SCALE INSECTS (HOMOPTERA, COCCOIDEA) IN KANSAS GREENHOUSES

by

EUGENE HOMER DAVIDSON

B. S., Colorado State College
of Agriculture and Mechanic Arts, 1950

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1951

TABLE OF CONTENTS

INTRODUCTION

Few groups of insects are of more outstanding importance as pests of plants than those specialized members of the order Homoptera comprising the superfamily Coccoidea, commonly called scale insects and mealy bugs. This is particularly true under greenhouse conditions, where there are few plants that are not subject to their attacks. Under the warm, humid conditions of the greenhouse, these insects find conditions at an optimum for their development and even the tropical species are often able to flourish in temperate regions. Furthermore, the transfer of infested greenhouse plants to non-infested greenhouses frequently results in new introduction of these tiny insect pests. It is the purpose of this paper to consider the general problem of greenhouse scales and mealy bugs in the state of Kansas, particularly to bring their nomenclature up to date and to provide keys and illustrative material which will permit their ready identification.

The state of Kansas is fortunate in having had a number of pioneer workers concerned with the Coccoidea, as well as several more recent workers. In 1899, Professor S. J. Hunter of the University of Kansas presented a paper "Coccidae of Kansas", in which he recorded 36 species. A great portion of the paper dealt with host-plant lists but several species described were new to science. A classic paper, "Scale Insects from Kansas Grasses", was published by P. J. Parrot of Kansas State College in 1900. In this paper several species new to science were described.

Professor George A. Dean of Kansas State College presented a check list of scales in Kansas in 1903, and in 1917 Dr. Paul B. Lawson of the University of Kansas published his fine taxonomic paper, "The Coccidae of Kansas." The latter paper included keys to all the species known at that time to occur in Kansas, as well as descriptions of every species, usually the original description.

Since 1917 very little work has been done on scales in Kansas, possibly due to the thorough job done by Lawson. The general study of scale insects has, however, undergone many important changes since 1917. New techniques are being employed, and different terms for the descriptions of the morphological details are in use. The Coccidae have been elevated from a family to a superfamily, the Coccoidea, and the subfamilies elevated to families; most of the genera, too, are construed differently from that of a few decades ago. The time therefore seems ripe for a restudying of the scales of Kansas in the light of these new developments. It is also desired to include such new species and records of Kansas scales as have come to light since 1917.

Because of the large number of species in this superfamily in Kansas, the present paper concerns itself only with the scale insects inhabiting a single ecological niche - the greenhouse.

In order to make this paper useful to as many people as possible, an attempt has been made to make it relatively nontechnical. A field key is included, which may be of some use to the greenhouse horticulturist, but such superficial characters as are

observed with a hand lens are not always an accurate way of identifying scales. The host list provided includes most of the more common greenhouse plants, though it does not pretend to be complete. By using this list one can frequently classify a species more quickly and easily. The descriptions given for each species include only the outstanding characters. This was done to avoid repetition and to make it easier for the non-technical person to classify scales. By familiarizing oneself with the plates and the section on nomenclature, it should be possible to understand the terms used in the keys and descriptions. Because male scales are relatively rare, all descriptions and keys refer to the female scale unless otherwise stated.

RESUME OF IMPORTANT LITERATURE IN THE CLASSIFICATION OF SCALE INSECTS

There is a vast amount of world literature on the Coccoidea. The earliest paper of any importance was that published by Targioni Tozzetti (1868). In this publication, which is written in Italian, four groups were recognized: Orthezites, Coccites, Lecanites, and Diaspites. In 1875 the French worker Signoret presented a complete study of the Coccoidea, which he divided into 17 sections. Professor J. H. Comstock, in 1881, followed Signoret's work but ranked the sections as subfamilies.

W. M. Maskell presented many papers between 1879 and 1897, based on work done in New Zealand in which he recognized eleven

divisions of the Coccoidea. In 1896, T. D. A. Cockerell, in his "Check-list of the Coccidae", identified ten subfamilies. He substituted the Asterolecaniinae for Lecanococcidae of Maskell. This is worth noting since the use of the Asterolecaniinae as a subfamily showed a trend toward present day classification. Green (1896-1909) published four volumes of his "Coccidae of Ceylon" and proposed the following eleven subfamilies: Conchaspinae, Diaspinae, Lecaninae, Hemicoccinae, Dactylopiinae, Tachordiinae, Coccinae, Idiococcinae, Brachysceliinae, Orthezиinae, and Monophlebinae. Tachardiinae was a new subfamily which included the lac insects. Each volume has excellent color illustrations. Newstead (1901) in his "Coccidae of the British Isles", adopted the classification of Green.

