A SURVEY OF ARTHROPOD PESTS IN OKLAHOMA GREENHOUSES IN FALL, WINTER, AND SPRING

by

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A SURVEY OF ARTHROPOD PESTS IN OKLAHOMA GREENHOUSES IN FALL, WINTER, AND SPRING

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PREFACE

It was brought to the authors attention by Dr. R. R. Walton, Professor of Entomology, that research work was needed on the different species of greenhouse pests encountered in greenhouses in Oklahoma. Since control measures often vary for different species, it was desirable that the more prevalent species be identified. In consideration of these conditions, the author selected as a thesis problem a survey of the arthropod pest species present in greenhouses and control materials and methods used against them.

The principal results presented in this paper are data on the identity of the more common and injurious species which included mites, aphids, scales, and mealybugs.

Although the information obtained is incomplete, the author believes that it can serve as a partial base for further research on the control of greenhouse pests in Oklahoma.

The author wishes to express his sincere appreciation to the staff members of the Department of Entomology who have made contributions to this project: Dr. R. R. Walton, my major adviser, for his thoughtful and helpful guidance in planning the survey and in preparing the thesis; Dr. W. A. Drew who aided in identification and assisted in preparation of the manuscript; Dr. D. E. Howell and Professor G. A. Bieberdorf, Entomology; Dr. H. I. Featherly, Botany; Dr. R. P. Ealy and Professor Richard N. Payne, Horticulture, for their helpful suggestions in the composition

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The author would also like to express his appreciation to Mr. Albert C. Apt, fellow graduate student, who prepared and identified the scale insects. For their able assistance, special thanks is given to Adair Stoner, Plant Pest Control Division, ARS, U.S.D.A., to Horace W. Van Cleave, State Survey Entomologist, and Robert T. Taylor, graduate student, who collected material from various parts of the state, and to Branley A. Branson, graduate student in Zoology, who identified the slugs.

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CHAPTER I

INTRODUCTION

Throughout the State of Oklahoma arthropod pests have long been a serious problem to greenhouse operators. Prior to this study, little information had been compiled concerning the major pest species involved. Strict legal regulations and the losses resulting from these pests have resulted in emphasis being placed on their identification and control.

Weigel (1919) reported that the annual loss due to insect attack on ornamentals under glass in the United States was estimated at 10 per cent of the value of the crops. Compton (1930) states that in Illinois the total damage done by insects and other injurious forms of animal life is estimated to range from 10 per cent to 25 per cent of the value of all the flowers and ornamentals grown under glass. Losses caused by these pests at the present time appear to be equal to or greater than in earlier years.

This paper is based on the identification and number of greenhouse pests collected, observations on pest conditions in greenhouses, and the author's interviews with greenhouse operators. Information presented in this paper includes taxonomic keys, taxonomic descriptions, incidence and distribution of pest species and a summary of greenhouse operators' reports on pest problems.

CHAPTER II

REVIEW OF LITERATURE

One of the earlier surveys of greenhouse pests was made by Weigel (1919). He listed more than sixty different kinds of pests infesting greenhouses. Plants most commonly attacked by these pests in order of importance were roses, orchids, chrysanthemums, ferns, and carnations. Compton (1930) made a similar study in Illinois extending over a period of seven years. Over one hundred and thirty-five greenhouse pests were included in his list. Chrysanthemums were found to be the most susceptible to serious damage by the largest number of pests. More than two dozen kinds of pests were observed to attack chrysanthemums.

In the state of Michigan, McDaniel (1931) listed numerous species of aphids, mites, mealybugs, scales, thrips, and various types of lepidopterous larvae as important pests of greenhouses.

One of the more recent and complete works on greenhouse pests was done by Pritchard (1949) in the State of California. He listed thirty-six groups of pests including 161 species. All but five of these groups were insects. Some of the more important groups and number of species found in each were: armored scales, 27; soft scales, 12; aphids, 24; thrips, 14; mealybugs, 9; red spider mites, 5; and whiteflies, 5. Red-spider mites and mealybugs were considered the most serious pests of ornamental plants.

Gesell et al. (1951) made the most recent exhaustive survey of literature. He listed 21 greenhouse pests which were commonly found in greenhouses in the State of Pennsylvania. These pests were listed in their respective groups and not identified as to species. Red spider or the two-spotted spider mite was found to be the most destructive pest.

Smith (1953) listed some of the early methods which were used in the control of greenhouse pests. These included cleaning out infested plant material, syringing with water, spraying with lime sulfur and common salt, and the use of glue in water to stick the mites to the foliage.

Other early pesticides used were lead arsenate, nicotine oleate, sulfur and HCN (hydrocyanic-acid gas) (Weigel et al. 1919). Since this time much has been done in the research of greenhouse pests.

From 1929 to 1947 many acaricides have been reported by research workers. Some of these were naphthalene flakes used as a fumigant, derris and rotenone used as sprays and selenium compounds used as a systemic (Smith, 1952).

In 1947 the first aerosols containing organic phosphates became available. The material first produced was TEPP (tetraethyl pyrophosphate) which controlled mites, aphids, whiteflies, and mealybugs without injuring foliage or flowers. This material was followed by parathion (O, O-diethyl-O-p-nitrophenyl thiophosphonate) in 1948 (Smith, 1952).

From 1948 to the present time miticides such as Aramite (2-[p-tert-butylphenoxy]-isopropyl-2-chloroethyl sulfite), Chlorobenzilate (ethyl 4, 4-dichlorobenzilate), demeton (O, O-diethyl[2-ethylmercaptoethyl] thiophosphate, a mixture of thiona and thiol isomers), sulfotepp (O,O,O,O,-tetraethyl dithiono pyrophosphate), Ovotran (p-chlorophenyl-p-chlorobenzene sulfonate), malathion (O, O-dimethyl dithiophosphate of diethyl

mercaptosuccinate) and sodium selenate have been recommended for the control of mites. The same materials have also been used effectively against mealybugs, scales, aphids, and other greenhouse pests (Purdue, 1954).

Dickinson (1958) listed three other miticides which have commonly been used. They are Guthion (O, O-dimethyl S-[4-oxo-1,2,3,-benzotriazinyl-3-methyl] phosphorodithioate), Tedion (2,4,5,4-tetrachloro diphenylsulphone) and endrin (1,2,3,4,10,10 herachloro-6,7-epoxy-1,4,4a,5,6,7,8, 8a-octahydro-1, 4-endo-endo-5,8-dimethanonaphtralene).

Some of the newer pesticides which have recently been introduced to the market are Mitox (p-chlorobenzyl p-chlorophenyl sulfide), Phosdrin (1-methoxycarbonyl-1-propen-2-yl-dimethylphosphate) and Trithion (S-[p-chlorophenylthio] methyl diethyl phosphorodithioate) (Ohio, 1959).

Pesticides used for other greenhouse pests are lindane (gamma isomer of benzene hexachloride), dieldrin (1,2,3,4,10,10-hexachloro-6,7,-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethano-naphthalene), DDT (2,2-bis- [p-chlorophenyl] -1,1,1-trichloroethane), chlordane (1,2,4,5,6,7, 8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene), Diazinon (O, O-diethyl O- [2-isopropyl-4-methyl-6-pyrimidinyl] phosphorothioate) and metaldehyde (metaacetaldehyde) (Ohio, 1959).

CHAPTER III

METHODS AND MATERIALS

Collections in greenhouses were made by two types of personnel during the period of September 20, 1958 to April 15, 1959. Eight inspectors of the State Board of Agriculture collected a total of 118 samples from 24 towns or cities. The author collected 77 samples from 18 towns or cities, making a combined total of 195 samples collected.

Figure 1 shows the locations of 39 cities and towns in which greenhouse pests collections were recorded during this survey.

Scale insect collections were not recorded on this map because a large part of these specimens were obtained in collections limited to scale insects.

Arachnid specimens were preserved by placing infested leaves in vials containing five per cent chloral hydrate. Bakelite caps were sealed with masking tape to prevent leakage during transit. Vials were shipped in mailing tubes. Scale insects on infested plant material were wrapped in soft paper and placed in mailing tubes. Other greenhouse pests were placed in vials of 70 per cent alcohol and shipped in the same manner. A label was attached to each sample giving the host plant, specific locality, date and collector.

Samples received were recorded in an accession book and, with the exception of mites, the specimens were transferred to 70 per cent alcohol

in shell vials (17 x 65 mm.). Arachnid material was left in its original vial until sufficient time could be found for mounting.

The mites were filtered from the five per cent chloral hydrate and leaves using a nine cm. smooth texture filter paper. The filter paper was then placed under a binocular dissecting microscope of 20 x magnification where the mites were separated from the filter paper with a minuten pin and placed in a stender lid containing five per cent chloral hydrate. A drop of Hoyer's mounting medium was placed in the center of a 3" x 1" microscopic slide. A dowel 2" x 1/16", equipped with a minuten pin with a loop in the end, was used to lift the mite from the chloral hydrate to the mounting medium. By means of a straight minuten pin the male mites were depressed into the medium and arranged in a lateral position, legs away from the observer with the head toward the right. This position was desired because the aedeagus could be more clearly seen from this angle. One mite was mounted per slide. A clean 12 mm. cover glass was placed on top of the drop of medium with a pair of sharp-tipped forceps. By looking into the dissecting microscope one could adjust the position of the mite by slightly pushing the cover glass one way or the other. This had to be done in most cases as the specimens moved out of their lateral position while the medium moved towards the edge of the cover glass.

Dr. H. Bruce Boudreaux (personal communication)[1] has perfected a technique for mounting the male mites. He examines the males immediately after mounting, and skids the cover glass to place the mite in position. Then, after a few hours of heating on a warming plate at about 50° C., he examines again and makes further adjustment to bring the male into the exact lateral position desired. This may have to be repeated several times

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[1] February, 1959.

during the hardening process. Once a slide has hardened, the only remedy is to expose it to a damp atmosphere or to soak off the cover glass in water and remount.

The author mounted the female mites with the dorsal side up and, in some cases, they too were mounted laterally so the first tarsal segment of the front leg could be more easily seen.

Two male mites and three females from each sample were mounted when available.

After the mites from each sample had been mounted they were given an accession number and placed in an oven. Slides were left in the oven from 24 to 72 hours to harden the medium and clear the specimens. The slides were then labeled and the mites identified.

Preparatory to the mounting of mealybugs, the insects were placed in a solution of 10 per cent KOH from 12 to 24 hours. When all the body contents had been removed, the specimens were transferred to a stender dish of 70 per cent ethyl alcohol and left for approximately 12 to 24 hours. The insects were then removed to a basic fuchsin stain, consisting of 1 gr. of powder per 100 ml. of 70 per cent ethyl alcohol and left for 24 hours. Specimens were dehydrated in a series of alcohols. The mealybugs were placed in a solution of beechwood creosote and then transferred to a mounting medium of balsam. Drying and labeling processes were the same as used for mites.

Mounting techniques used for aphids were the same as those used in mounting mealybugs with the exception of the staining process. A stain consisting of acid fuchsin 0.2 g. in 100 cc. of water was used in some cases and, in others, the specimens were left unstained. The author found

little difference between stained and unstained material as far as identification purposes were concerned.

Other specimens found were preserved in 70 per cent alcohol.

Illustrations were presented in several ways. Where the whole specimen was drawn, a bioscope equipped with a 2, 6, or 10 x ocular was used to project the specimen on a sheet of drawing paper. From this process, a basic outline of the specimen was obtained. Details were then added by using a compound microscope. Free hand drawing was used in cases where only parts of a specimen were used to represent a species. This was accomplished by the author as he viewed the object under a compound microscope or a phase microscope with an oil immersion dark contrast medium phase objective.

CHAPTER IV

RESULTS

Greenhouse pests were collected from 39 cities or towns during the period of September 20, 1958 to April 15, 1959. Where possible, specimens were identified to species. The groups found in the survey were mites, aphids, soft and armored scales, mealybugs, thrips, parasitic hymenoptera, whiteflies, rove beetles, armyworms, millipedes, sowbugs, and slugs.

The species collected are presented according to their taxonomic groups, including a taxonomic description, author observations, host plants with number of collections, location, and total number of collections.

A survey summary of the group is represented at the end of each group.

Acarina

The Mites

Mites are minute to microscopic arthropods; usually having an oval shaped body composed of a cephalothorax and abdomen; four pair of jointed legs (adult stage), sometimes three in the nymphal stage; and either being phytophagous, predaceous, parasitic, or acting as scavengers.

Mites which were found during the survey may be separated by the following key. The key pertains to adult males and females unless otherwise specified. Plates I and II illustrate the various characteristics

used in separating the different species of mites collected.

Key to the Mites

1. Long submarginal setae extending from the hysterosoma region of the body; two long humeral setae extending between legs II and III (Plate I-2).....Tyrophagus longior (Gervais) [p.11]

   Long submarginal setae absent from the hysterosoma region of the body; long humeral setae absent between legs II and III.....2.

2.(1) Leg IV of females ending with a whip like apical seta (Plate I-1A); 2nd segment of leg IV on males with a hyaline membranous lobe along the inner margin (Plate I-1B).....Tarsonemus pallidus (Banks) [p.12]

   Leg IV of female lacking whip like apical seta; leg IV of males without hyaline membranous lobe along inner margin of the second segment.....3.

3.(2) Last tarsal segment ending abruptly, stub like; last tarsal segment having rod-like sensory setae (Plate I-3).....Brevipalpus inornatus (Banks) [p.13]

   Last tarsal segment not stub like, gradually tapering; tarsal segments without rod-like sensory setae (Plate I-4).....Tetranychidae spp.

Key to the Tetranychidae

1. Empodium claw like; with a series of hairs along the inner margin (Plate II-1).....Petrobia harti (Ewing) [p.13]

   Empodium rudimentary, without a series of hairs along the inner margin (Plate I-4B).....2.

2.(1) Male and female with empodium spur (Plate II-2); aedeagus barb broadly rounded anteriorly (Plate II-7).....Tetranychus tumidus Banks [p.14]

   Empodium without a spur; aedeagus barb not broadly rounded.....3.

3.(2) Tarsus I of female with proxmal duplex setae in line with other proxmal setae (Plate II-3); aedeagal barb sharply pointed anteriorly, forming a curved beak posteriorly (Plate II-8).....Tetranychus desertorum Banks [p.15]

   Tarsus I of female with proxmal duplex setae not in line with other proxmal setae (Plate I-4B); aedeagus not as above.....Tetranychus complex.....4.

