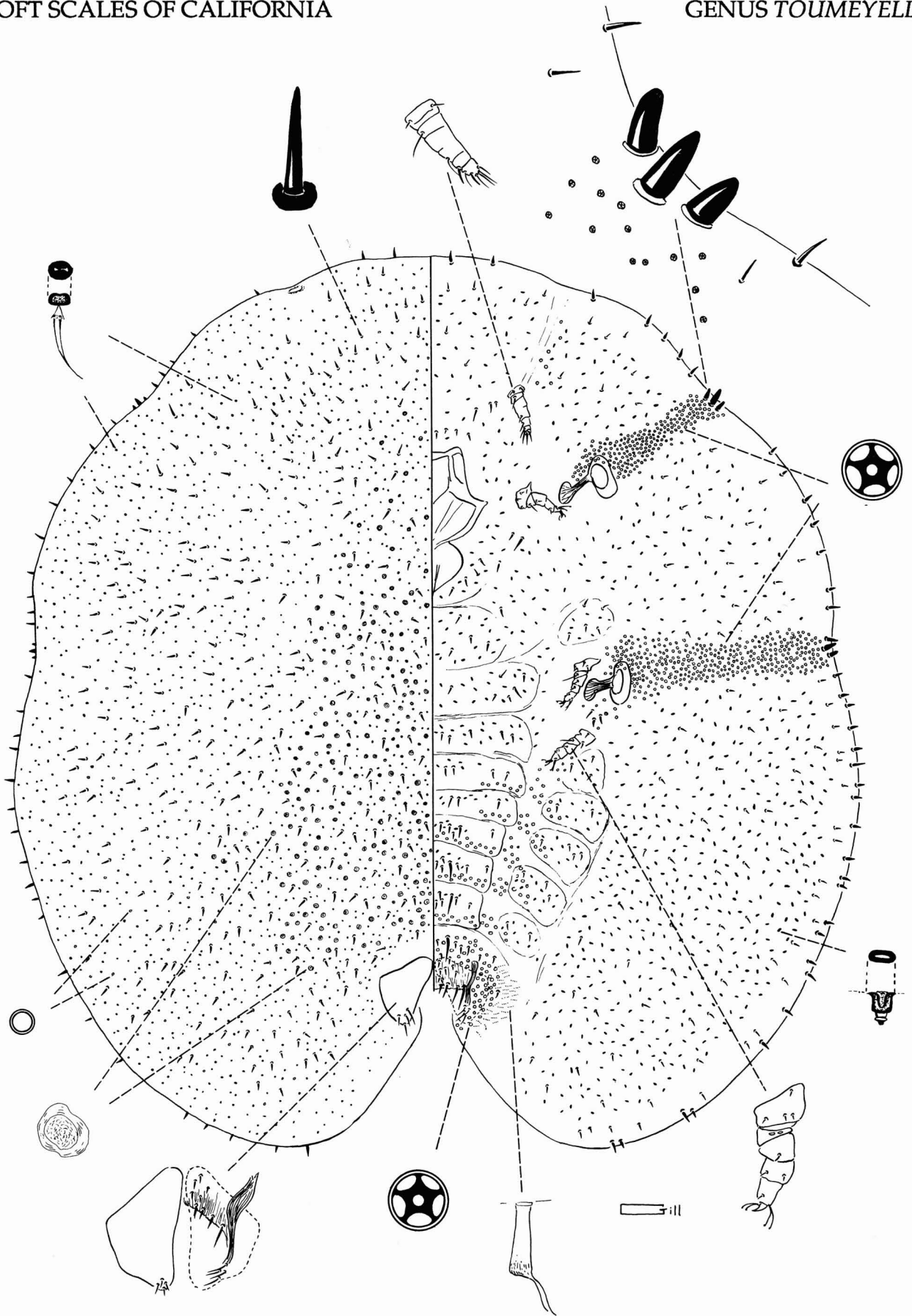


Fig. 46: *Toumeyella liriodendri* (Gmelin).