Mrs. M. E. Fernald (1903) published the first "Catalog of the Coccidae of the World," in which nine subfamilies were recognized. Lindinger (1912) presented the first book from Germany on scales, including many excellent photographs and illustrations. Between 1905 and 1920 many papers were written by various authors but they covered localized areas or certain small groups. MacGillivray, in 1921, published an important book called simply "The Coccidae". His classification included 16 subfamilies as follows: Monophlebinae, Margarodinae, Kuwaniinae, Tylococcinae, Callipappinae, Coccinae, Cylindrococcinae, Orthezиinae, Phenacoleachiinae, Tachardiinae, Apiomorphinae, Eriococcinae, Kermesiinae, Lecaniinae, Conchaspinae, and Diaspidinae.

Very little work was done on classification from the date of MacGillivray's work up to 1937, when G. F. Ferris began his extensive monograph, the "Atlas of Scale Insects of North America." He advanced the family Coccidae, to a superfamily, the Coccoidea, and recognized eleven families; Margarodidae, Orthezиidae, Lacciferidae (Tachardiidae), Kermidae, Dactylopiidae, Pseudococcidae, Aclerdidae, Asterolecaniidae, Coccidae, Conchaspidae, and Diaspididae. The keys and descriptions in the present paper have been taken and modified from Ferris' very important "Atlas".

LIFE HISTORY

In order to understand the habits, appearance, and various stages of scale insects, it is necessary to know something about their life cycle. The armored scales (Diaspididae) have approximately the same life cycle in all species. Reproduction takes place usually by laying eggs, although a few species produce living young. The females of the oviparous species lay their eggs under the scale and shortly after the last egg is laid, the shriveled female dies. The young called "crawlers", crawl a short distance from beneath the parent scale, actively seek a suitable place on the host plant, and upon finding this location, insert their mouth parts into the plant and commence feeding by sucking out the sap. At this stage the crawlers have distinct legs and antennae.

As soon as the crawler has inserted its beak, it begins to secrete coarse cottony threads from the anterior end of the body and smaller threads from the posterior end. These threads form a net over the insect. After feeding a short time, the females molt and lose their legs and antennae. The cast skin is incorporated into the protective scale-like covering where it serves as the inside lining for the body of the scale insect. The female molts twice, remaining under the protective scale and never moving to a new location.

The male crawlers appear identical with the females until the first molt but they retain their antennae and legs. The male scale goes through four molts and finally emerges as a well developed, winged insect (Plate X, Fig. A). They do not feed as adults but move about actively seeking female scales to mate with and after mating, they die. The female is ready to reproduce shortly after mating.

The soft scales (Coccidae) do not form a covering of wax that is separate from the body wall, but the body wall itself serves as the protective covering. The soft scales have prominent antennae and legs during their entire life. Both sexes are active during all immature stages and are able to migrate from one plant to another. The adult female is unable to crawl after the eggs have formed under her body. The adult males resemble the males of the armored scales.

The mealybug, with the exception of the long-tailed mealybug, lay eggs. P. adonidum reproduces by birth of nymphs

(ovivivíparous). The citrus mealybug, P. citri, adults deposit eggs in a cottony, waxy sack under the posterior end of the body. Shortly after this the adult dies. The eggs hatch in approximately one week and the nymphs remain in the sack for a short time and then crawl over the plant, feeding and moving from one part to another. The nymphs are oval, cream colored, and have smooth bodies. Within a short time they begin to excrete a waxy, white, cottony substance which covers their body. From this stage on, the nymphs differ little in appearance from the adults except in size. The males resemble other male scale insects.

CONTROL OF GREENHOUSE SCALES

There are few plants cultivated under glass which are not subject to scale attack. Under the ideal conditions of the greenhouse, scales have a short life cycle and build up in large numbers very rapidly.

A routine control program should be set up and followed in order to get satisfactory control. This program should include a periodical application of some insecticide. Unsatisfactory control of scales occurs when these insects are allowed to become established in large numbers before they are dealt with. A monthly spray or fumigant should be applied whether the scales are visually present or not.

Difficulties arise in the eradication of scales and mealy bugs because the eggs and young nymphs are protected by the waxy

covering of the parent. Often the feeding habits of these insects make them difficult to control successfully because they feed in the axils and folds of leaves.