4.(3) Females with dorsal integumentary folds between the lumbar and sacral setae bearing oblong and flattened lobes (Plate II-4); aedeagal barb anteriorly and posteriorly acute, with the dorsal surface evenly rounded (Plate II-9).....
.....Tetranychus telarius (Linnaeus) / p.15 /

Females with dorsal integumentary folds between the lumbar setae not flattened and oblong; aedeagus not as above.....5.

5.(4) Females with dorsal integumentary folds between the lumbar and sacral setae erect, having a hump shape appearance (Plate II-5); aedeagal barb slightly rounded anteriorly, dorsal margin concave, barb pointed posteriorly (Plate II-10).....
.....Tetranychus cinnabarinus (Boisduval) / p.18 /

Female with ventral integumentary folds found between the three pair of pregenital hysterosomal setae bearing oblong lobes (Plate II-6); aedeagal barb knobbed anteriorly, dorsal surface of barb indented (Plate II-11).....
.....Tetranychus lobosus Boudreaux / p.19 /

Tyroglyphidae
Tyrophagus longior (Gervais)
The Grain Mite

This species is easily separated from the other mites collected by the long submarginal setae extending from the hysterosoma region of the body. Most of these setae extend from the anterior part of the hysterosoma. These setae are sometimes as long or half as long as the body. Other characteristics found: two long humeral setae between the second and third leg; distal end of tibia with a dorsal tibial spine as long as or longer than the last tarsal segment; two inter and two outer propodosomatic setae found dorsally on the propodosoma.

Tyrophagus longior was found in two samples. One specimen was found in a sample which contained Tetranychus telarius. The other sample collected contained from ten to fifteen specimens. No damage was reported from this mite.

Host Plants with Number of Collections: Chrysanthemum (1) Cyclamen(1)

Location (County): Oklahoma

Total Number of Collections: 2

Tarsonemidae
Tarsonemus pallidus (Banks)
The Cyclamen Mite

This whitish to brownish mite can be separated from the other mites found by its small size, .228 to .272 mm.; elliptical shape, having a boat like appearance; leg IV of female ending with a whip-like apical seta; second segment, leg IV of male with a membranous lobe along the inner margin, long tactile setae on ventral side of tibia.

The author examined several plants during his survey which were thought to be infested with this mite. Only one sample taken proved to be infested with cyclamen mites. Because of size and color, these mites were never seen with the naked eye. The only way these mites could be found was by checking for cyclamen mite damage or by using a small hand lense. The author found that the greenhouse operator was quite accurate in pointing out this damage. These mites were very hard to kill. They were found to be alive after a period of twelve hours in a vial of chloral hydrate.

Host Plant with Number of Collections: Snapdragon (1)

Location (County): Garvin

Total Number of Collections: 1

Tenuipalpidae
Brevipalpus inornatus (Banks)
The Privet Mite

Brevipalpus inornatus can be distinguished from the other mites found by its small size, .306 to .374 mm. in length, and its dark red color. Structural characteristics which separate it are: second segment abruptly narrowed basally in the adult form (This character is not shown in Plate I); last tarsal segment with stub-like aspect; outer margin of legs rough and uneven, more so in the nymphs than adults.

The only specimen collected came from azaleas where severe damage was noticed. The foliage which had been attacked by these mites had a yellow appearance. Because of its color, this mite was more easily seen than some of the other small mites under field conditions.

Host Plant with Number of Collections: Azalea (1)

Location (County): Lincoln

Total Number of Collections: 1

Tetranychidae
Petrobia harti (Ewing)

The following characters make Petrobia harti relatively easy to separate from other Tetranychus spp.: tarsi I of male and female with a claw like empodium; two rows of tenent hairs along the inner margin of the claw; setae along the dorsal surface of the body spatulate in male, pilose in female; dorsal setae of female set on projected tubercles; male with four pair of very long legs, sometimes two to three times as long as the body; female with anterior and posterior legs 1½ to twice as

long as the body; adeagus narrow, tapering to a point.

Petrobia harti was recorded from three samples. In every case it was found on sheepsorrel which was growing on or underneath the greenhouse benches. Greenhouse operators reported this mite was confined to sheepsorrel. No cases were found where it was a pest of ornamentals. In one instance chrysanthemums and sheepsorrel were found growing together. In this case only the sheepsorrel was infested.

Host Plants with Number of Collections: Sheepsorrel (2)

Location (County): Oklahoma, Grady

Total Number of Collections: 2

Tetranychus tumidus Banks
The Tumid Spider Mite

The empodial spur on the last tarsal segment of males and females is the main characteristic used in identifying this species. The two specimens which were positively identified as T. tumidus had the spur projecting out just above the empodium claw. Other characters used to separate this species were: thick sensilla on the end of the palpus; aedeagal barb broadly rounded anteriorly, posterior tip pointed.

One sample was positive T. tumidus and three others were given tentative identifications. In the four samples only two males were found. In one sample this species was recorded with T. desertorum on Joseph's coat.

Host Plants with Number of Collections: Joseph's coat(1), Sheepsorrel(1), Chenille(1), Bougainvillea(1)

Location (County): Tulsa, Oklahoma, Grady

Total Number of Collections: 4

Tetranychus desertorum Banks
The Desert Spider Mite

Tarsus I of female with proximal duplex setae in, or almost in, direct line with other proximal setae; aedeagal barb sharply pointed anteriorly and broadly rounded posteriorly forming a beak. These are the characters which separate this species from other mites that were found.

Tetranychus desertorum was found in one sample which came from Joseph's coat. As reported by the greenhouse operator this plant was growing underneath the greenhouse bench, with the mites being confined to this particular plant. In a previous survey of mites of Oklahoma made by Furr (1955), he indicated that T. desertorum was probably the most frequently encountered species in Oklahoma, being distributed generally throughout the state.

Host Plant with Number of Collections: Joseph's coat.(1)

Location (County): Oklahoma

Total Number of Collections: 1

Tetranychus telarius (Linnaeus)
The Two-Spotted Spider Mite

Tetranychus telarius differs from other members of the genus found in greenhouses in that the females have dorsal integumentary folds between the lumbar and sacral setae bearing oblong and flattened lobes (not present in diapausing females); aedeagal barb acute, anteriorly and posteriorly, with a dorsally directed bend of about 90°; dorsal surface evenly rounded.

The author found it very difficult to distinguish between T. telarius and T. cinnabarinus females using the above characteristics. It was only after careful examination, using a phase microscope with an oil immersion dark contrast medium phase objective, that these folds could be located. Still it was difficult to determine between T. telarius and T. cinnabarinus in most instances. The location and a description of these lobes are illustrated in plate I-4 for T. telarius and plate I-5 for T. cinnabarinus. The illustrations exaggerate to some extent on the clarity by which these lobes may be seen. The author found after careful examination that the lobes could be more accurately found between the lumbar and sacral setae. In many instances females had prominent striae on the skin, but lacked lobes on the outer edges of the folds. These females were designated as being in the diapause state. Fifteen of the 46 samples of T. telarius and T. cinnabarinus taken contained diapausing females. In all but one case, at least one male or female, not in the diapause state, was found thus permitting an identification.

T. telarius and T. atlanticus females are listed as being indistinguishable and a positive identification is impossible unless male specimens are present. As no T. atlanticus males were collected, it would be reasonably safe to assume all females were T. telarius.

Some of the females collected were classified as deutonymphs. These were recognized by the absence of the much wrinkled skin surrounding the genital opening. No genital opening was present in the young stages.

The color was another factor which was often used to separate these species but proved to be misleading during certain periods of the year.

Dr. H. Bruce Boudreaux (personal communication)[2] stated:

In late fall the mites go into diapause for the winter. The females turn a bright reddish orange, stop feeding and ovipositing until spring returns. This process may be initiated as early as October in Louisiana, and in the northern States as early as late August. This may cause confusion since often both diapause females and normal summer females occur together. In T. telarius, whose summer females are green with two prominent black spots, the appearance of diapause females might seem to indicate the presence of another species. On summer females the lobes may be difficult to see if the mount is of a young or starved female, particularly if the mounting material is thick and does not press down on the mite. The lobes normally are upright, and the coverglass must turn these down sideways in order to see their shape. An alternative is to look for the lobes on large folds of the cuticle, where the skin striae are sideways, thus bringing the lobes into view from the side.

The author found after examining a large number of specimens that a distinction could be made between the two species, although in some instances distinctions were still very difficult to determine.

Some difficulty was had by the author in distinguishing between the males of T. telarius and T. cinnabarinus. Dr. Boudreaux (personal communication)[3] stated:

If the aedeagus is slightly askew, the distinctive shape of the upper surface will be distorted. They must be strictly in laterial view, since the tip of the aedeagus is really a sort of disc. The disc shape of the tip of the aedeagus is found especially in close relatives of telarius. Other species of the genus may have a different arrangement.

Tetranychus telarius was the most common species found in the greenhouse survey. It was found in 41 samples out of the 59 samples taken. In three samples it was found with other genera and species. These were T. lobosus, T. cinnabarinus, and Petrobia harti.

The writer, in making his survey, found light to severe damage resulting from this species. In several instances the plants were found to show loss of green color from the injury of these mites, although in most cases damage was light to moderate.

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[2] February, 1959.

[3] Ibid.

Host Plants with Number of Collections: Chrysanthemum(19), Rose(4), Carnation(3), Gardenia(2), English Ivy(2), Sheepsorrel(2), Chenille(1), Ornamental pepper plant(1), Hibiscus(1), Abelia(1), Tomato(1), Lantana(1), Ageratum (1), Bougainvillea(1), Oxalis(1)

Locations (County): Payne, Oklahoma, Tulsa, Garfield, Stephens, Craig, Osage, Nowata, Comanche, Noble, Kay, Lincoln, Pontotoc, Seminole, Pottawatomie, Grady, McCurtain, Texas, Wood, Kingfisher.

Total Number of Collections: 41

Tetranychus cinnabarinus (Boisduval)
The Four-Spotted Spider Mite

Tetranychus cinnabarinus females are similar to T. telarius females in that both have integumentary folds between the lumbar and sacral setae which bear lobes. The lobes on the integumentary folds of T. cinnabarinus are erect and hump shaped while T. telarius are oblong and flattened (Plate II-4 and 5). The difficulty in distinguishing between these two species is discussed more fully in the discussion of T. telarius. Males are more easily distinguished if properly mounted, in that the aedeagal barb of T. cinnabarinus is slightly rounded anteriorly; dorsal margin concave; barb pointed posteriorly while in T. telarius the aedeagal barb is posteriorly and anteriorly acute.

In several specimens of T. cinnabarinus examined by Dr. Boudreaux he found extra setae on the fore tibia and tarsus (polychaete or "multisetis"). He stated, "This condition changes to and from normal in populations especially in greenhouses." This is also common in T. telarius.

For a positive identification between the two species, the author would recommend that large samples be obtained so an adequate number of males could be had. If the males are properly mounted, the two species could be more accurately determined than trying to distinguish between the females.

Tetranychus cinnabarinus was found on a total of five plants in four counties.

Under field conditions, this species cannot be accurately separated from T. telarius on the basis of color because of the diapause state that both mites go through. T. telarius has been known to have two dark spots dorsally and T. cinnabarinus four dark spots dorsally when not in the diapause state. A tentative identification could be made in the field using a hand lens if done in the summer rather than during the fall or winter months. At this time, the females turn a bright reddish orange.

Plants with Number of Collections: Tomato(2), Chrysanthemum(1), Hibiscus (1), Lantana(1), Pansy(1).

Location (County): Tulsa, Craig, Pawnee, Stephens.

Total Number of Collections: 6

Tetranychus lobosus Boudreaux

Females of T. lobosus have oblong lobes appearing along the ventral integumentary folds between the three pair of pregenital hysterosomal setae; males with aedeagal barb knobbed anteriorly, dorsal surface of barb indented.

Only one female specimen of T. lobosus was collected. This particular specimen came from gardenia found in Tulsa County. When this mite

was collected, it was found to be of a bright crimson red, distinctly different from this standpoint to other tetranychid species. The greenhouse operator made the remark that the gardenia plants had just arrived from a greenhouse in Topeka, Kansas the day before.

Host Plant with Number of Collections: Gardenia (1).

Location (County): Tulsa

Total Number of Collections: 1

Survey Summary of the Mites

A total of nine different species of mites were found in the survey representing four families and five genera. Tetranychus telarius was the most commonly found mite. It was collected independently in 38 of the 59 samples taken and three other times with another species. It was followed by Tetranychus cinnabarinus in six samples and Tetraychus tumidus in four samples. Mites were found on a total of 19 different plant species collected from 22 counties.

Chrysanthemum was the greenhouse plant most widely attacked by Tetranychus telarius. T. telarius was recorded on this plant twice with other mites and 19 times independently, followed by sheepsorrel, five times, and roses, four times.

Homoptera
Aphidae
The Aphids

The family Aphidae are characterized by the following features: sucking mouthparts, soft-bodies, and cornicles (usually present). They are winged or wingless, and are usually found in colonies.

A key to the aphids found in the greenhouse survey is given below. The classification used by the author follows Theobald (1926, 1927, 1929). Plate III illustrates the various characteristics used in separating the different species of aphids collected.

Key to the Aphidae

1. Cornicle reticulated (Plate III-2).....Macrosiphoniella sanborni Gillette/ p.22/

   Cornicle not reticulated.....2.

2.(1) Cornicle smooth, not imbricated; expanded basally (Plate III-3).....Anuraphis helichrysi Kaltenbach/ p.23/

   Cornicle imbricated; not expanded basally (Plate III-4).....3.

3.(2) Prominent frontal tubercles not exceeding the vertex (Plate III-5).....Aphis gossypii Glover/ p.23/

   Prominent frontal tubercles exceeding the vertex.....4.

4.(3) Prominent frontal tubercles porrect (Plate III-6).....Myzus persicae (Sulzer)/ p.24/

   Frontal tubercles sloping outwards diverging; not extending forward horizontally (Plate III-7)Macrosiphum sp. Passerini/ p.25/

Macrosiphoniella sanborni Gillette
The Chrysanthemum Aphid

Macrosiphoniella sanborni (Macrosiphum sanborni [Russell, 1952])
may be separated from other species found by the following characteristics: cornicles with distal area reticulated, basal area imbricated (very easily seen under low power magnification); cauda long and slender, usually longer than the cornicles, except in nymphal forms; cauda with four to five pair of hairs protruding from each side; frontal tubercles sloping outward. Russell (1952) gives the color of the body as brown to black with cauda and entire cornicle black.

The chrysanthemum aphid was collected twice from chrysanthemums during this survey. In another instance Macrosiphoniella sp. was collected from chrysanthemums but was not positively identified as M. sanborni. In this same sample, M. sanborni and Aphis sp. were both collected from the same plant. This particular aphid was described by one greenhouse operator as an aphid which would build up in large numbers but seemed to infest isolated plants. Whenever disturbed, the aphid was observed to rear up on its hind legs. Light to moderate infestations were found by the author on plants infested with this aphid.