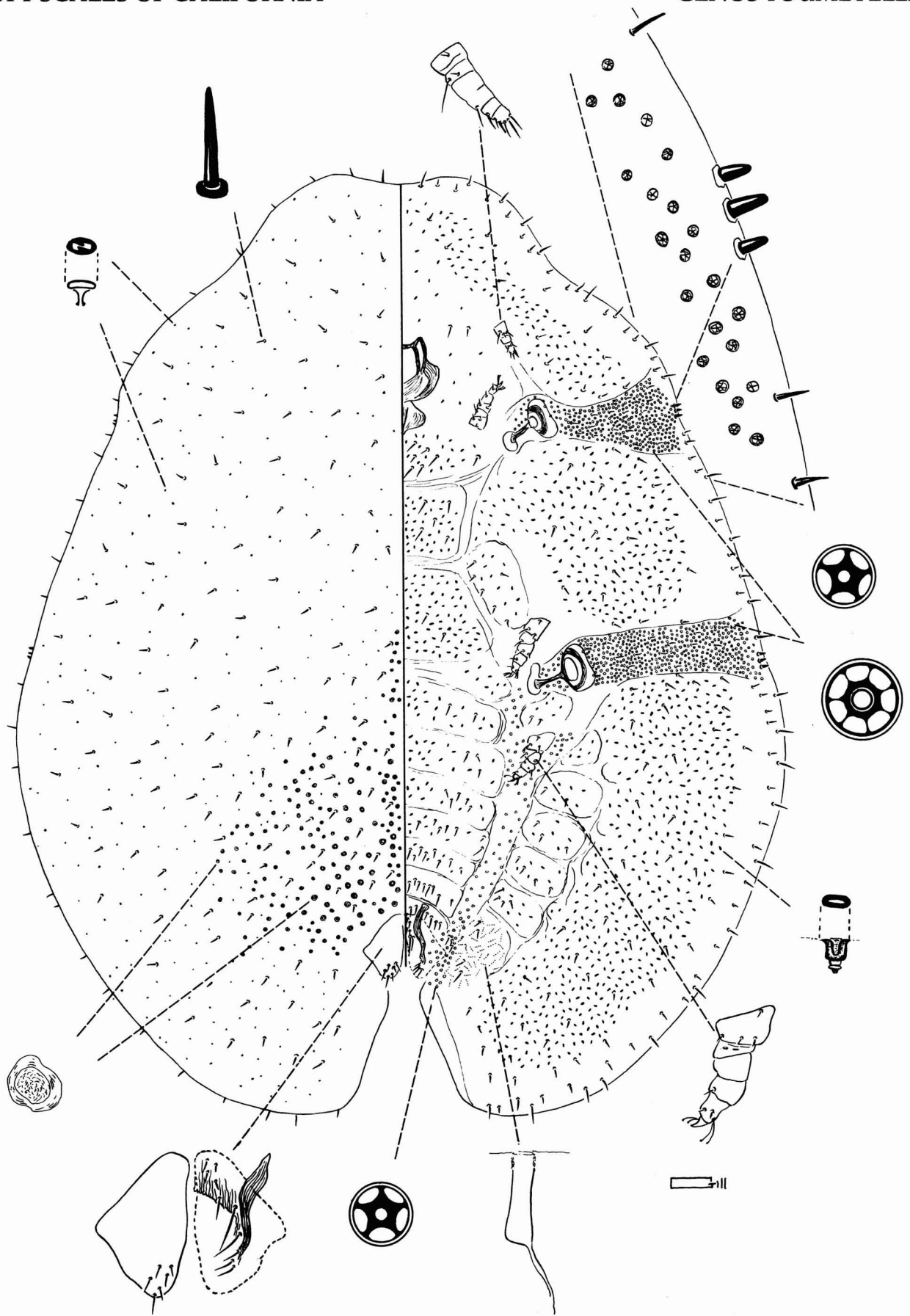


Fig. 47: *Toumeyella pinicola* Ferris.