The best control, if it is practical, is to remove the scales from the plant. This can be done if there are relatively few plants but it is not plausible when a large number of plants are concerned. Soap and water, applied with hand brushes, can be used for this process, or a stream of water will remove certain species of scales and mealy bugs. After most of the scales have been removed in this way the plants should be transferred to a small room where they can be sprayed with a nicotine wash consisting of 1/2-3/4 oz. nicotine in 10 gallons of water with an emulsifying agent. The plants should be drenched. A white oil spray may be used instead of the nicotine (Miles, 1948).

One difficulty in spraying greenhouse plants is that many species of plants are injured by these toxic sprays. Dietz (1916) recommended spraying palms and other plants not burned by oils with fish oil or cotton seed oil emulsion in the following amounts: oil, one gallon; soap, one pound; water, ten gallons. Mealy bugs can be controlled by nicotine sulphate 1-400 and an emulsifier. Metcalf and Flint (1939) recommend a thiocyanate spray which is non-injurious to plants.

Fumigation is the best control for large numbers of plants but it has the disadvantage of having toxic effects on some plant species. Sodium cyanide or calcium cyanide (1/4-1/3 oz. per 1,000 cu. ft.) will give good control.

DDT gives successful control of some scales, but its use is limited to the genera Lepidosaphes, Parlatoria, Chrysomphalus, Diaspis, Coccus, and Saissetia (Keifer, 1946)

Parathion in aerosols used at the rate of 1 gram to 1000 cu.ft. of air space has been used for greenhouse insect control. The temperature should be 70°-85° F. and the insecticide should be allowed to act upon the insects for about four hours. Parathion is limited in its use because it is not toxic to as many species of scales as calcium cyanide (Smith et al., 1948).

TECHNIQUE FOR MOUNTING SCALES

The characters of taxonomic value of the superfamily Coccoidea are microscopic and therefore require special preparation before they can be studied under the microscope. The scale insect bodies, whether large or small, have many structures that are vestigal or of microscopic size; therefore, in order to see these structures, the scale bodies must be cleared and the wax excretion removed. Many specimens used for study will be dried up females that have laid their eggs and died. By treating these with certain chemicals, their bodies can be restored to their original shape and size. The method proposed by Nye (1947) has been used by the present worker except for a few modifications, and is described below.

The first step in preparation of armored scale insects is to remove the insect from the waxy covering. This should be done

under a binocular microscope with a needle or pin. With soft scales the waxy covering comprises part of the body and hence does not have to be removed.

Next drop the insect in a ten percent KOH solution and leave it for 24 hours. This period can be shortened by heating the KOH solution but there is danger of getting it too hot and the scales will boil out. If the insect is heated in KOH it will take 10-15 minutes depending on the species. The KOH solution clarifies the insect.

Transfer the insect from the KOH to a 10 percent acetic acid solution in order to dehydrate the insect. Leave the scale in this solution for 10 minutes then change the solution to a 100 percent glacial acetic acid and subject the scale to two solutions of this strength for 10 minutes each. Following this the insect can be stained. Gage (1919) proposed the following stain; säurefuchsin, 0.5 gram; HCl (10%), 25cc; and distilled water, 300 cc. The time required to stain the scale will depend on the species but it should not take over 5 minutes. If over-stained, the insect can be cleared by placing it in KOH again. From the stain, place the scale in the 100 percent glacial acetic acid solution for 5 minutes.

Subjecting scales directly to balsam causes shrinking and formation of bubbles in the body. Therefore, dilute premounting mixtures allow the balsam to slowly infiltrate to all parts of the body before it is mounted in pure balsam. The premounting mixtures consist of balsam and carboxylol (pure carbolic acid

crystals, 1 part; xylol, 3 parts by volume), in varying amounts. Transfer the scale from the glacial acetic acid to 10 percent balsam plus 90 percent carboxylol for 5 minutes. The amount of balsam is increased to 25 percent in the next solution and then 50 percent, with carboxylol making up the rest of the 100 percent. Leave the insect in each solution for 5 minutes.

From the 50 percent balsam the insect is placed in pure balsam on a slide. Not over four or five scales should be placed on one slide. A cover slip is placed over the scales and pressed down firmly to get all excess balsam from beneath. The slides should remain flat for about a month in order for the balsam to harden.

Great care should be taken in labeling the slide with the essential data that is pertinent to the scale insect mounted. Gummed linen or rag paper labels should be used because they do not discolor or come off over a long period of time. Two labels should be applied to each slide, one at each end of the slide. It is desirable to use India ink in lettering the labels. The right hand label should contain the scientific name of the scale insect, the name of the determiner, and the date of the determination. On the left hand label should be printed the host plant name, locality, date, and name of collector.