Host Plants with Number of Collections: Chrysanthemum (3)

Locations (County): Tulsa, Oklahoma, Comanche

Total Number of Collections: 3

Anuraphis helichrysi Kaltenbach
The Leaf-Curl Plum Aphid

Anuraphis helichrysi (Aphis helichrysi Russell, 1952) was distinguished from other aphids found by the following characteristics: cornicles smooth, lacking reticulations and imbrications, (except for one row at distal end); cornicles expanded basally; frontal tubercles similar to Aphis sp.; cauda short and broad, often concealed by the abdomen, two to three pairs of hairs along each side, approximately the same length as the cornicles. Russell (1952) list this species as having a variety of colors from pale green and lemon yellow to black.

This particular aphid was only found on one plant; cineraria, where a heavy infestation was recorded.

Host Plant with Number of Collections: Cineraria (1)

Location (County): Muskogee

Total Number of Collections: 1

Aphis gossypii Glover
The Cotton Aphid
or
Melon Aphid

Aphis gossypii has many distinguishing characters which separate it from other species collected. Some of these characters are: frontal tubercles not extending beyond the vertex; cornicles cyclindrical, imbricated, slightly expanded at the base; cauda usually lined with two to three pairs of hairs; antenna generally not as long as the body. Russell (1952) lists this aphid as having a variable color from whitish lemon-yellow to blackish green in different individuals often in the same colony, color of cornicle (black), color of cauda (not black).

This species was collected on a total of nine plants with chrysanthemum being the most popular. Aphis gossypii was taken from this plant three times during the survey. In most cases, light to moderate infestations of apterous females were found on infested plants. Little damage usually resulted from this species as it was easily controlled. Aphis gossypii and Myzus spp. were both collected from the same plant in one sample.

Host Plants with Number of Collections: Chrysanthemum(4), Velvet plant (1), Hibiscus(1), Kalanchoe(1), Tomato(1), Hyacinth(1), Common Flowering Quince(1), Begonia(1)

Locations (County): Tillman, Oklahoma, Jackson, Comanche, Tulsa, Noble, Grady, Lincoln, Choctaw.

Total Number of Collections: 16

Myzus persicae (Sulzer)
The Green Peach Aphid

Characteristics of the tubercles were the main identifying traits of this species: frontal tubercles extending forward horizontally appearing humped shape; cornicles imbricated, slender, cylindrical, slightly swollen from the middle to the apex; cauda from 1/3 to 2/3 the length of the cornicle lined with three pair of lateral hairs; antennae about the same length as body. Russell (1952) gives the color as pale green with dark green longitudinal stripes in early summer aptera and dark dorsal patch (sometimes broken into bands) in all alate forms.

Myzus persicae was second only to Aphis gossypii in number of samples collected. This species was found a total of 11 times on nine different plants. Myzus spp. undetermined was found on two plants. The host plant

list is by no means complete but indicates to some extent that this species is a general feeder. As in Aphis gossypii plants were found to be heavily infested with this species. More winged forms were collected of Myzus persicae than any other species.

Host Plants with Number of Collections: Chrysanthemum(2), Ornamental pepper plant(2), Snapdragon(1), Geranium(1), Hibiscus(1), Lantana(1), Verbena(1), Coleus(1), Schefflera(1).

Locations (County): Tulsa, Greer, Cotton, Seminole, Woods, Payne, Oklahoma, Cimarron.

Total Number of Collections: 11

Macrosiphum spp. Passerini

This genus was collected in only two samples. A species determination was not made because the samples contained an insufficient amount of material. Characteristics which separate it from other specimens collected are: frontal tubercles sloping outward, diverging; cornicles long, slender, cylindrical, imbricated; antennae as long or longer than the body; cauda and legs long and slender. Color of specimens collected had orange and green bodies.

This aphid was collected in two samples. In one case only one specimen was found in the sample. Several specimens were collected in the other sample but no record of infestation was recorded.

Host Plants with Number of Collections: Petunia(1), Chrysanthemum(1).

Location (County): Tulsa

Total Number of Collections: 2

Survey Summary of the Aphids

A total of 39 samples of aphids were collected from greenhouses during the survey, representing five genera and five species. Aphis gossypii was the most common species collected, closely followed by Myzus persicae. Only twice during the survey were two different species collected from the same plant. As in the case of mites, chrysanthemums seemed to be the favorite aphid host plant. They were collected from this plant 11 times.

Homoptera
Coccidae and Diaspididae
Soft and Armored Scales

These insects are very difficult to describe because they undergo a great many changes during their life cycle. The sexes also differ in appearance. Characteristics of scale insects are: females wingless, males usually winged (one pair); antennae fully developed or minute; sucking mouthparts; mobile or immobile, and legs either absent or fully developed.

Characteristics of the soft scales (Coccidae) are: usually fully developed legs; anal cleft covered by a operculum formed of two plates, and usually a well developed segmented antennae.

The armored scales (Diaspididae) differ from the soft scales in that they have an unsegmented antennae after the first stage; a usually well developed pygidial area; tubular ducts usually present; female, legs absent, body covered with a hard or soft shell-like material, and usually immobile after the first stage.

Female soft scales and armored scales found may be separated by the following key. The classification and color of armored scales follows Ferris (1937, 1938, 1942). The classification and color of soft scales follows Zimmerman (1948). Plates IV to XI inclusive illustrates the various characteristics used in separating the different species of soft and armored scales collected.

Key to the Coccidae and Diaspididae

1. Anal opening covered by an operculum formed of two plates; usually well developed legs (Plate IV-1)(Coccidae).....2.

   Anal opening not covered by such plates; legs lacking after first stage (Plate IV-2)(Diaspididae).....4.

2.(1) Antennae usually six segmented; stigmatic depressions distinct with marginal setae numerous (Plate V-1).....
.....*Ceroplastes* (probably *floridensis*) Comstock [p.29]

   Antennae more than six segmented; stigmatic depressions indistinct, lacking numerous marginal setae.....3.

3.(2) Ventral tubular ducts absent; antennae normally seven segmented (Plate V-2).....*Coccus hesperidum* Linnaeus [p.30]

   Ventral tubular ducts present; antennae normally eight segmented (Plate VI-1).....*Saissetia oleae* (Bernard) [p.30]

4.(1) Prosoma normally with lateral lobes; median pygidial lobes narrow forming a deep medium notch (Plate VI-2).....
.....*Diaspis boisduvalii* Signoret [p.31]

   Prosoma without lateral lobes; median pygidial lobes not narrow forming a deep median notch.....5.

5.(4) Perivulvar pores lacking (Plate VII-1).....
.....*Quadraspidiotus perniciosus* (Comstock) [p.31]

   Perivulvar pores present.....6.

6.(5) Perivulvar pores in four groups; one bar at the base of each duct .....7.

   Perivulvar pores in five groups; two bars at the base of each duct.....8.

7.(6) Median, second and third pygidial lobes well developed; perivulvar pores in groups of four or less (Plate VII-2).....
.....*Chrysomphalus bifasciculatus* Ferris [p.32]

   Median lobes large and well developed; perivulvar pores in groups of five or more (Plate VIII-1).....
.....*Hemiberlesia lataniae* (Signoret) [p.32]

8.(6) Metathorax distinctly lobed; yoke forming a prominent sclerosis between the median lobes (Plate VIII-2).....
.....Pinnaspis aspidistrae (Signoret)/ p.33/

Metathorax usually not distinctly lobed (except Lepidosaphes camelliae); yoke not forming a prominent sclerosis between the median lobes.....9.

9.(8) Body devoid of all but minute size ducts except along the margin of the pygidium; antennae set close together at the anterior margin of the head.....10.

Body equipped with many medium to large size ducts; antennae not set close together at the anterior margin of the head.....11.

10.(9) Fleshy tubercle projecting between the antennae; anterior margin of the median lobe jagged (Plate IX-1).....
.....Fiorinia theae Green/ p.33/

Fleshy tubercle between the antennae absent; anterior margin of the median lobe smooth. (Plate IX-2).....
.....Fiorinia fioriniae (Targioni-Tozzetti)/ p.34/

11.(9) Dorsal ducts very large, only slightly smaller than the marginal ducts of the pygidium; dorsal ducts absent on segment seven (Plate X-1).....Lepidosaphes camelliae Hoke/ p.34/

Dorsal ducts distinctly smaller than the marginal ducts; dorsal ducts present on segment seven.....12.

12.(11) Body narrow at posterior end broadened at anterior end; leech-like (Plate X-2).....Unaspis euonymi (Comstock)/ p.34/

Body greatly broadened at the posterior end, circular-like; tapering at anterior end (Plate XI-1).....
.....Diaspis echinocacti (Bouché)/ p.35/

Coccidae
Ceroplastes (probably floridensis) Comstock
The Florida Wax Scale

Only one specimen of Ceroplastes (probably floridensis) was collected during the survey. Since this specimen was retained in Washington after a verification had been made, the author followed Zimmerman (1948) who gave the following description of the genus:

Distinguishing characteristics are: marginal setae in stigmatic clefts numerous, short, stout and conical or hemispherical; anal operculum surrounded by sclerotized area which tends to be more or less elevated and produced, the plates thus borne at apex of a more or less conical projection; body covered with an adherent mass of wax and antennae six segmented. Color of the mature female is brownish to grayish white.

Host Plant with Number of Collections: Gardenia (1)

Location (County): Ellis

Total Number of Collections: 1

Coccus hesperidum Linnaeus
The Soft Scale

Coccus hesperidum can be distinguished from other species found by: ventral tubular ducts absent, except sometimes in thoracic region; antennae, normally seven segmented; anal plates quadrate; and two slender setae on first segment of antennae. Color of mature female, yellowish brown.

Host Plants with Number of Collections: Dieffenbachia(1), Poinsettia(4), English Ivy(3), Schefflera(2), Sweet Orange(1), Viburnum(1), Lemon(1), Indian paint brush(1), Holly(1), Azalea(1), Philodendron(1).

Locations (County): Pontotoc, Tulsa, Lincoln, Noble, Muskogee, Oklahoma, Washington, Alfalfa, Shawnee, Osage.

Total Number of Collections: 17

Saissetia oleae (Bernard)
The Black Scale

The most peculiar characteristic of Saissetia oleae are the two transverse ridges plus a longitudinal ridge on the dorsal surface of the body which forms an H. Other distinguishing characteristics are: ventral

tubular ducts present; antennae normally eight segmented, setae absent on first segment. Color of mature female, dark brown to black.

Host Plants with Number of Collections: Poinsettia(2), Fiddle-leaf fig (3), Gardenia(1), Rubber plant (1), Fern(1), Chrysanthemum(1).

Locations (County): Payne, Tulsa, Craig

Total Number of Collections: 9

Diaspididae
Diaspis boisduvalii Signoret
The Boisduval's Scale

This species is easily separated from the other armored scales found by the lateral lobes which are located on the prosoma. In some cases these are small and not noticeable. Other characteristics are: median lobes narrow, forming a deep notch; outer margin tooth-like; perivulvar pores in five groups; dorsal ducts with two bars across the basal end. Color of mature female, white to transparent.

Host Plants with Number of Collections: Orchid (1).

Location (County): Tulsa

Total Number of Collections: 1

Quadraspidiotus perniciosus (Comstock)
The San Jose Scale

The absence of the perivulvar pores was the main characteristic used in identifying this species. Other characteristics used to separate this species from others collected are: dorsal ducts slender, one bar extending across the basal end; median and second lobe distinct, third lobe scarcely visible; plates between lobes fringed. Color of mature female, gray.

Host Plants with Number of Collections: Indian rubber fig(1), English ivy(1).

Location (County): Tulsa

Total Number of Collections: 2

Chrysomphalus bifasciculatus Ferris
The Bifasciculate Scale

Chrysomphalus bifasciculatus is distinguished from other species found by well developed pygidial lobes; distinct indentations between pygidial lobes and fringe plates; pygidial area sclerotized; perivulvar pores in four groups, and four pores or less per group. Color of mature female, light to dark brown.

Host Plants with Number of Collections: English ivy(1), Palm-leaf begonia(1), Philodendron(1), Azalea(1), Rubber plant(2).

Locations (County): Tulsa, Pottawatomie, Washington, Seminole.

Total Number of Collections: 6

Hemiberlesia lataniae (Signoret)
The Latania Scale

One pair of well developed sclerotized median lobes is the most distinguishing characteristic of this species. Other characteristics used to separate this species from other scale insects found are: second and third pygidial lobes lined with fringe plates; plates strongly toothed; four groups of perivulvar pores usually in groups of five or more. Color of mature female white to grey.

Host Plants with Number of Collections: Schefflera(1), Euonymus(1)

Location (County): Okmulgee, Craig

Total Number of Collections: 2

Pinnaspis aspidistrae (Signoret)
The Fern Scale

The fern scale can be easily recognized by the following characteristics: strongly lobed metathorax; a yoke forming a sclerosis between the median lobes; well developed spines projecting from the lower part of the metathorax and pygidial area; perivulvar pores in five groups with numerous pores in each group. Color of mature female, brown.

Host Plants with Number of Collections: Fern(1).

Location (County): Washington

Number of Collections: 1

Fiorinia theae Green
The Tea Scale

A fleshy tubercle projecting outward between the antennae separates this species from other scale insects found. Other important characteristics are: basal part of antennae large and conspicious, protruding from each side of the fleshy tubercle; outer margin of median, second and third lobe strongly toothed. Color of mature female, brown.

The true outline of Fiorinia theae is very difficult to see in mounted material. The specimen is enclosed in a shell-like covering in which it is quite difficult to separate from the specimen itself. By using the fine adjustment on a compound microscope, the general outline of the specimen can generally be brought into view.

Host Plants with Number of Collections: Camellia(1), Holly(4).

Location (County): Tulsa, Oklahoma, Payne

Total Number of Collections: 5

Fiorinia fioriniae (Targioni-Tozzetti)
Palm Fiorinia Scale

Fiorinia fioriniae differs from the above species in that it lacks a fleshy tubercle between the antennae. Other characteristics are: outer margin of the median lobe smooth; well developed spines along the lower margin of the metathorax and pygidial area; perivulvar pores in five groups, and many pores per group. Color of mature female, yellowish or brown to translucent.

Host Plant with Number of Collections: Camellia(1).