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COLLECTION DATA FOR MORPHOLOGICAL FIGURES

3. *Ceroplastes cirripediformis*, Lahaina, Maui, Hawaii, XI-3-72, no host data, E. L. Paddock collector.
4. *Ceroplastes cistudiformis*, San Diego, San Diego County California, I-21-76, ex *Solandra*, Bock and Rhys collectors.
5. *Ceroplastes irregularis*, Bishop, Inyo County California, X-4-73, ex *Eurotia lanata*, E. L. Paddock collector.
6. *Ceroplastes sinensis*, Milpitas, Santa Clara County California, VI-20-72, ex *Ilex cornuta*, Ehmann collector.
7. *Coccus hesperidum*, data not available.
8. *Coccus longulus*, Mountain View, Santa Clara County California, XII-4-73, ex *Acacia longifolia*, C. S. Koehler collector.
9. *Coccus pseudoesperidum*, Berkeley, Alameda County California, XI-15-43, ex *Cymbidium*, G. B. Laing collector.
10. *Coccus pseudomagnoliarum*, Hemet, Riverside County California, IV-15-71, ex *Citrus*, H. Cook et al collectors.
11. *Eriopeltis festucae*, data not available.
12. *Eucalymnatus tessellatus*, Montecito, Santa Barbara County California, I-28-65, ex *Rhopalostylis baueri*, Beevors and Nickerson collectors.
13. *Eulecanium caryae*, Indianapolis, Indiana, VII-52, ex elm, P. Ulman collector.
14. *Eulecanium cerasorum*, Sacramento, Sacramento County California, III-9-64, ex *Juglans*, M. Scribner collector.
15. *Eulecanium excrescens*, Lake Temescal, Alameda County California, III-21-46, ex plum, H. L. McKenzie collector.
16. *Eulecanium kunoense*, San Jose, Santa Clara County California, IV-21-72, ex *Pyracantha*, C. Insalaco.
17. *Eulecanium tiliae*, St. Helena, Napa County California, II-28-74, ex *Cornus*, Thorp collector.
18. *Luzulaspis caricis*, Mt. Shasta, Siskiyou County California, IX-3-01, ex *Carex breweri*, E. M. Ehrhorn collector.
19. *Luzulaspis minima*, Eagle Lake, Tulare County California, VIII-26-46, ex *Carex*, G. F. Ferris collector.
20. *Metapulvinaria lycii*, Cameron, Kern County California, VII-1-81, ex *Lycium cooperi*, D. Poore collector.
21. *Parasaissetia nigra*, Sacramento, Sacramento County California, X-27-76, ex *Ficus decora*, P. Siebert and C. Mellor collectors.
22. *Parthenolecanium corni*, Modesto, Stanislaus County California, IV-12-83, ex *Pistachio*, collector unknown.
23. *Parthenolecanium fletcheri*, San Rafael, Marin County California, IV-22-63, ex *Taxus*, R. Garvey collector.
24. *Parthenolecanium persicae*, Sacramento, Sacramento County California, III-21-64, ex *Daphne*, T. B. Gallion collector.
25. *Parthenolecanium pruinosum*, Linden, San Joaquin County California, IV-8-67, ex walnut, A. E. Michelbacher and H. L. McKenzie collectors.
26. *Parthenolecanium quercifex*, Sacramento, Sacramento County California, IV-11-75, ex *Quercus palustris*, R. J. Gill collector.
27. *Philephedra ephedrae*, Wrightwood, Los Angeles County California, VII-7-65, ex *Ephedra*, W. Dyer collector.
28. *Physokermes concolor*, Douglas City, Trinity County California, V-21-63, ex *Abies concolor*, R. F. Wilkey collector.
29. *Physokermes hemicryphus*, Niles, Alameda County California, V-8-58, ex *Picea*, F. Duffie et al collectors.
30. *Physokermes insignicola*, Fremont, Alameda County California, V-9-62, ex *Pinus*, M. Hansen collector.
31. *Physokermes taxifoliae*, Sonoma, Sonoma County California, IV-73, ex fir, J. Sallee collector.
32. *Protopulvinaria, pyriformis*, Pacific Palisades, Los Angeles County California, II-26-65, ex *Persea americana*, A. Beresford and D. Estes collectors.
33. *Pulvinaria bigeloviae*, Spring Garden, Plumas County California, VI-4-63, ex *Chrysothamnus*, T. R. Haig collector.
34. *Pulvinaria citricola*, College Park, Maryland, V-74, ex *Pyracantha*, M. Stoetzel collector.
35. *Pulvinaria delottoi*, Oakland, Alameda County California, XI-7-73, ex *Mesembryanthemum*, R. Dunkle.
36. *Pulvinaria floccifera*, Sebastopol, Sonoma County California, IV-30-69, ex *Pittosporum*, Leuconen and McCracken collectors.
37. *Pulvinaria hydrangeae*, San Jose, Santa Clara County California, V-2-66, ex *Hydrangea*, M. Cottle collector.
38. *Pulvinaria innumerabilis*, Berwyn Heights, Maryland, XII-11-68, ex tuliptree, C. W. McComb collector.
39. *Pulvinaria mesembryanthemi*, Napa, Napa County California, X-24-73, ex *Mesembryanthemum*, P. S. Crane collector.
40. *Pulvinaria phaiaae*, Quarantine from New York, V-18-36, ex orchid, Williams and Caldwell collectors.
41. *Pulvinaria rhois*, Mountain View, San Mateo County California, no date, ex *Rhus diversiloba*. (probably type material)
42. *Pulvinaria vitis*, Petaluma, Marin County California, V-2-67, ex *Populus nigra*, H. Lange and H. Michalk collectors.
43. *Saissetia coffeae*, Sacramento, Sacramento County California, VI-7-67 ex *Dicksonia*, P. Siebert collector.