MORPHOLOGY AND TERMINOLOGY

Diaspididae

In all Coccoidea, there is a tendency for all the body segments to fuse together and thus the head, thorax, and abdomen are not distinct regions. The head, prothorax, and mesothorax are closely combined and this region is referred to as the prosoma. The abdomen is composed of eleven segments, only eight of which are visible, segments 9-11 being greatly reduced in size. The median lobes are present on the eighth segment. The pygidium is formed by the segments anterior to the ninth, bending posteriorly around segments 9-11. Abdominal segments 5-11 are usually included in the pygidium and this structure is clearly definable from the other parts of the body.

The legs, antennae, and eyes are absent in most species but are present as vestigial structures in a few genera. The mouthparts, comprising the rostrum, are attached to the prothorax and appear as a U-shaped structure. These structures are not used in classification.

The pygidial lobes are flattened, rounded, sclerotized processes arising from the lateral margins. The number of lobes varies depending on the species. The median lobes appear at the apex of the pygidium and are a part of the eighth abdominal segment. If a second and third pair of lobes appear they belong to the seventh and sixth segments respectively. A fourth pair may be present on the fifth segment. Other marginal processes

are present on the pygidium. These structures are classified as plates and gland spines. The gland spines appear only in the tribe Diaspidini and are elongated, conical structures with a single microduct opening at the apex. The plates are present in the tribe Aspidiotini and are broad, fringed, or branched. A single microduct pore terminates at the apex of one of the fringes of each plate. Sclerotized areas along the margin of the pygidium appear as slender, elongated processes and are called paraphyses.

Wax used in the detachable part of the scale is produced by glands which open through ducts. These ducts are located on the pygidium and may also be present on other abdominal segments and on the prosoma. The term macroducts refers to the larger ducts, while the term microducts refers to the smaller ones, which are so small as to be very difficult to detect. These ducts are crossed by either one or two narrow, sclerotized areas, and are said to be either 1-barred or 2-barred.

The anus is a circular opening without setae around it, located on the dorsal side of the pygidium. The vulva is situated in the same area but opens on the ventral side of the pygidium. In many species perivulvar pores in four or five groups are located at a short distance around the vulva. (Plate II, Fig. A, B, C).

Coccidae

The body of the "soft scales" is said to be naked although it is covered with a small amount of wax. It does not have the detachable, waxy covering that the "armored scales" do. There is no indication of segmentation and hence the three body regions are indistinguishable.

The antennae usually consist of six to eight segments and are well developed (Plate I, Fig. B). The mouth parts are similar to those of other scales. The legs are present and well developed. Both the antennae and legs are easily detected under a microscope. Wax pores are numerous but have no special significance in classification.

A very striking character in the structure of the "soft scales" is the anal cleft which is a longitudinal slit extending from the apex of the abdomen to the anus. Other outstanding characters are the two anal plates covering the anal setae on the dorsal side. Each plate is frequently referred to as an operculum. The anus is located anterior to the plates and is surrounded by an anal ring which bears 6-10 anal setae. An anal tube extends from the anus to the plates. Various setae of the anal plates are used in classification. The posterior end of the anal tube bears two to four fringed setae on each anal plate. Apical setae appear at the apex of the anal plates and subapical setae appear between the fringed setae and apical setae (Plate I, Fig. A, B, D, F).

Pseudococcidae

The body segmentation of the mealy bugs is distinct. The legs, antennae, and mouth parts are well developed. The wax pores, or cerores, are used in classification because they differ in shape, and the setae around them differ in number. The cerores are arranged in rows along the lateral margins of the insect.

An anal ring is present with 6 anal setae. The anal ring bears wax glands which are present in two rows (Plate I, Fig. C). An anal lobe is present on either side of the anal ring. Present on the anal lobes are setae, usually as long as the anal setae, or longer.

FIELD KEY TO SPECIES

1. Female not flat or covered by exuviae (incorporated moulted skins); large scales 2
Female small, usually flat, covered by easily detached exuviae (incorporated moulted skins); small scales 8

2. Legs long and prominent; body covered with heavy white, waxy lamellae, the posterior ones overhanging a marsupium or pouch; body olive green (Plate III, Fig. B) . . . . Orthezia insignis Douglas
Legs shorter; not covered with heavy, white, waxy lamellae; marsupium absent 3

3. Body covered by a white mealy secretion; body with filaments extending from the margin 4
Body not covered by a white mealy secretion; no filaments; caudal portion of abdomen cleft 5

4. Marginal filaments short, all about the same length (Plate III, Fig. A) Citrus mealybug (Pseudococcus citri Risso)
Marginal filaments same as P. citri except four very long filaments at tip of abdomen . . . . Long tailed mealybug (Pseudococcus adonidum Linn.)