Location (County): Tulsa

Total Number of Collections: 1

Lepidosaphes camelliae Hoke
The Camellia Scale

Distinguishing characteristics which separate Lepidosaphes camelliae from the other species collected are the well developed abdominal lobes; very large two-barred dorsal ducts, only slightly smaller than the marginal ducts of the pygidium; dorsal ducts absent on segment seven; pygidial lobes well developed, slightly sclerotized; perivulvar pores in five groups. Color of mature female, a brownish color.

Host Plants with Number of Collections: Camellia(1), Holly (3).

Location (County): Tulsa, Payne

Total Number of Collections: 4

Unaspis euonymi (Comstock)
The Euonymus Scale

Unaspis euonymi can be distinguished from other species by the following characteristics: leech-like type of body, well developed

abdominal segments; numerous two-barred dorsal ducts; median lobe well developed, second and third lobe well developed and deeply bilobed. Color of mature female, purplish to dark brown.

Host Plant with Number of Collections: Euonymus(1).

Location (County): Tulsa

Total Number of Collections: 1

Diaspis echinocacti (Bouché)
The Cactus Scale

The only distinguishing feature that the author could find to distinguish Diaspis echinocacti from other species found was the outline of the scale itself. The body is greatly broadened at the posterior end and tapering in at the anterior end. Other characteristics of this species are: numerous dorsal ducts in the pygidial region; median, second and third lobes well developed; perivulvar pores in five groups, and pygidial lobes heavily sclerotized. Color of mature female, white.

Host Plants and Number of Collections: Cactus(1), Orchid(1).

Location (County): Greer, Tulsa

Total Number of Collections: 2

Survey Summary of the Scale Insects

Three species of soft scales and 10 species of armored scales were identified from a total of 48 samples collected. Eleven genera were represented in the collection. Coccus hesperidum was the most prevalent soft scale found. It was found in 15 of the 48 samples recorded.

Saissetia oleae was found in 10 samples. Chrysomphalus bifasciculatus was the most common armored scale found. It was collected in six samples. Soft and armored scales were found on a total of 20 different plant species from 15 different counties.

Holly and poinsettia were the greenhouse plants most widely attacked. Scales were found on each of these greenhouse plants six times. No two species were ever found on the same plant.

As the survey was carried on for approximately 16 months, the study of scale insects in greenhouses is considered by the author to be fairly complete.

Homoptera
Pseudococcidae
The Mealybugs

In this group are listed those scale insects that are commonly called mealybugs. These insects have soft oval bodies and, in most cases, are covered with a whitish or yellowish powdery waxy secretion. The size varies from 1/3 to 1/5 of an inch in length. Waxy filaments are often formed around the body or, in some cases, humps of wax are formed over the top of the body. Structural characteristics which will generally separate mealybugs from armored scales and soft scales are usually two pair of dorsal ostioles present on the head and seventh abdomenal segment and a pair of anal lobes forming a conspicuous dorsal plate.

The classification used by the author follows Ferris (1950). Plate XII illustrates the various characteristics used in separating the different species of mealybugs collected.

Mealybugs which were found during the survey may be separated by the following key. This key only applies to female specimens.

Key to the Pseudococcidae

1. Circulus very peculiar in shape, somewhat oval, with a projection extending from each side (Plate XII-2).....
.....Phenacoccus gossypii Townsend and Cockerell [p.38]

Circulus not as above, similar to (Plate XII-3).....2.

2.(1) Only one pair of cerarii; large dorsal tubular ducts present...
(Plate XII-7).....Ferrisiana virgata (Cockerell) [p.38]

More than one pair of cerarii; ducts not as above.....3.

3.(2) Normally 18 pair of cerarii; anal lobe cerarii surrounded by a loosely scattered mass of pores (Plate XII-5).....
.....Planococcus citri (Risso) [p.39]

Never more than 17 pair of cerarii; anal lobe cerarii surrounded by a large compact mass of pores (Plate XII-4).....
.....Pseudococcus adonidum (Linnaeus) [p.40]

Phenacoccus gossypii Townsend and Cockerell
The Mexican Mealybug

Phenacoccus gossypii is distinguished from other mealybugs that were collected by having a nine-segmented antennae. The most distinguishing characteristic is the circulus. To the writer, this resembles an old hat with the brim turned up. This characteristic is so obvious, that by careful examination, it can be seen under field conditions.

Pritchard (1949) used the following field characteristics to separate this species:

A white powdery wax covering the body except for four rows of thinly waxed depressions down the back. Short filaments are present along the sides, the hind ones being about one-fourth the length of the body. A grayish water-like fluid is ejected from pores on the back when it is irritated. The cottony egg masses are large and uniform.

The Mexican mealybug was found on a total of four plants with chrysanthemum being the most preferred host. It was recorded three times on this plant.

Host Plants with Number of Collections: Chrysanthemum(3), Lantana(1), Verbena(1).

Locations (County): Tulsa, Comanche, Noble, Kingfisher

Total Number of Collections: 5

Ferrisiana virgata (Cockerell)
The Striped Mealybug

The only specimen collected of Ferrisiana virgata in the survey just concluded was retained in Washington after a verification had been

made. No specimen was available at the time of this writing so the author followed Ferris (1950) in describing the species and in making his drawing.

The most conspicuous feature of the species is the presence of the large, dorsal, tubular ducts, these being quite numerous and arranged in a quite definite pattern; anal lobe cerarias consisting of two quite large and stout conical setae, two or three slender setae, and a somewhat variable concentration of trilocular pores.

Pritchard (1949) described the mealybug as follows:

The body of the mealybug is dark purple and thinly covered with powder except for two black, broken lines down the back. Numerous long and very delicate filaments are secreted. It ordinarily rests with most of the body held elevated from the plant. No eggs are laid.

Host Plant with Number of Collections: Chinese evergreen(1).

Location (County): Stephens

Total Number of Collections: 1

Planococcus citri (Risso)
The Citrus Mealybug

Planococcus citri can be distinguished from other mealybugs found by the following characteristics: sclerotized bar inward from the base of the anal lobe setae; anal lobe setae surrounded by a small cluster of pores, (in the mounting procedures, this setae is sometimes destroyed if care is not taken to preserve it); eighteen pair of cerarii along the margin of the body from the frontal cerarii to the anal lobe cerarii. (This characteristic can be easily seen in properly stained specimens).

Pritchard (1949) described this species as follows:

This species has a body covered evenly and heavily with a white powdery wax except for a fainter, narrow streak down the middle. Short filaments are present along the sides, the hind ones being about one-fourth the length of the body. Irregular, cottony egg masses are laid which contain as many as 500 eggs.

Planococcus citri was found in 11 of the 19 samples taken. This species was found to have a variety of host plants. In several cases,

heavily infested plants were recorded but in general only light infestation was noticed.

Host Plants with Number of Collections: Philodendron(1), Geranium(1), Nephthytis(1), Euonymus(1), Croton(1), English ivy(1), Aralia(1), Amaryllis(1), Anthurium(1), Coleus(1), Kalanchoe(1).

Location (County): Oklahoma, Tulsa, Grady, Choctaw, Payne

Total Number of Collections: 11

Pseudococcus adonidum (Linnaeus)
The Long-Tailed Mealybug

Pseudococcus adonidum is quite similar to Planococcus citri in that each have a similar number of cerarii. Pseudococcus adonidum differs only in that it has 17 pair of cerarii instead of 18 pair as in P. citri. Two large conical setae are located in each of the anal lobe cerarii areas surrounded by a large mass of pores. The pores are surrounded by an oval shaped sclerotized area.

Pritchard (1949) identified the species as follows:

Pseudococcus adonidum has a body thinly covered with white wax with a broad faint stripe down the middle. Filaments along the sides are often one-half the width of the body, and the terminal ones are as long as the body or longer. No eggs are laid and living young are produced.

This species was only found in three samples. In one sample it was collected with Planococcus citri. This was the only case where two different species were found together.

Host Plants with Numbers of Collections: Pothos(1), Euonymus(1), Philodendron(1).

Locations (County): Tulsa, Oklahoma, Comanche.

Total Number of Collections: 3

Survey Summary of the Mealybugs

Nineteen samples of mealybugs were taken during this survey period representing four genera and four species. Planococcus citri was the most prevalent as it was found in 11 of the 19 samples recorded. Ferrisiana virgata was the least prevalent being found in only one sample. Mealybugs were found on a total of 17 different plant species collected from 9 counties.

It appears that this survey may be used to determine the approximate number and kinds of species which are important in greenhouses during the winter months. However, because of a limited number of samples included in this survey, it cannot be used to give an accurate and exact rating of importance of the various species.

Other Pests Found in Greenhouses During the Fall, Winter, and Spring

The following pests were not found in sufficient number to warrant keys or detailed descriptions. Where possible, classification was made to genus and species. All specimens are listed as to host plants with number of collections, habitats, locations (counties collected in), and total number of collections made.

Thysanoptera
Thripidae
Frankliniella occidentalis (Pergande)
Western Flower Thrip

Host Plant with Total Number of Collections: Snapdragon(1).

Location (County): Garvin

Total Number of Collections: 1

Homoptera
Aleyrodidae
Trialeurodes spp.

Host Plant with Total Number of Collections: Verbena(2).

Location (County): Oklahoma, Noble

Total Number of Collections: 2

Hymenoptera
Encyrtidae
Microterys cincticornis Ashmead
Encyrtids

Host Plant with Total Number of Collections: Dieffenbachia (collected with a sample of scales).

Location (County): Pontotoc

Total Number of Collections: 1

Hymenoptera
Braconidae
Aphidius (Lysiphlebus) testaceipes (Cresson)
Braconids

Host Plant with Total Number of Collections: Kalanchoe (collected in a sample of aphids).

Location (County): Tulsa

Total Number of Collections: 1

Coleoptera
Staphylinidae
Hesperobium cribratum (LeConte)
Rove Beetles

Habitat: Floor of greenhouse(1)

Location (County): Craig

Total Number of Collections: 1

Lepidoptera
Arctiidae
Genus unidentified

Host Plant with Total Number of Collections: Chrysanthemum(1).

Location (County): Tulsa

Total Number of Collections: 1

Mollusca
Slugs
Limacidae
Deroceras reticulatum (Mulley)

Habitat: Floor of greenhouse(3)

Location (County): Tulsa, Muskogee, McCurtain

Total Number of Collections: 3

Limax marginatus (Mulley)

Habitat: Floor of greenhouse(5)

Location (County): Pottawatomie, Seminole, Garvin, Choctaw, Oklahoma.

Total Number of Collections: 5

Veronicellidae
Veronicella O. occidentalis Ferussac

Habitat: Floor of greenhouse (1)

Location (County): Oklahoma

Total Number of Collections: 1

Diplopoda
Millipedes
Unidentified

Habitat: Floor of greenhouse(1)

Location (County): McCurtain

Total Number of Collections: 1

Crustacea
Isopoda
Sowbugs and Pillbugs
Unidentified

Habitat: Floor of greenhouse(4)

Location (County): Muskogee, Grady, Choctaw, McCurtain

Total Number of Collections: 4

Greenhouse Operators' Report

During the winter of 1958-1959, the author inspected 41 greenhouses throughout the state of Oklahoma for greenhouse pests.

The first 25 operators interviewed were asked to name their most important greenhouse pests. The remaining 16 operators were provided with a list of 10 common greenhouse pests for consideration in making this rating. Six operators failed to give an answer to this question. The other 35 operators named at least one major greenhouse pest. In most cases the operator named only two or three types. The ratings of pests by operators are given in Table 1.

TABLE 1

Order of Importance of Pests Reported by Greenhouse Operators

Name of Greenhouse Pests	Percentage of Operators Rating Pests			
	First	Second	Third	Below Third
Tetranychid Mites	75	13	3	9
Aphids	15	53	13	19
Mealybugs	8	8	12	72
Slugs	--	5	13	82
Thrips	--	5	8	87
Caterpillars	--	3	8	89
Scales	--	--	3	97
Cyclamen Mites	--	--	3	97

Tetranychid mites was the most prevalent choice as the major greenhouse pest. Aphids, mealybugs, slugs, thrips, and caterpillars followed in that order. Cyclamen mites and scales were each listed once. Other greenhouse pests which were mentioned as giving trouble were whiteflies and rats.

Tetranychid mites were named by 75 per cent of the greenhouse operators as their most important greenhouse pest, by 13 per cent as their second, and by three per cent as their third most important pest. Nine per cent of the greenhouse operators interviewed failed to give Tetranychid mites a placing among their top three pests.

Aphids were rated as the most important greenhouse pest by 15 per cent of the greenhouse operators, of second importance by 53 per cent, and of third importance by 13 per cent. Nineteen per cent of the operators failed to give aphids a placing among the top three pests.

Mealybugs were listed by eight per cent of the operators as first, by eight per cent as second, and by 12 per cent as third. Seventy-two per cent failed to give mealybugs a placing. Thrips were rated second by five per cent of the operators and third by eight per cent.

Slugs were rated second by five per cent of the operators and third by 13 per cent. Caterpillars were listed second and third respectively by three per cent and eight per cent of the operators. Cyclamen mites and scales each were listed third by three per cent of the operators. Two operators listed two pests for their third choice. One operator listed tetranychid mites and mealybugs in third place, and another placed cyclamen mites and thrips in the third position.

Nine greenhouse operators reported pests problems were greater during the spring season. Seven thought there was little difference the year around. Every season of the year was listed by at least one operator as being most favorable for pest development. Five operators listed other seasons of the year when pest problems were more prevalent. Two operators stated they did not have much trouble with greenhouse pests any time of the year.

Operators varied in their opinions regarding the effect of humidity and temperature on pest development. Some stated moderate temperatures were most favorable with both low and high temperatures depressing development. One operator believed that rapid development and a short life cycle occurring at high temperatures produced the most serious problems. Two operators thought that tetranychid mites were more common under hot dry conditions.

On the basis of operators' opinions and the author's observations, chrysanthemums appeared to be the most susceptible to tetranychid mite infestation. An inspection of 41 greenhouses revealed four houses with heavy infestations, 11 with moderate infestations, 15 with light, and seven with no observable infestation.

In the latter part of the study, several operators were questioned regarding mite resistance in chrysanthemums. The majority of these had not noticed differences in resistance between varieties. One operator thought Shoe Smith and Luynia showed resistance and that Indianapolis, 49'er, Humdinger, and Whites' were more susceptible. Another operator listed Bonnaffon and Delux as moderately resistant and thought new varieties were more susceptible than the older ones.

Operators were interrogated concerning the kinds of pesticides used. Table II gives a summary of chemicals used for mites. Table III gives a summary of other insecticides used for the control of pests other than mites.

A total of 15 different pesticides were reported by operators in Table II. Ten operators depended on a single pesticide. The 26 remaining operators employed two or more chemicals, generally in an alternating schedule. Five operators failed to give an answer to this question. Fourteen owners employed two pesticides, eight used three, two used four, and two utilized five pesticides.