44. *Saissetia miranda*, El Centro, Imperial County California, I-7-78, ex fig, R.A. Flock collector.
45. *Saissetia oleae*, W. Sacramento, Yolo County California, VIII-27-68, ex mistletoe in ash, Eiler and Payne collectors.
46. *Toumeyella liriodendri*, San Jose, Santa Clara County California, IX-6-62, ex tuliptree, Prado and Smith collectors.

COLLECTION DATA FOR COLOR PLATES

1. *Coccus hesperidum*, Sacramento, Sacramento County, California, V-9-63, ex Omoto?.
2. *Coccus hesperidum*, Mission, Texas at La Habra, California, 1-28-82, ex *Ficus benjamina*, C. Robertson collector.
3. *Coccus hesperidum*, Willows, Glenn County California, 3-24-80, ex *Laurus nobilis*, G. Stenlund collector.
4. *Coccus hesperidum*, same as 3.
5. *Coccus hesperidum*, same as 3.
6. *Coccus hesperidum*, same as 3.
7. *Coccus hesperidum*, same as 3.
8. *Coccus hesperidum*, same as 3.
9. *Coccus pseudoheperidum*, ex vanda orchid, no other data.
10. *Coccus pseudomagnoliarum*, Chico, Butte County California, IV-24-79, ex *Citrus*, Dodd collector.
11. *Coccus pseudomagnoliarum*, Fresno, Fresno County California, 1-21-80, ex *Citrus*, N Smith collector.
12. *Coccus longulus*, Chula Vista, San Diego County California, XI-23-71, *Acacia latifolia*, Beker and Paddock collectors.
13. *Ceroplastes irregularis*, Fresno, Fresno County California, II-27-75, ex *Atriplex polycarpa*, A. Gilbert et al collectors.
14. *Ceroplastes irregularis*, same as 13.
15. *Coccus longulus*, Mountain View, Santa Clara County California, XII-4-73, ex *Acacia longifolia*, C. Koehler collector.
16. *Ceroplastes cirripediformis*, Sacramento, Sacramento County California, III-25-86, ex *Maytens*, S. Zukin collector.
17. *Ceroplastes sinensis*, Fremont, Alameda County, California, IV-6-72, ex *Schinus molle*, Henning collector.
18. *Ceroplastes sinensis*, San Jose, Santa Clara County California, I-9-79, ex lemon, Dickson and Gonzales collectors.
19. *Ceroplastes cistudiformis*, Vista, San Diego County California, IV-11-74, *Beloperone guttata*, Jespersion collector.
20. *Ceroplastes cirripediformis*, Visalia, Tulare County California, VIII-8-74, ex *Photinia*, Thomas et al collectors.
21. *Coccus pseudomagnoliarum*, data not available.
22. *Eulecanium cerasorum*, data not available.
23. *Ceroplastes sinensis*, Fremont, Alameda County, California, IV-6-72, ex *Schinus molle*, Henning collector.
24. *Ceroplastes sinensis*, same as 23.
25. *Eulecanium tiliae*, Portland, Oregon at Nevada City, California, I-30-76, ex *Cornus rubra*, E. Gunderson collector.
26. *Parthenolecanium corni*, photographed IV-27-72, no other data.
27. *Parthenolecanium corni*, no data available.
28. *Parthenolecanium corni*, Sutter's Fort, Sacramento County California, IV-23-79, ex toyon, R. Gill and R. Harris collectors.
29. *Parthenolecanium persicae*, Menlo Park, Alameda County California, II-19-63, ex *Daphne*, R. P. Allen and D. R. Taylor collectors.
30. *Parthenolecanium persicae*, same as 29.
31. *Parthenolecanium quercifex*, Fairfield, Solano County California, IV-19-79, ex oak, Caruso collector.
32. *Parthenolecanium quercifex*, same as 31.