5. Body slightly convex, almost flat, light in color . . 6
Body strongly convex and hemispherical, color darker 7

6. Body relatively short and oval (Plate IV, Fig. A) . . . . Soft scale (Coccus hesperidum Linn.)
Body elongated . . . . Coccus elongatus Sign.

7. Dorsum with one distinct longitudinal ridge and two transverse ridges forming an "H"; very dark brown in color . . . . . Black scale (Saissetia olea Bernard)

Dorsum smooth; color lighter (Plate IV, Fig. A) . . . . . Hemispherical scale (Saissetia hemisphaerica Targ.)

8. Scale circular, flat; color light brown to gray or white 9

Scale oval or elongated; color variable 16

9. Scale with exuviae central 10

Scale with exuviae subcentral or near one end 13

10. Scale white; exuviae dark; host: Cactaceae (Plate VI, Fig. A) . . . . . Cactus scale (Diaspis echinocacti Comst.)

Scale dark or yellow colored; not occurring on cactus 11

11. Exuviae of scale semitransparent, allowing the red or orange outline of the adult female to show through; principal host citrus (Plate VI, Fig. B) . . . . . California red scale (Aonidiella aurantii Mask.)

Exuviae not semitransparent; principal host not citrus; exuviae nipple shaped 12

12. Scale very dark brown in color, central exuviae paler (Plate VII, Fig. A) . . . . . Florida red scale (Chrysomphalus ficus Ashmead)

Light brown or yellow, flat and thin; exuviae dark . . . . . Dictyospermum scale (Chrysomphalus dictyospermi Morgan)

13. Scale convex 14

Scale flat 15

14. First exuviae very distinct from the other exuviae being placed to one side; scale has slightly tilted appearance; color white to gray; principal host palm . . . . . Hemiberlesia lataniae (Sign.)

First exuviae not distinct; scale has a strongly tilted over appearance; color gray; principal host orange . . . . . Hemiberlesia rapax (Comst.)

15. Scale white, semitransparent and quite thin. . . . . Diaspis boisduvalii Sign.

Scale white or gray, not transparent; outline of scale often irregular (Plate VII, Fig. B). . . . . Oleander scale (Aspidiotus hederae Vall.)

16. Scale oval, flat, brown in color 17

Scale elongated; exuviae terminal 19

17. Scale having central exuviae; brownish yellow; semitransparent; young scales may be circular (Plate VIII, Fig. A). . . . . Hemiberlesia cyanophylli Sign.

Exuviae not central 18

18. Exuviae subcentral, second exuviae not large, scale thick; gray to brown. . . . . Chaff scale (Parlatoria pergandii Comst.)

Exuviae terminal; scale thin and delicate, semitransparent; second exuviae larger, yellowish brown (Plate V, Fig. B) (Plate VIII, Fig. B) . . . . . Parlatoria proteus (Curtis)

19. Scale elongated but very broad at posterior end; host ferns . . . . . Fern scale (Pinnaspis aspidistrae Sign.)
Scale very long and only slightly broadened at posterior end if at all; host citrus 20

20. Scale very long and slender; size up to 3 mm. (Plate V, Fig. A). Glover scale (Lepidosaphes gloverii Packard)
Scale slightly broadened toward posterior end . . . . . Purple scale (Lepidosaphes Beckii Newman)

COMMON HOST PLANTS OF GREENHOUSE SCALE INSECTS

Begonia - Coccus hesperidum.

Cactus - Aspidiotus hederae, Chrysomphalus ficus, Diaspis boisduvalii, Diaspis echinocacti.

Coleus - Orthezia graminis, Pseudococcus citri.

Ivy - Aspidiotus hederae, Chrysomphalus dictyospermi, Chrysomphalus ficus, Coccus elongatus, Coccus hesperidum, Hemiberlesia cyanophylli, Parlatoria proteus, Pseudococcus citri, Saissetia olea.

Ferns - Coccus hesperidum, Pinnaspis aspidistrae, Pseudococcus adonidum, Saissetia hemisphaerica.

Oleander - Chrysomphalus ficus, Coccus hesperidum, Saissetia hemisphaerica, Saissetia olea.