Parathion was the most widely used toxicant, being employed by 17 operators, in all cases alternated with one or more other pesticides. Malathion was used by a total of 16 operators, four of these depending on it entirely, eight using it in a schedule with one other material, and four alternating it with three or more pesticides. TEPP, Chlorobenzilate and Kelthane were used by nine, eight, and eight operators respectively. Six operators employed Aramite. Each of the remaining chemicals was used by one to four operators.

Water under pressure and a syringe washing method were used with satisfactory results by one operator.

According to operators, the multiple use of pesticides was employed because of specificity of chemicals and to prevent or solve problems of pests' resistance.

One of the more progressive and larger operators gave a brief summary of his experience with pesticides. After a period when parathion was highly effective, control with this material became gradually less

TABLE II

Pesticides Reported by Greenhouse Operators as Used Primarily for Control of Mites

Pesticides	Number of Operators Using One Pesticide	Greenhouse Operators Using an Alternating Schedule	
		Pesticides Used	Number of Operators Reporting
A. Aramite		C,E	1
B. Cyanide	1	C,I	1
C. Chlorobenzilate		E,L	1
D. Diazimon		H,L	1
E. Dimite		H,J	1
F. Dithion		H,I	1
G. Endrin	1	J,O	1
H. Kelthane		J,L	6
I. Lindane		L,N	1
J. Malathion	4	A,I,N	1
K. Nicofume	1	A,C,L	1
L. Parathion		C,H,L	2
M. Tedion	1	E,H,N	1
N. TEPP	2	F,J,L	1
O. Volchloral		J,L,N	2
		A,C,E,H	1
		A,F,L,N	1
		A,C,D,H,J	1
		A,C,F,L,N	1

TABLE III

Number of Greenhouse Operators Reporting the Use of Various Insecticides For the Control of Pests Other than Mites

Name of Greenhouse Pests	Pesticides Used						
	Malathion	DDT	TEPP	Sulfur	Endrin	Metaldehyde	Dieldrin
Thrips	1	2					
Aphids			3				
Scales	1			1			
Mealybugs	2				1		
Slugs						3	2
Caterpillars	1						

satisfactory. Dithion was tried but was discarded for Aramite. Aramite was used because of its long residual period of control. When this material became less effective, Kelthane was selected as the toxicant. Satisfactory control was obtained, but this compound appeared to stunt plants. Kelthane is now used only in spot treatments. Currently, Tedion is the chief miticide employed.

Operators were questioned concerning the presence of pesticides' resistance to greenhouse mites. Nineteen operators said that resistance appeared to be present among mites. No resistance was reported by seven operators.

Fourteen operators, out of a group of 16 that commented on needed research, said mites merited more attention in relation to control. Three stated that better control was needed on both mites and aphids. One

operator was satisfied with the chemicals he was now using while another said he would like to see more emphasis put on plant systemics.

One greenhouse operator reported leaf mold, rot, and unsatisfactory arthropod control resulted from spraying on cloudy days while high humidity existed. On sunny days more effective control resulted.

Some operators applied chemicals in a fairly regular schedule, regardless of the level of infestation, while others applied them only when injurious or threatening populations developed. Eighteen operators used a control program involving applications at intervals of two to four weeks. Five operators applied regularly at two-week intervals and two at one-week intervals. One operator used a one-week to ten-day interval during the summer and a two-to-three-week interval during the winter. Six operators applied a control treatment only when injurious infestations were present.

During the winter, aerosol bombs and sprays were often used in an alternating schedule. Since it was necessary for air vents to be left open and air conditioning operated during the summer, only sprays were generally used during this period. One operator believed that air conditioning fans pulled in thrips and mites, especially when wheat was being harvested in nearby fields. Two operators employed only aerosol bombs because of the saving in time and less danger of spreading plant diseases as compared with the use of sprays. Only sprays were used by two operators because their houses did not have sufficiently tight construction to permit effective aerosol treatment. In a few instances, the use of aerosols was prevented because the operators' living quarters were attached to the greenhouse. It appeared that greenhouse operators made their choice between aerosols and sprays on the basis of convenience rather than effectiveness.

TEPP and Aramite, when applied in an aerosol bomb, were reported to cause injury to snapdragons when in bloom, and to cyclamen plants. No reports of this type of damage were made as a result of using sprays.

In two instances, the Challenger Aerosol and the Hi-Fog machine were used in applying pesticides.

CHAPTER V

SUMMARY AND CONCLUSIONS

A survey was made to determine the more important pest species present in greenhouses in Oklahoma. Samples were collected from September 20, 1958 to April 15, 1959 with the exception of scale insects. A total of 195 samples were collected from 39 cities or towns. Thirty-nine species were taken from 68 different host plants.

The most prevalent group found was mites which were collected in 59 samples. This group was represented by four families, five genera, and nine species. The most commonly found species was Tetranychus telarius which was recorded in 41 of the 59 samples collected.

Aphids were the most commonly found insect in the survey. These pests were collected in 39 samples. The group was represented by five genera and five species. The most commonly found species was Aphis gossypii collected in 16 samples, closely followed by Myzus persicae which was present in 11 samples.

Soft and armored scales were collected in 48 samples from January, 1958 to April, 1959. Eleven genera representing three species of soft scales and ten species of armored scales were found in the survey. The most abundant soft scale found was Coccus hesperidum followed by Saissetia oleae. Chrysomphalus bifasciculatus was the most commonly found armored scale.

Nineteen samples of mealybugs were collected during the survey, representing four genera and four species. Planococcus citri was the most prevalent species collected. Because of the limited number of samples, no one species could be designated as the most important.

Other pests collected in limited numbers during the survey includes thrips, parasitic hymenoptera, whiteflies, rove beetles, armyworms, millipedes, sowbugs, and slugs.

The survey results are valid for fall, winter, and early spring conditions in Oklahoma greenhouses, but do not represent pest populations during the summer.

From personal interviews with 41 greenhouse operators, the following trends were determined: (1) most important pests were tetranychid mites, aphids, and mealybugs, (2) ten operators used a single pesticide, 26 used two or more chemicals, while five failed to report on the question, and (3) parathion followed by malathion, TEPP, Chlorobenzilate, Kelthane, and Aramite were the most widely used toxicants.

From the author's observations, more research is needed in the control of tetranychid mites. Most of the operators seemed to be at a loss in trying to find out how to keep down the resistance of tetranychid mites.

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APPENDIX

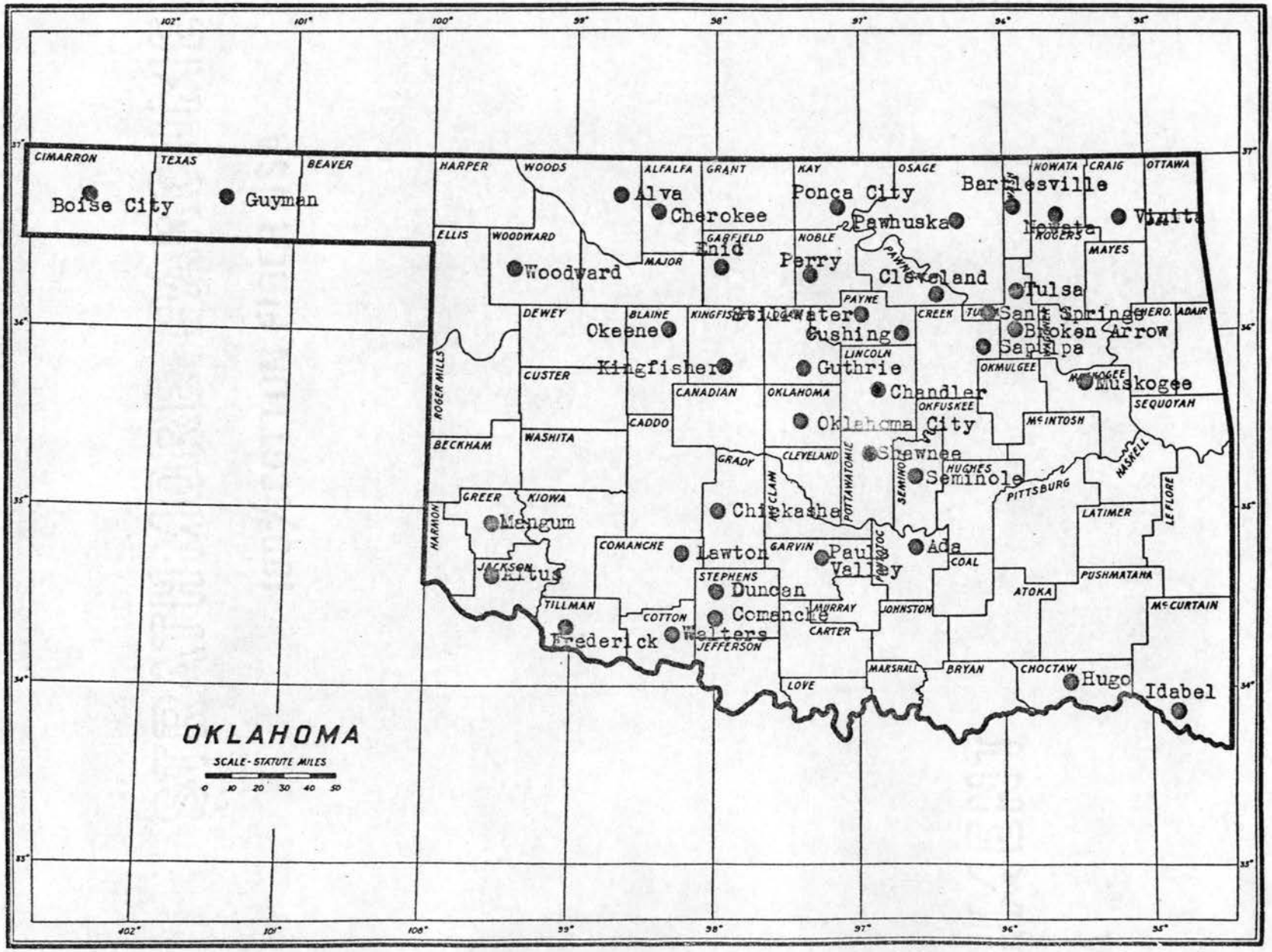


Fig. 1 Cities and Towns in which Greenhouse Pest Samples were Collected from September 20, 1958 to April 15, 1959

Plate I

Acarina
Mites

1A, Leg IV of male Tarsonemus sp. (adult) after (Baker et al. 1958). 1B, Female Tarsonemus sp. (adult). 2, Female Tyrophagus longier (adult). 3, Brevipalpus inornatus (nymph). 4A, General morphology of female Tetranychus (adult). 4B, Tarsus I of Tetranychus sp. 4C, Aedeagus of Tetranychus sp.

Plate I

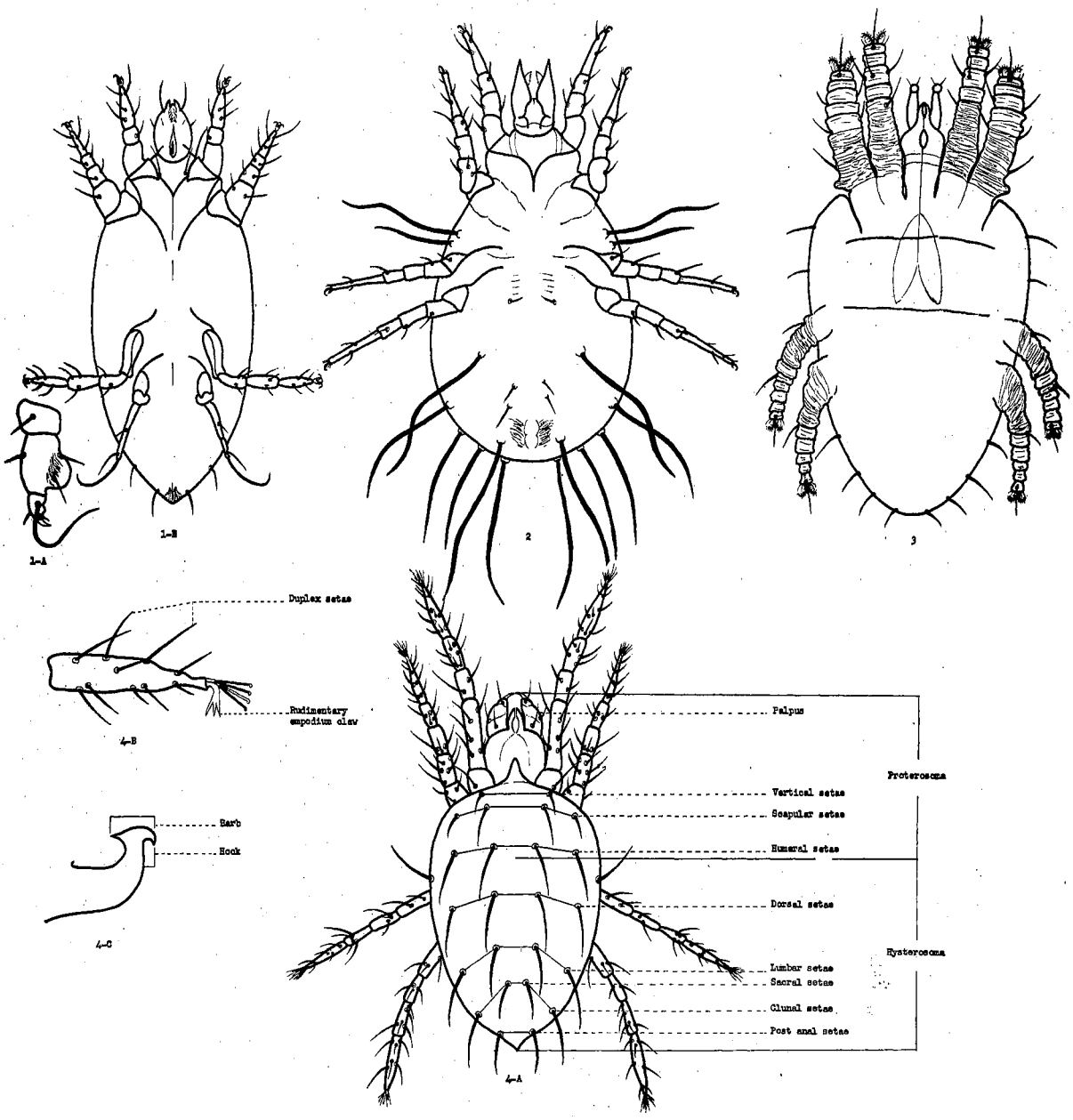

1-A
1-B
2
3
Duplex setae
Rudimentary empodium claw
4-B
Barb
Hook
4-C
Palpus
Proterosoma
Vertical setae
Scapular setae
Humeral setae
Dorsal setae
Hysterosoma
Lumbar setae
Sacral setae
Clunal setae
Post anal setae
4-A

Plate II

Tetranychidae
Mites

1, Tarsus I of Petrobia harti (female). 2, Tarsus I of Tetranychus tumidus (female). 3, Tarsus I of Tetranychus desertorum (female). 4, Dorsal integumentary lobes and folds of Tetranychus telarius (female). 5, Dorsal integumentary lobes and folds of Tetranychus cinnabarinus (female). 6, Ventral integumentary folds of Tetranychus lobosus (female). 7, Aedeagus of Tetranychus tumidus. 8, Aedeagus of Tetranychus desertorum. 9, Aedeagus of Tetranychus telarius. 10, Aedeagus of Tetranychus cinnabarinus. 11, Aedeagus of Tetranychus lobosus after (Boudreaux, 1956).