33. *Parthenolecanium quercifex*, same as 31.
34. *Eulecanium kunoense*, Sacramento, Sacramento County California, III-10-78, ex plum, P. S. Crane collector.
35. *Eulecanium kunoense*, Sacramento, Sacramento County California, III-22-78, ex plum, P. S. Crane collector.
36. *Eulecanium kunoense*, same as 35.
37. *Eulecanium tiliae*, same as 25.
38. *Eulecanium tiliae*, same as 25.
39. *Eulecanium tiliae*, same as 25.
40. *Eucalymnatus tessellatus*, Hawaii at Santa Barbara, California, I-4-82, ex raphis palm, Piper and Roberts collectors.
41. *Eulecanium cerasorum*, San Jose, Alameda County California, I-30-80, ex flowering magnolia, Bejarano collector.
42. *Eulecanium cerasorum*, Sacramento, Sacramento County California, IV-1-81, ex *Liquidambar*.
43. *Eulecanium excrescens*, Monroe, Benton County Oregon, III-81, ex *Pyracantha*, R. Westcott and R. Long collectors.
44. *Eulecanium excrescens*, same as 43.
45. *Eulecanium excrescens*, Portland, Oregon, V-12-80, ex flowering magnolia, R. Furniss collector.
46. *Saissetia oleae*, Sacramento, Sacramento County California, IV-17-80, ex *Nerium oleander*, R. J. Gill

SOFT SCALES OF CALIFORNIA

- collector.
47. *Physokermes taxifoliae*, Muscovite Corners, Napa County California, IV-14-79, ex Douglas fir, C. and T. Kono collectors.
 48. *Pulvinaria floccifera*, E. Sacramento, Sacramento County California, III-21-63, ex *Pittosporum*, M. Scribner collector.
 49. *Parasaissetia nigra*, no data.
 50. *Protopulvinaria pyriformis*, no data.
 51. *Saissetia coffeae*, Yreka, Siskiyou County California, VIII-12-77, ex spider plant, J. Kincaid collector.
 52. *Parthenolecanium fletcheri*, Tulelake, Modoc County California, VI-12-62, ex *Arborvitae*, T. Haig collector.
 53. *Eulecanium kunoense*, no data.
 54. *Parthenolecanium prunosum*, no data, probably San Joaquin County California, see text.
 55. *Physokermes taxifoliae*, same as 47.
 56. *Metapulvinaria lycii*, Cameron, Kern County California, VII-11-81, ex *Lycium cooperi*, D. Poore collector.
 57. *Metapulvinaria lycii*, same as 56.
 58. *Physokermes taxifoliae*, same as 47.
 59. *Physokermes concolor*, Sciott's Tract, El Dorado County, California, VI-21-76, ex fir, M. Scribner collector.
 60. *Physokermes hemicyphus*, San Mateo, San Mateo County California, V-3-68, ex *Picea pungens*, W. Davis collector.
 61. *Physokermes insignicola*, Albany, Alameda County California, II-26-80, ex Bishop pine, Whitaker and Langston collectors.
 62. *Physokermes insignicola*, same as 61.
 63. *Protopulvinaria pyriformis*, San Diego, San Diego County California, V-9-78, ex ivy, Pickett and Barefoot collectors.
 64. *Saissetia oleae*, Sacramento, Sacramento County California, no date, ex ash, R.J. Gill collector.
 65. *Saissetia miranda*, El Centro, Imperial County California, I-17-78, ex fig, R. Flock collector.
 66. *Saissetia miranda*, same as 65.
 67. *Saissetia oleae*, Sonoma, Sonoma County California, I-13-77, ex *Magnolia soulangeana*.
 68. *Saissetia oleae*, same as 67.
 69. *Toumeyella pinicola*, Santa Rosa, Sonoma County California, II-25-81, ex pine, Bradbury and West-off collectors.
 70. *Saissetia coffeae*, same as 51.