Orchid - Aspidiotus hederae, Chrysomphalus dictyospermi, Coccus hesperidum, Diaspis boisduvalii, Hemiberlesia cyanophylli, Parlatoria proteus.

Palm - Chrysomphalus ficus, Diaspis boisduvalii, Hemiberlesia cyanophylli, Hemiberlesia lataniae, Saissetia hemisphaerica.

Rubber plant - Chrysomphalus dictyospermi, Coccus hesperidum.

KEY TO FAMILIES AFTER FERRIS (1942)

1. Adult female covered by a secreted waxy scale into which the exuviae are incorporated; abdominal segments terminating in a pygidium; antennae vestigial and legs lacking or vestigial; anal ring non-setigerous and anus without plates; sessile . . . . . Diaspididae

Adult female not covered by a secreted waxy scale (exuviae); no pygidium; legs and antennae normal 2

2. Adult female with operculum; caudal portion of abdomen cleft (Plate X, Fig. B) . . . . . Coccidae

Adult female without operculum; abdominal extremity not cleft; anal ring setigerous 3

3. Adult female long legged; body covered with heavy, white, waxy lamellae; marsupium present. . . . . Ortheziidae

Adult female short legged; without waxy lamellae; marsupium absent; covered by a waxy secretion; anal lobes present . . . . . .Pseudococcidae

FAMILY ORTHEZIIDAE

Genus Orthezia Bosc.

Generic Characters. The adults are very active. Body covered with white lamellae which form an ovisac or marsupium at the posterior extremity of the body. Legs long. Antennae seven to eight segmented.

Species Description. (A) Orthezia insignis Douglas.

1887 Orthezia insignis Douglas. Ent. Month. Mag. 24:95-101.

1903 Orthezia insignis Fernald. Mass. Hatch Expt. Sta. Bul. 88:34.

1925 Orthezia insignis Morrison. Jour. Agr. Res. U.S.D.A. 30 (2):144.

Body color dark green or black; body short, oval shaped, surrounded by a marginal group of snow white lamellae, the anterior ones (first three) much reduced in size, gradually increasing in length posteriorly, the posterior ones elongated and overhanging the marsupium, the middle three posterior lamellae shorter with the middle one being the shortest. Dorsal side of body bare except for two longitudinal narrow lines of short, white lammellate projections; these lines begin at the base of each antennae and extend backward a short distance and then converge, but then curve out again and remain that way to the posterior part of the body. Marsupium narrowed posteriorly, more or less ribbed dorsally, its length sometimes nearly twice that of the body.

This scale was discovered in the Kansas State College collection. It was collected at Linsborg, Kansas, Jan. 25, 1926, on Coleus. This is the first report of this scale in the state although it is a common insect in greenhouses of surrounding states. This species is very destructive to coleus, Lantana, Verbena, and Chrysanthemum because it has well developed legs and is active in all life stages (Plate III, Fig. B).

FAMILY PSEUDOCOCCIDAE

Genus Pseudococcus Westwood

Generic Characters. Anal ring of six hairs; anal lobes present but not prominent. Legs short and well developed. Antennae seven or eight segmented.

Key to Species. The following key is for those species of Pseudococcus found in Kansas.

1. Hair of anal lobes twice as long as the anal ring hairs . . . . . citri

2. Hair of anal lobes short and not any longer than anal ring hairs . . . . . adonidum

(A) Pseudococcus citri (Risso). "Citrus mealybug".

1813 Dorthesia citri Risso. Essai Hist. Nat. desOranges.

1903 Pseudococcus citri Fernald. Mass. Hatch Expt. Sta. Bul. 88:99.

1917 Pseudococcus citri Lawson. Kans. Univ. Bul. 18:177.

Marginal wax filaments subequal and short, except those on the anal lobes which are slightly longer. Body with at least 17 pairs of wax pores, each with two conical shaped spines and those on the anal lobes with two setae in addition. Anal ring with two rows of wax pores on outer and inner margin (Plate I, Fig. C). Antennae eight segmented.

This species is the common mealybug or citrus mealybug of the greenhouse. It is a common insect all over the state and prefers to feed upon the tender, growing tips of plants, the upper and lower surfaces of leaves, and at the base of the leaf stems and branches. This species was first recorded in the state by Dean from the Kansas State College greenhouse on lemon and orange. Most greenhouse plant species are attacked but the soft foliage plants are more susceptible such as coleus, fuchsia, cactus, croton, fern, gardenia, begonia, and geranium (Plate III, Fig. A).

(B) Pseudococcus adonidum (Linn.).