Plate II

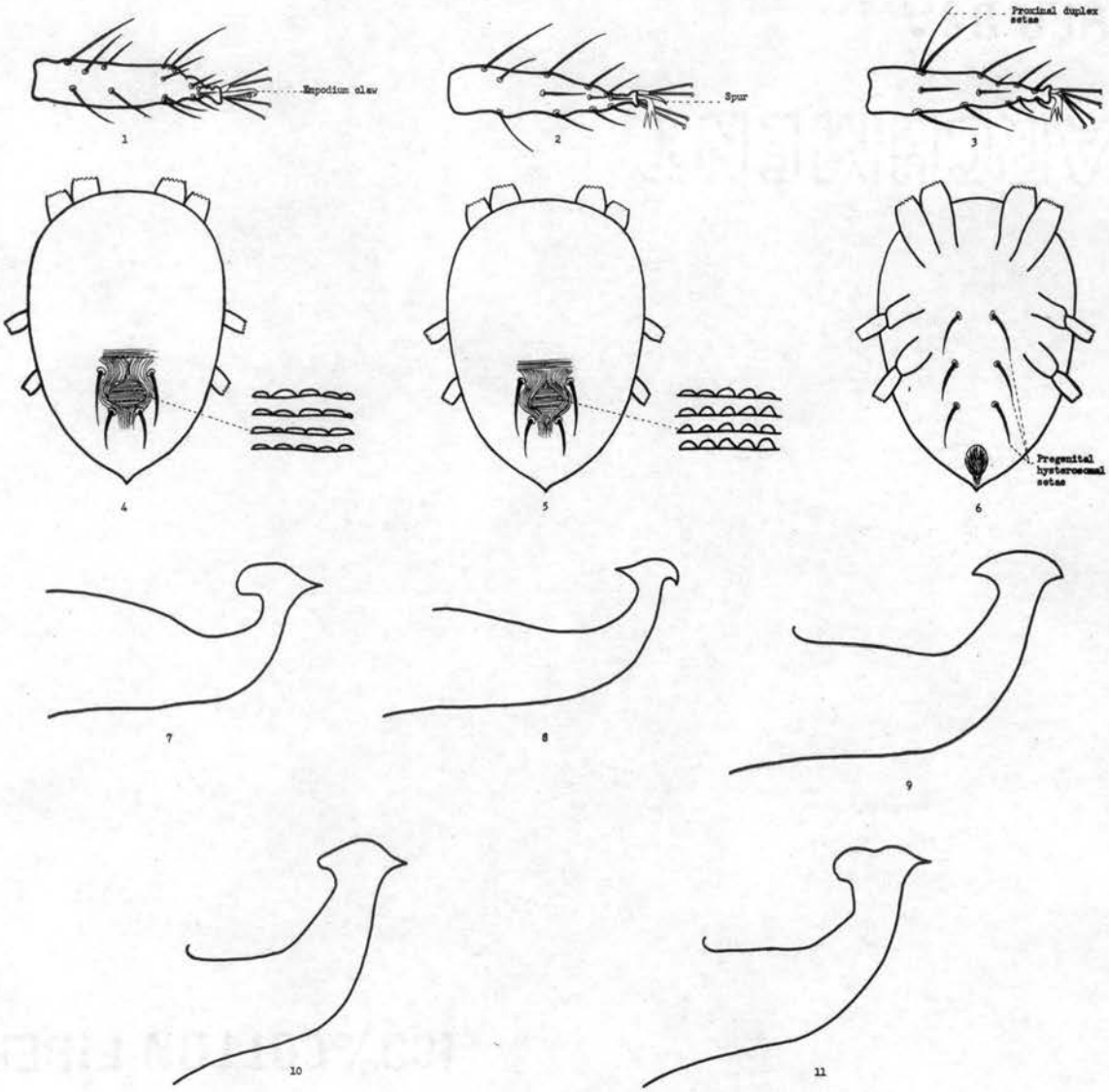
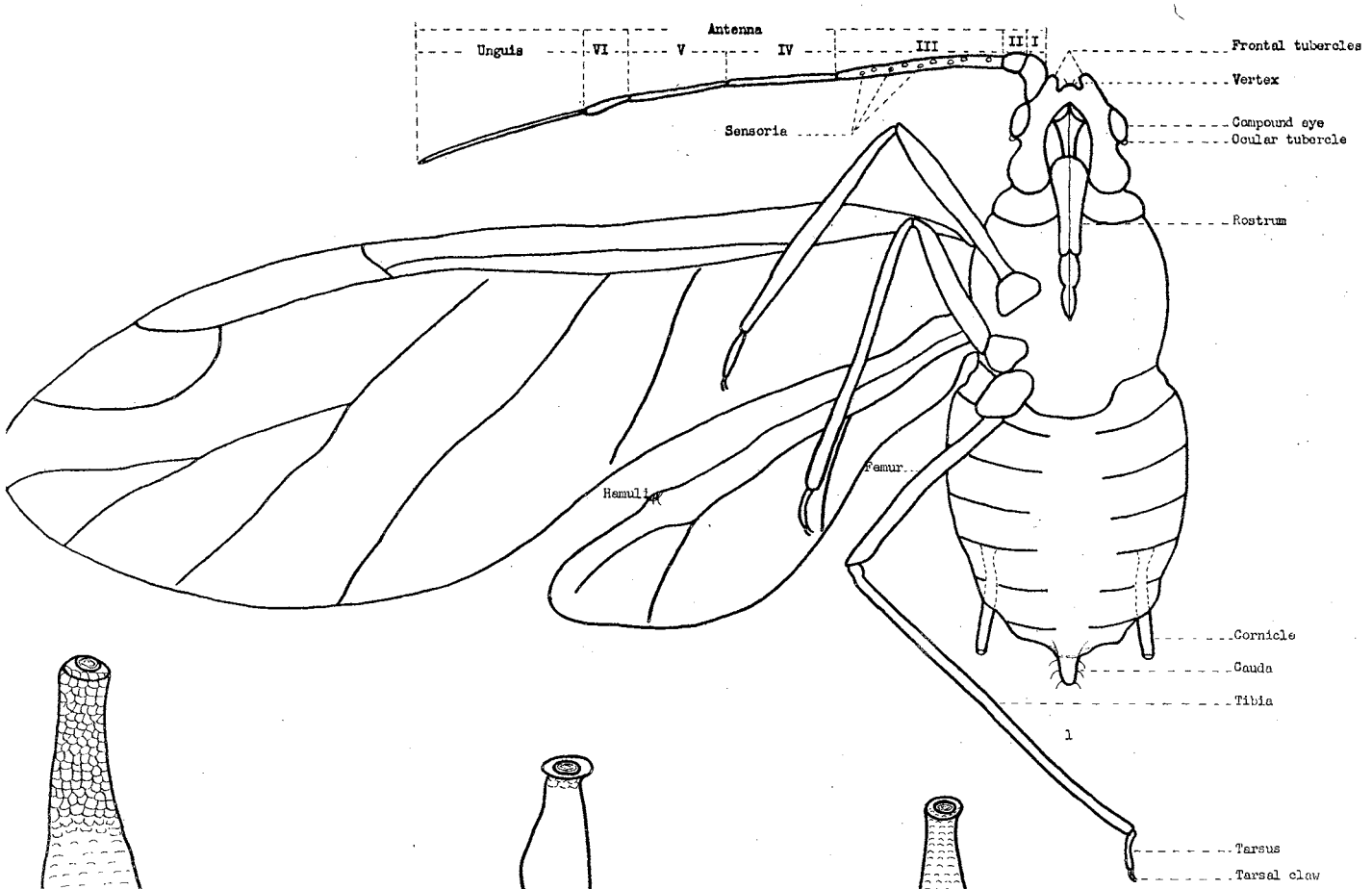

Empodium claw
Spur
Proximal duplex setae
Pregenital hysterosomal setae
1
2
3
4
5
6
7
8
9
10
11

Plate III

Aphidae
Aphids

1, General morphology of adult aphid (ventral view). 2, Cornicle of Macrosiphoniella sanborni (adult). 3, Cornicle of Anuraphis helichrysi (nymph). 4, Imbricated cornicle. 5, Frontal tubercles of Aphis gossypii (adult). 6, Frontal tubercles of Myzus persicae (adult) 7, Frontal tubercles of Macrosiphum sp. (adult).

Plate III

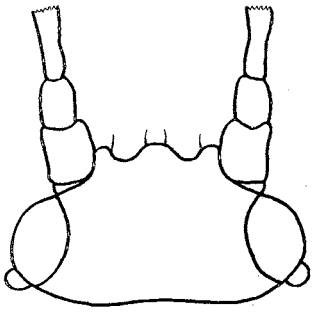


1

2

3

4



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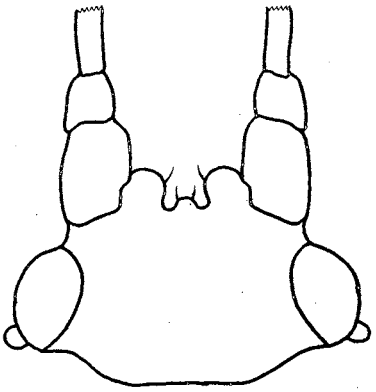

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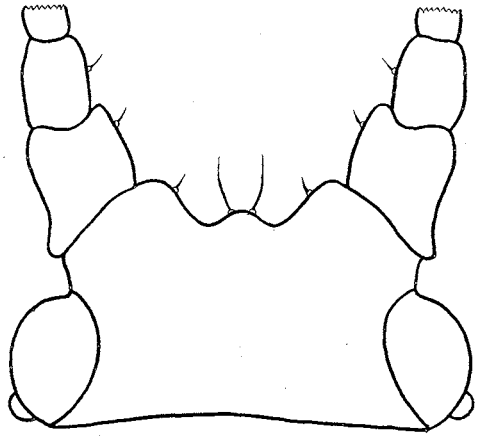


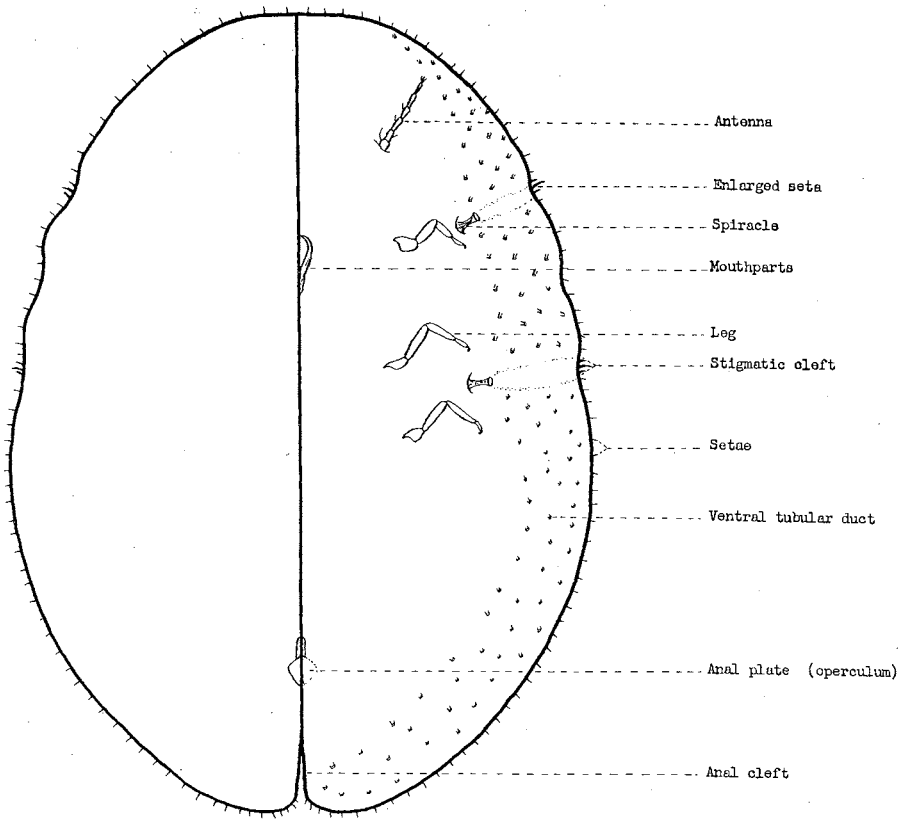
7

Plate IV

Coccidae and Diaspididae
Soft and Armored Scales

1, General morphology of adult female soft scale (Coccidae). 2A, General morphology of adult female armored scale (Diaspididae). 2B, General morphology of the ventral pygidial margin of adult female armored scale.