COLLECTION DATA

71. *Saissetia coffeae*, Ireland at Lodi, California, V-5-77, ex *Dieffenbachia*, M. Croce collector.
72. *Toumeyella pinicola*, Campbell, Santa Clara County California, IX-13-77, ex Monterey pine, D. Bass collector.
73. *Pulvinaria innumerabilis*, Lost Hills, Kern County California, IV-10-86, ex *Pistacio*, Castero and Flaherty collectors.
74. *Pulvinaria innumerabilis*, Riverbank, Stanislaus County California, V-13-85, ex grape, Macedo collector.
75. *Pulvinaria innumerabilis*, Dorris, Siskiyou County California, I-30-81, ex *Crataegus*, I. Schreiber collector.
76. *Pulvinaria floccifera*, Crescent City, Del Norte County California, V-6-80, ex *Camellia*, Trujillo collector.
77. *Pulvinaria vitis*, Petaluma, Marin County California, V-2-62, ex *Populus nigra*, H. Michalk collector.
78. *Pulvinaria vitis*, Monroe, Benton County Oregon, IV-7-81, ex *Pyracantha*, R. W. Long collector.
79. *Pulvinaria floccifera*, same as 76.
80. *Pulvinaria bigeloviae*, Likely, Modoc County California, V-23-63, ex *Chrysothamnus parryi*, T. Haig collector.
81. *Pulvinaria bigeloviae*, Bishop, Inyo County California, IV-15-81, ex *Chrysothamnus*, R. J. Gill collector.
82. *Pulvinaria mesembryanthemi*, Ft. Ross, Sonoma County California, X-3-84, ex iceplant, Breckenridge and Vernon collectors.
83. *Pulvinaria mesembryanthemi*, same as 82.
84. *Pulvinaria mesembryanthemi*, Oakland, Alameda County California, ex iceplant, J. Washburn collector.
85. *Pulvinaria mesembryanthemi*, probably Napa, Napa County California, courtesy J. Joos and C. S. Koehler.
86. *Pulvinaria delottoi*, San Jose, Santa Clara County California, I-5-78, ex *Mesembryanthemum*, Fontana collector.
87. *Pulvinaria delottoi*, Oakland, Alameda County California, X7-73, ex *Mesembryanthemum*, R. Dunkle collector.
88. *Pulvinaria delottoi*, same as 86.
89. *Toumeyella liriodendri*, San Leandro, Alameda County California, V-25-82, ex deciduous magnolia, R. Bingham and E. Whitaker collectors.
90. *Toumeyella liriodendri*, no data.

COLLECTION AND PRESERVATION TECHNIQUES

The common method of collecting scale insects is to place them in alcohol in the field. The California Department of Food and Agriculture uses 70% isopropyl alcohol for this purpose. However, soft scales do not preserve well in alcohol and become very difficult or impossible to clear properly. They are best collected by removing an infested part of the host, which is then allowed to dry naturally. Steps should be taken to suppress mold growth.