1762 Coccus adonidum Linnaeus. Syst. Nat. Ed. 12, p. 140.

1903 Pseudococcus longipinus Fernald. Mass. Hatch Expt. Sta. Bul. 88:104.

1909 Pseudococcus adonidum Sanders. Jour. Econ. Ent. 2:431.

1911 Pseudococcus longipennis Douglas. 4th Rpt. Ind. State Ent., p. 159.

1917 Pseudococcus adonidum Lawson. Kans. Univ. Bul. 18:196.

Four anal filaments very long, sometimes as long as the body. Body with a brown band over the middle of the back. Seventeen pairs of wax pores present and with more than two setae to each

wax pore. Anal lobe setae shorter than anal ring setae. Antennae eight segmented.

This species is referred to as the long tailed mealybug and gets its name from the four anal filaments which may be as long as the body. This species differs from P. citri in that it produces its young alive. Its habits of feeding and host selection are the same as P. citri. Dean reported this species to be common in almost every conservatory in the state but Lawson, with whom the writer agrees, stated that the long tailed mealybug was very rare.

FAMILY COCCIDAE

Genus Coccus Linn.

Generic Characters. Body slightly convex, oval, or elongated. Derm pores small and scattered. Antennae and legs well developed. Anal ring with eight hairs; pair of dorsal anal plates present.

Key to Species. The following key is for those species of Coccus found in Kansas.

1. Body oval; antennae eight segmented . . . . hesperidum
Body long; antennae seven segmented. . . . . elongatus

(A) Coccus hesperidum Linn. The "Soft scale."

1758 Coccus hesperidum Linnaeus. Syst. Nat. Ed. 10, p. 455.
1880 Lecanium hesperidum Comstock. Rpt. U.S.D.A., p. 358.

1917 Coccus hesperidum Lawson. Kans. Univ. Bul. 18:196.

Body color yellow-brown. Anal plates narrow, twice as long as broad, the angles rounded; a small V-shaped angle is formed at the anterior end of the plates where they come together; two fringe setae, three to four subapical setae, and four very small apical setae to each plate (Plate I, Fig. A). Anal ring with eight long anal setae. Antennae seven segmented.

This scale is a common insect all over the state and is known as the soft scale. Its recorded hosts number 75, of which the following are the most common: rubber plant, oleander, citrus, English ivy, and ferns. This species is ovoviviparous, producing one or two young daily for a period of one month, and does most of its feeding on the stems and mid-ribs of leaves. Besides the injury to a plant by sucking the sap, this serious pest excretes a honey dew upon which a black fungus grows, making the plant unsightly. First report of this scale in Kansas was by Dean (Plate IV, Fig. B).

(B) Coccus elongatus (Sign.).

1873 Lecanium elongatum Signoret. Ann. Soc. Ent. Fr. 5(3):404.

1903 Coccus longulum Fernald. Mass. Hatch Expt. Sta. Bul. 88:171.

1909 Coccus longulus Dean. Kans. Acad. Sci. Proc., p. 267.

1917 Coccus elongatus Lawson. Kans. Univ. Bul. 18:197.

Body color yellowish brown to dark brown. Anal plates one-third longer than broad; four sub-apical, one discal, three apical setae, and four fringe setae on each plate (Plate I, Fig.D).

Antennae eight segmented with the third segment the longest and without setae (Plate I and X, Fig. B).

This species was first recorded by Dean on Arbutilon, at the Kansas State College greenhouse. It does not rank as a serious pest because a fungus disease, caused by Isaria lecanifera, attacks it and keeps its numbers low. The elongated body and discal setae on the anal plates will separate it from C. hesperidum.

Genus Saissetia Deplanches

Generic Characters. Body strongly convex and almost hemispherical. Derm closely crowded with circular or oval pores. Anal ring with eight hairs.

Key to Species. The following key is for those species of Saissetia found in Kansas.

1. Derm pores small and separated (Plate I, Fig. E); dorsum without any ridges; antennae seven segmented . . . . . hemisphaerica

Derm pores large and touching each other (Plate I, Fig. F); dorsum with one longitudinal and two transverse ridges to form an "H"; antennae eight segmented. . . . . .oleae

(A) Saissetia hemisphaerica (Targ.) "Hemispherical scale".