Plate IV


Antenna
Enlarged seta
Spiracle
Mouthparts
Leg
Stigmatic cleft
Setae
Ventral tubular duct
Anal plate (operculum)
Anal cleft

1

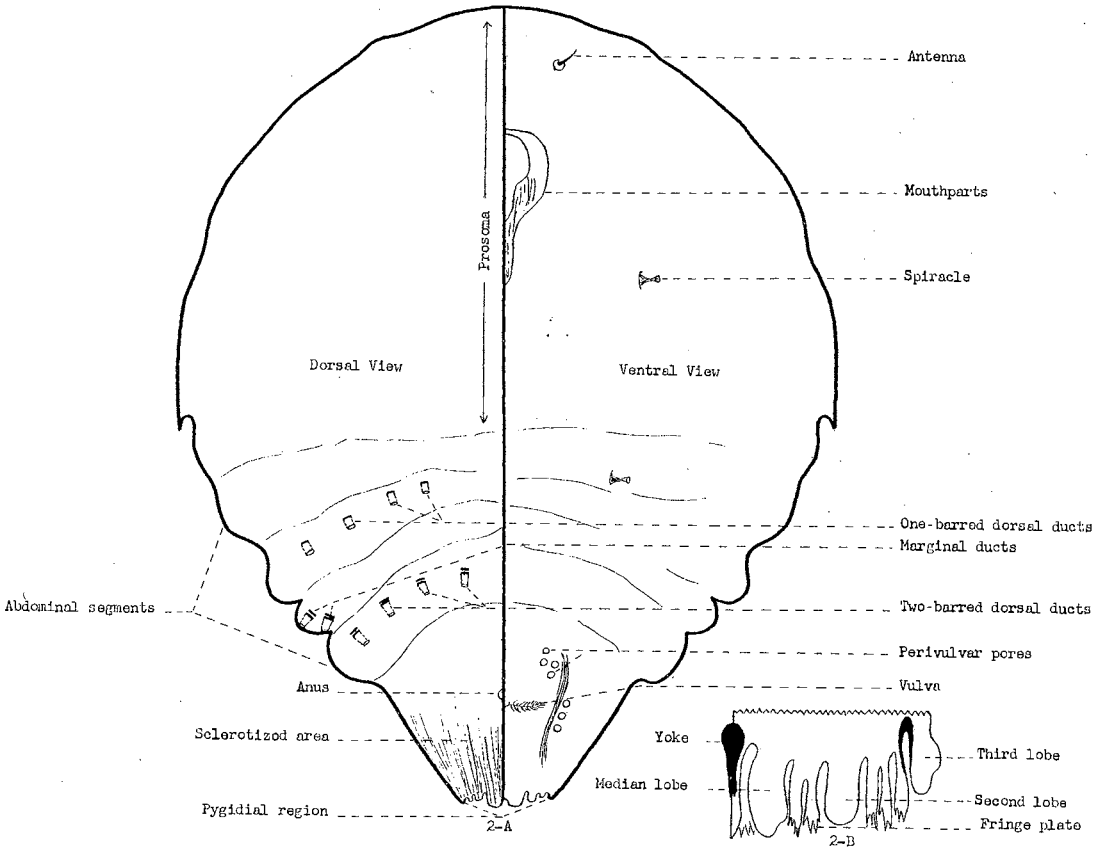
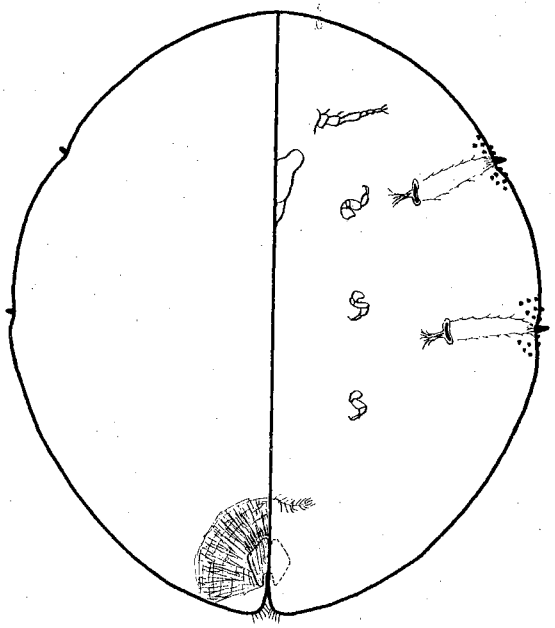

Antenna
Mouthparts
Spiracle
Prosoma
Dorsal View
Ventral View
One-barred dorsal ducts
Marginal ducts
Abdominal segments
Two-barred dorsal ducts
Perivulvar pores
Anus
Vulva
Sclerotized area
Pygidial region
2-A
Yoke
Median lobe
Third lobe
Second lobe
Fringe plate
2-B

Plate V

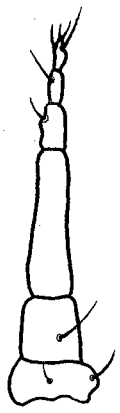
Coccidae

1A, *Ceroplastes* sp. 1B, Antenna. 1C, Anal plates, after Ferris (Zimmerman, 1948). 2A, *Coccus hesperidum*. 2B, Antenna. 2C, Anal plates.

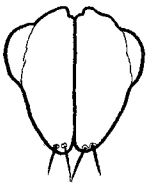
Plate V



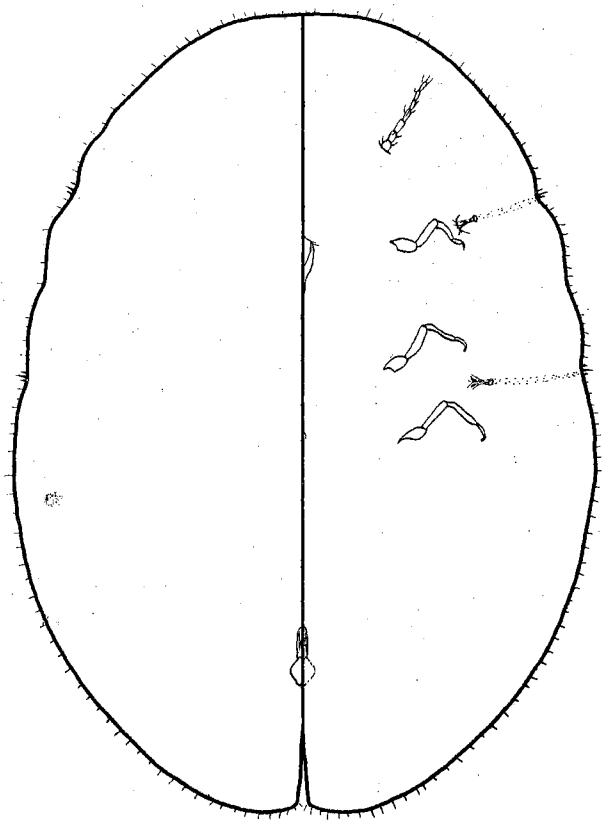
1-A



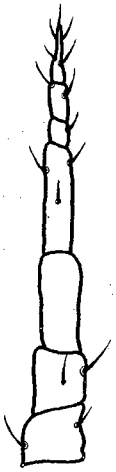
1-B



1-C



2-A



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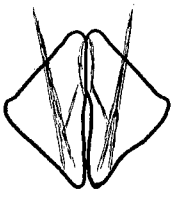


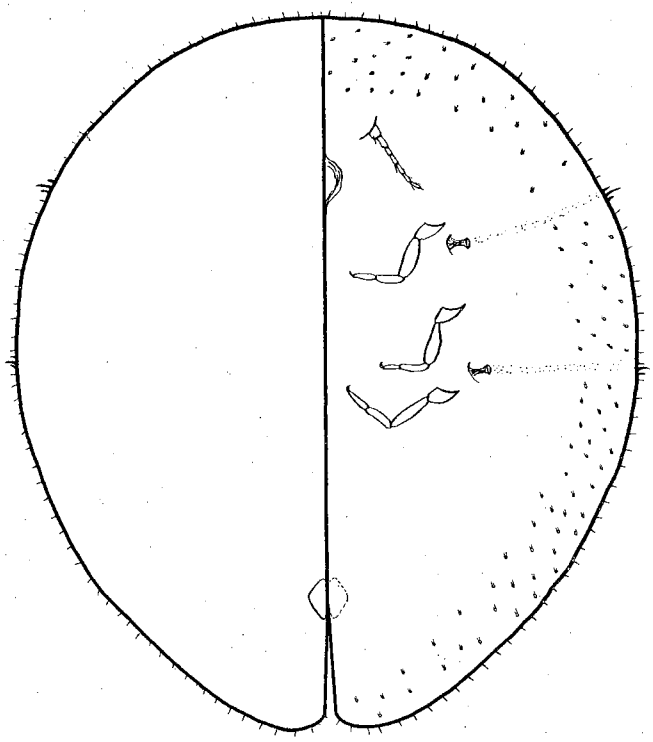
2-C

Plate VI

Coccidae and Diaspididae

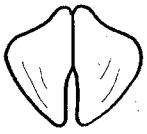
1A, *Saissetia oleae*, 1B, Antenna. 1C, Anal plates. 2A, *Diaspis boisduvalii*. 2B, Ventral pygidial margin.

Plate VI

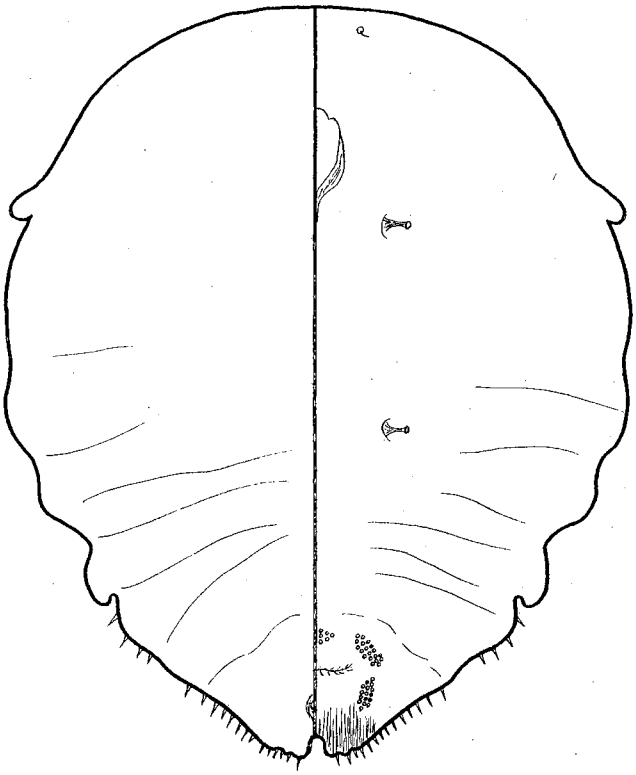


1-A

1-B



1-C



2-A

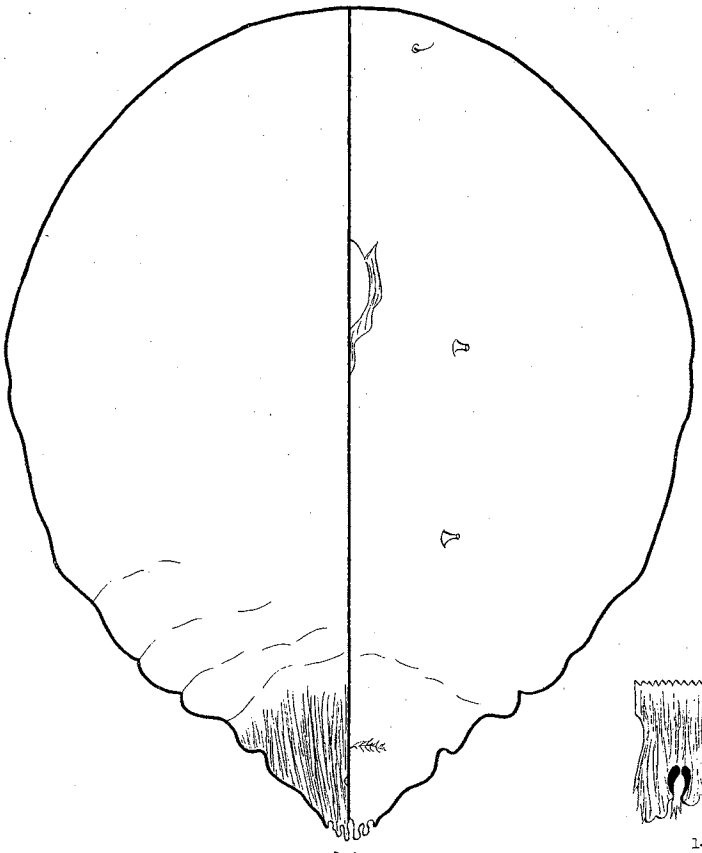
2-B

Plate VII

Diaspididae

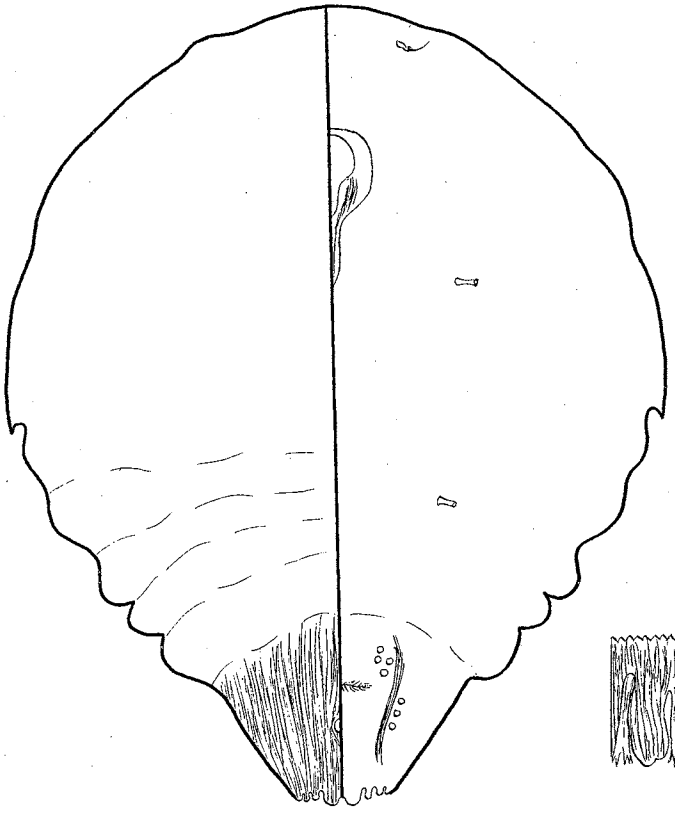
1A, Quadraspidiotus pernicious. 1B, Ventral pygidial margin. 2A, Chrysomphalus bifasciculatus. 2B, Ventral pygidial margin.