In order to be preserved and identified properly, soft scales must be cleared completely by removing the internal body contents, leaving only the exo-skeleton and appendages intact. Specimens are then stained and placed on microscope slides for study under high magnifications. All of the slide mounted specimens used in producing the morphological illustrations used in this book are preserved in Canada balsam. Balsam is the current standard permanent mounting medium for scale insects. Euparal is another acceptable permanent medium. Temporary media such as Hoyer's or polyvinyl alcohol (PVA) are also used for less important specimens or when rapid determinations are required.

Specimens should be cleared first in potassium hydroxide (10%) or a combination of potassium hydroxide and Essig's aphid fluid (20 parts 85% lactic acid; 2 parts liquified phenol; 4 parts glacial acetic acid; 1 part distilled water). The specimens are usually stained with either acid fuchsin, lignin pink or a combination of the two. The following clearing-staining procedure is currently used for soft scales in the California Department of Food and Agriculture Homoptera Laboratory. The procedure has been developed and modified over the years by numerous individuals including Harold Morrison, Richard Wilkey, Tokuwo Kono and the author. The procedure is not a rigid one and is often modified to suit conditions.

SLIDE MOUNTING PROCEDURE FOR SOFT SCALES

1. Prepare several small tools from stainless steel insect pins which can be flattened and bent at various angles to form spatulas. The spatula shapes allow easy pumping of the scale to remove the liquified body contents and allow easy transferring of the specimens from one reagent to another.
2. If not already in alcohol, remove specimens gently from the host substrate and place in clean 70% isopropyl alcohol. (Alcohol is necessary here because the body waxes of the soft scales would cause them to float in the surface tension of plain water.) Make a small midlateral incision on one side of the scale body. Remove immediately to potassium hydroxide (KOH).
3. Soak specimens in cold 10% KOH for 1 to 24 hours. DO NOT HEAT. Specimens may be pumped and teased lightly during this step to aid in the clearing process. Fresh specimens are usually cleared adequately in 1 to 2 hours.
4. Remove to isopropyl alcohol to aid in neutralizing the KOH. Let stand for 5-15 minutes.
5. Place in Essig's aphid fluid (EAF) containing several drops of the preferred staining agent. Let stand for 10-15 minutes to further neutralize the KOH. Heat at 50°C. for 1 to 24 hours. Move to clean, new, unstained EAF. Tease and pump specimens until as clear as possible. Re-heat for 1 hour if necessary.
6. Place specimens in cellosolve (ethylene glycol monoethyl ether) for removal of all of the EAF and for dehydration of the specimens prior to placing in balsam.
7. Place specimens in tetrahydrofuran (THF), a wax solvent, for five minutes if necessary.
8. Place specimens in a drop of balsam on a microscope slide and add a cover glass.

PHOTOGRAPHIC TECHNIQUES

The color plates included in this volume were produced primarily by the author. However, Tokuwo Kono and George Buxton supplied a number of the pictures of soft scales collected prior to 1972. Those pictures were produced with standard 35 mm format single lens reflex cameras with close up lenses and bellows attachments.

All of the author's pictures, except plate 64, were produced in a different manner. The pictures were taken through a Wild M-5 stereo microscope with a Zeiss C-35 camera attachment. Illumination was by electronic strobe. Film is Kodachrome 25 color slide film. Magnifications of the author's photographs range from 1.5X to 12X magnification on the 35 by 24 mm film plane. The pictures were then enlarged to the 65 by 54 mm format used in this volume.

ILLUSTRATION AND PAGE LAYOUT TECHNIQUES

Morphological illustrations 3-47 were drawn from actual slide mounted specimens. Specimens were chosen which had at least one half of the body intact and generally not noticeably distorted. The specimen slide was placed on a Bausch and Lomb bioscope slide projector. The image of the specimen was then projected onto the drawing surface. Magnifications varied with each specimen and are not to scale since each illustration had to fit a certain page size. Soft scale body shapes and sizes change so drastically in relation to other constant sclerotized body structures as legs and mouth parts that proportional scaling is not possible. Each full size drawing contains the ventral aspect on the right side and the dorsal aspect on the left.

The illustrations in Figure 1 were scanned into a Macintosh Plus™ computer via Thunderware's Thunderscan™ and re-drawn using Adobe's Illustrator™. The typesetting and layout were done on the Macintosh using Aldus Pagemaker 2.0a™. Printing was done on an Apple Laser Writer Plus™.

KEY TO CALIFORNIA SOFT SCALES BASED ON HOST

A complete host listing for the soft scales of California does not exist. The following host chart was originally designed to aid in field recognition of soft scale species based on groups of hosts. The chart is reproduced here with the hope that it will alleviate to a certain extent the lack of such a listing. The host chart should also provide an easy-to-use guide to the TENTATIVE field identification of California soft scales. Field determinations should be considered tentative for the following reasons:

1. Positive identifications of soft scales require complex laboratory procedures and should be made only by a qualified taxonomist.
2. Soft scales vary drastically in size, shape and color depending on the age and condition of the specimens.
3. Not all California soft scales are represented in this field key, check also the host index for other species that might be found on these particular hosts.
4. This key should not be used in an attempt to identify species intercepted in quarantine because many other similar species occur outside of California.

Tentative field determinations of soft scales can be accomplished more easily by first realizing that certain plants or types of plants may have a specific group of soft scales that will be found on them. Therefore, if one studies the types of plants listed in the following chart and compares field specimens with the photographs of soft scale species included in this book, field determinations may be made more quickly and accurately. Remember however that some species of soft scales such as brown soft scale and black scale are highly polyphagous, feeding on many host plants. Therefore they may not necessarily be listed for certain hosts either here or in the text. If a species is known to be polyphagous, it is so designated in the text.

Citrus

brown soft scale
citricola scale
black scale
hemispherical scale
barnacle scale
Chinese wax scale
nigra scale
pyriform scale

Ornamentals (Evergreen)

brown soft scale
black scale
Chinese wax scale
barnacle scale
tortoise wax scale
pyriform scale
cottony camellia scale
cottony hydrangea scale
long brown scale

Ornamentals (Deciduous)

European fruit lecanium
calico scale
black scale
thorn scale
cottony maple scale
excrescent scale

General Fruit and Nut Crops

(Prunus, Malus, Pyrus, Juglans)

European fruit lecanium
frosted scale
Kuno scale
cottony vine scale
cottony maple scale
fruit tree pulvinaria

Olive

black scale

Pine, Fir, Spruce

irregular pine scale
Monterey pine scale
spruce bud scale
Douglas fir scale
fir bud scale

Tuliptree and Deciduous Magnolia

European fruit lecanium
calico scale
black scale
tuliptree scale

Oak

oak lecanium

Ornamentals (Indoors)

brown soft scale
hemispherical scale
Mexican black scale

Arborvitae and Yew

Fletcher scale

Acacia and Carob

long brown scale

Desert Shrubs

cottony sagebrush scale
irregular wax scale
lycium soft scale

Other Native Shrubs

(Madrone, Ceanothus, Toyon)

European fruit lecanium

Iceplant

iceplant scale
DeLotto ice plant scale

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<i>Atriplex</i> ,	20	<i>Hibiscus</i> ,	55	plum,	41, 43, 91, 92
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<i>Baccharis</i> ,	21	hydrangea,	88	pome fruits,	64
<i>Beloperone</i> ,	19	<i>Hymenoclea</i> ,	85	<i>ponderosa, Pinus</i> ,	74
<i>Bigelovia</i> ,	85	iceplant,	86, 89,128	poplar,	92
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19, 21, 30, 58, 86, 87, 104,128		<i>monophylla, Pinus</i> ,	75	<i>Solanum</i> ,	55
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(Emboldened text represents currently used suggested common names or current Entomological Society of America approved common names. Standard text represents historical common names no longer in use).

arborvitae soft scale,	62	cottony vine scale,	92	long brown scale,	28
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brown elm scale,	60	elongate soft scale,	28	New York plum scale,	60
brown fruit scale,	60	ephedra scale,	71	nigra scale,	57
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brown scale,	44, 60	European fruit lecanium,	44	oak lecanium,	65
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calico scale,	41	excrecent scale,	42	orchid soft scale,	28
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