Plate VII

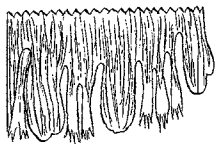


1-A

1-B



2-A



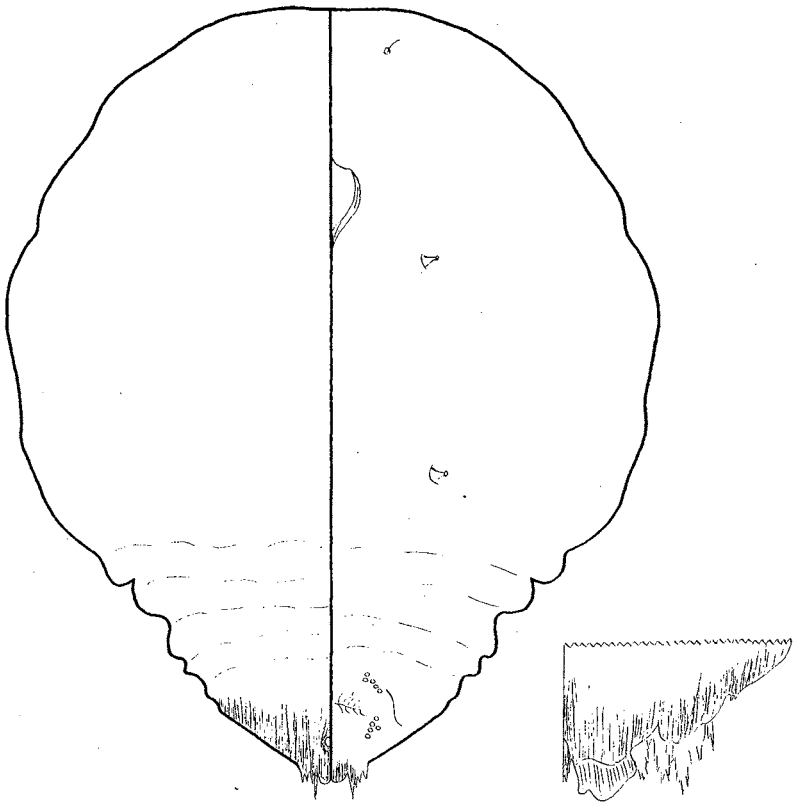
2-B

Plate VIII

Diaspididae

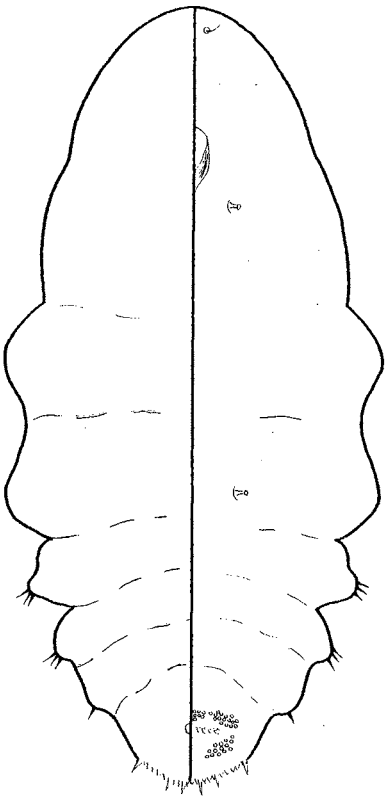
1A, Hemiberlesia lataniae. 1B, Ventral pygidial margin. 2A, Pinnaspis aspidistrae. 2B, Ventral pygidial margin.

Plate VIII



1-A

1-B



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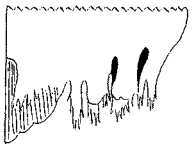


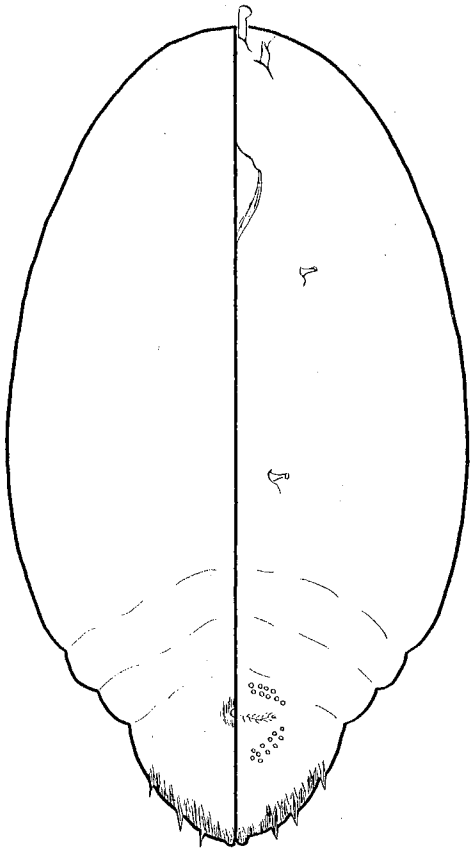
2-B

Plate IX

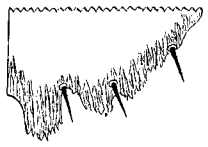
Diaspididae

1A, Fiorinia theae. 1B, Ventral pygidial margin. 2A, Fiorinia fioriniae. 2B, Ventral pygidial margin.

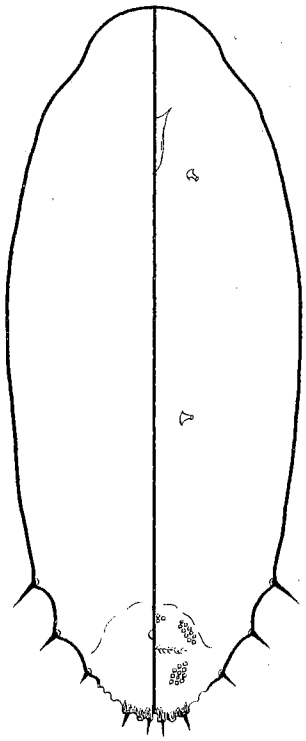
Plate IX



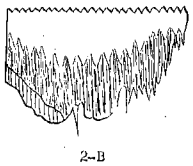
1-A



1-B



2-A



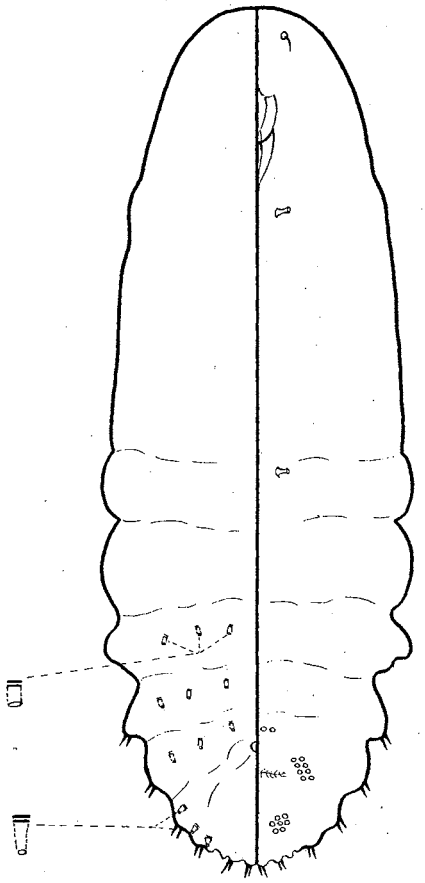
2-B

Plate X

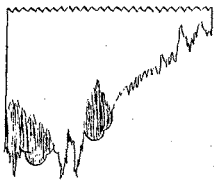
Diaspididae

1A, *Lepidosaphes camelliae*. 1B, Ventral pygidial margin. 2A, *Unaspis euonymi*. 2B, Ventral pygidial margin.

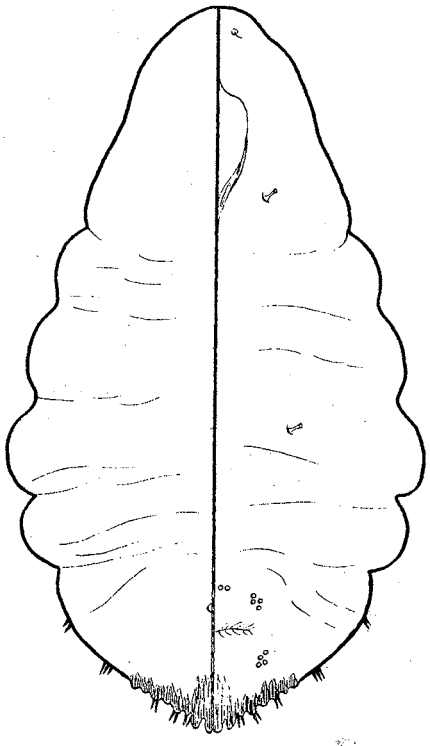
Plate X



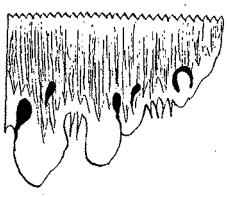
1-A



1-B



2-A



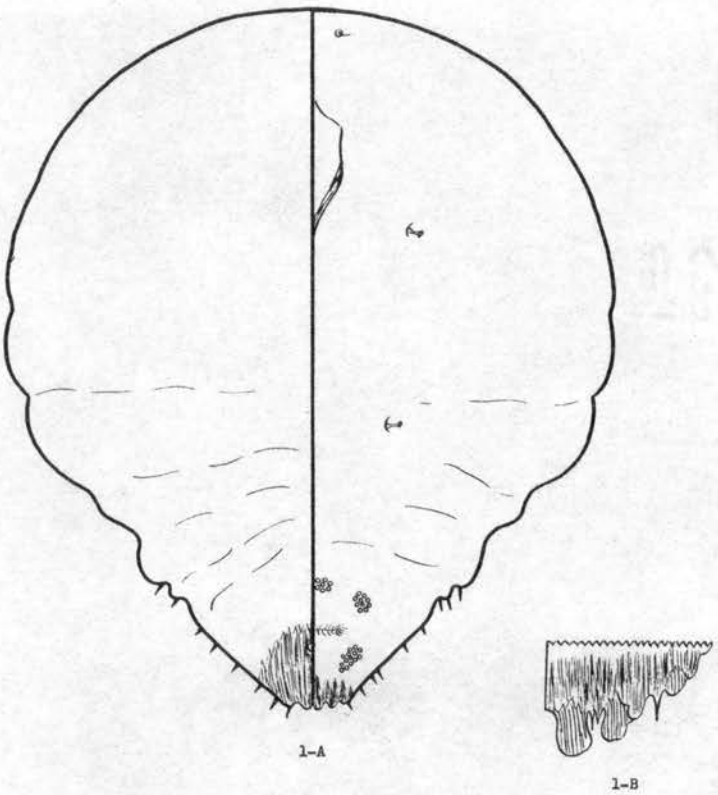
2-B

Plate XI

Diaspididae

1A, Diaspis echinocacti. 1B, Ventral pygidial margin.

Plate XI



1-A

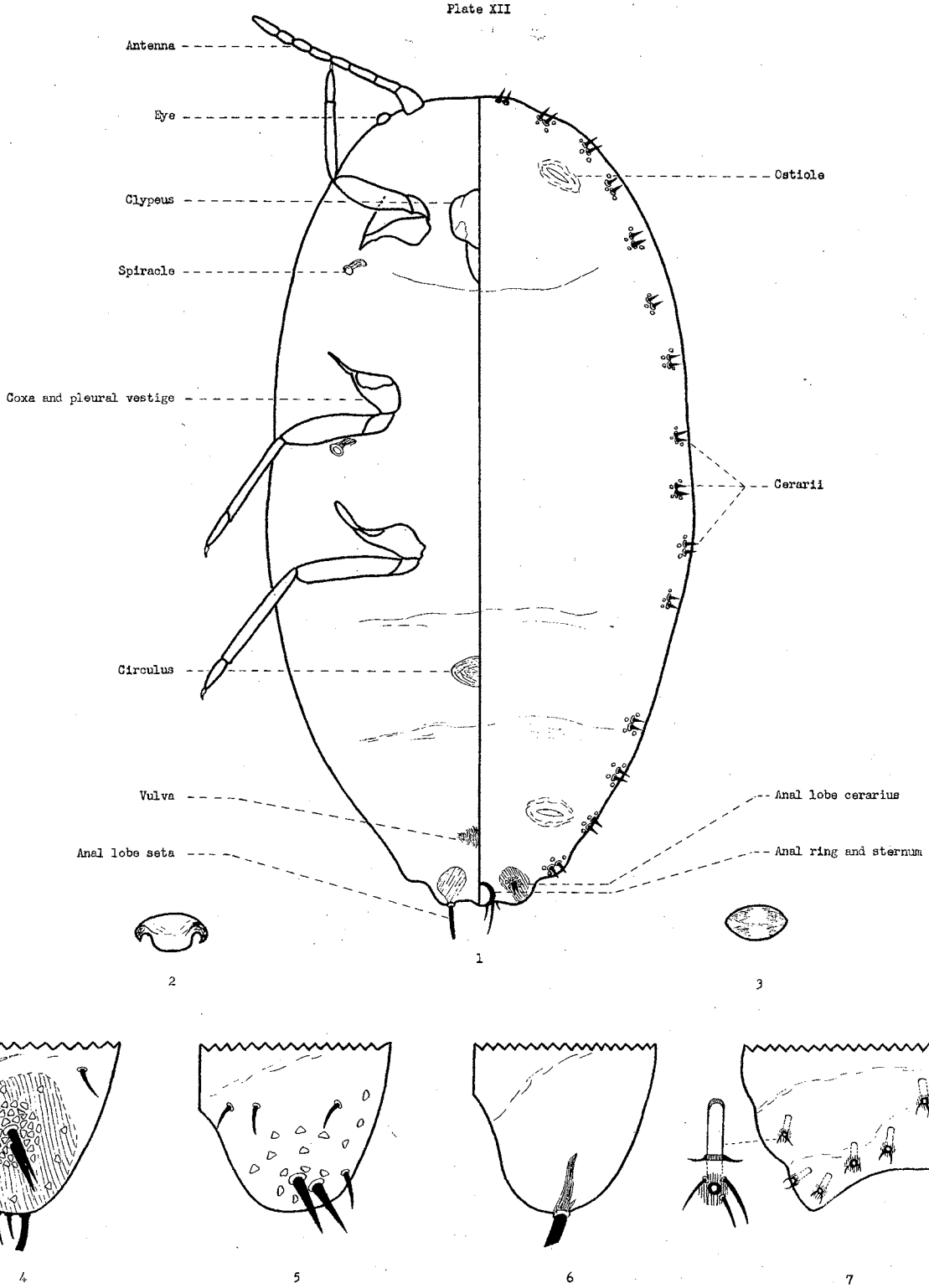
1-B

Plate XII

Pseudococcidae

1, General morphology of an adult female mealybug. 2, Circulus of Phenacoccus gossypii. 3, Circulus of other species found. 4, Anal lobe cerarii of Phenacoccus adonidum. 5, Anal lobe cerarii of Planococcus citri. 6, Sclerotized bar in base of anal lobe setae of Planococcus citri. 7, Dorsal tubular ducts of Ferrisiana virgata, after (Ferris, 1950).

Plate XII


Antenna
Eye
Clypeus
Spiracle
Coxa and pleural vestige
Circulus
Vulva
Anal lobe seta
Ostiole
Cerarii
Anal lobe cerarius
Anal ring and sternum
1
2
3
4
5
6
7

VITA

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