1867 Lecanium hemisphaerica Targioni. Studii sul Cocc., p. 27.

1896 Lecanium coffeae Green. Coco. Ceylon 1:1.

1899 Saissetia hemisphaerica Cockerell. Proc. Acad. Nat. Sci. Phila., p. 270.

1903 Lecanium hemisphaerica Thro. Cornell Univ. Agr. Expt. Sta. Bul. 209:215.

1917 Saissetia hemisphaerica Lawson. Kans. Univ. Bul. 18:200.

Body elliptical; dark brown. Anal plates twice as long as broad; each plate with three apical setae, two or three subapical setae, and one discal setae; four fringe setae on each plate. Antennae eight segmented.

This species is known as the hemispherical scale and can be very serious at times, although it is generally considered of secondary importance to the floriculturists. It occurs on a considerable variety of hosts, particularly ferns, Chrysanthemum, and oleanders. It is much more common than S. oleae, occurring all over the state; it may be confused with S. oleae except for not having the "H" on the dorsum. Males are rare in this species and reproduction is generally by parthenogenesis. The eggs (400-500) are laid beneath the female's body. Dean recorded this scale from greenhouses all over the state on ferns (Plate IV, Fig. A).

(B) Saissetia oleae (Bernard). "Black scale".

1782 Chermes oleae Bernard. Mem. d'Hist. Nat. Acad. Marseille, p. 108.

1881 Lecanium oleae Comstock. Rpt. U.S.D.A., p. 336.

1917 Saissetia oleae Lawson. Kans. Univ. Bul. 18:200.

Body oval in form, black with one median and two transverse ridges in the form of an "H" on dorsum. Anal plate with four sub-apical setae, three apical setae, one discal seta; four fringe setae on each plate. Antennae eight segmented.

This greenhouse scale insect is known as the black scale and is a very important pest in the temperate regions but in Kansas greenhouses it is not abundant, although the literature implies this. The presence of an "H" on the dorsum will separate S. oleae. The scales appear on the stems and mid-ribs of leaves. Honey dew is given off in great abundance and attracts other insects. The female lays an average of 2,000 eggs over a period of one month. The young grow slowly, requiring six to eight months to reach maturity. Its known hosts are numerous but in this state Ficus, oleander, and poinsetta are the principal hosts. Dean recorded it first on oleanders in Kansas State College greenhouses.

FAMILY DIASPIDIDAE

Key to Tribes and Genera

1. Macroducts 2-barred; second pygidial lobes with some indication of being bilobed (except in Parlatoria); gland spines present . . . . . (Diaspidini) 2
Macroducts 1-barred; second pygidial lobes not bilobed; fringed plates present . . . . . (Aspidiotini) 5

2. Median lobes united by a sclerotic yoke at base . . . . . Pinnaspis

Median lobes not yoked together 3

3. Gland spines short, broad, and fringed with teeth of unequal length . . . . . Parlatoria

Gland spines narrow and single toothed 4

4. Body elongated, spindle shaped; second lobe present and bilobed; third lobe only a sclerotized point . . . . . Lepidosaphes

Body conical; second and third lobes present and both bilobed . . . . . Diaspis

5. Pygidium with paraphyses lacking; three pairs of lobes present; fourth lobe not even present as a point . . . . . Aspidiotus

Pygidium with paraphyses arising from bases of lobes or between lobes; at least three pairs of lobes present, more lobes sometimes indicated by a point 6

6. Three pairs of well developed lobes present 7

Median lobes well developed, but second and third lobes represented only by non-sclerotized points . . . Hemiberlesia

7. Cephalothoracic lateral lobes partially enclosing pygidium; perivulvar pores lacking . . . . Aonidiella

Prosoma normal; perivulvar pores present . . . . Chrysomphalus

Genus Diaspis Costa

Generic Characters. Body oval. Pygidium with three pairs of well developed lobes, the second and third pygidial lobes bilobed. A prominent gland spur is present on the fourth abdominal segment. Dorsal ducts 2-barred; marginal ducts of pygidium arranged with one duct between median and second lobes, and a pair of ducts at the base of the third lobes. Gland spines small. Five groups of perivulvar pores present, (Plate II, Figs. B,C).

Key to Species. The following key is for those species of Diaspis found in Kansas.

1. Median lobes of pygidium widely separated and forming a deep notch by their retraction into the apex of the pygidium (Plate II, Fig. B); lateral lobes present on prosoma (Plate II, Fig. C) . . . . . boisduvalii

Median lobes of pygidium widely separated but not forming a deep notch; no lateral lobes . . . . . echinocacti

(A) Diaspis boisduvalii Signoret.

1869 Diaspis boisduvalii Signoret. Ann. Soc. Ent. Fr. 4(9): 432.

1917 Diaspis boisduvalii Lawson. Kans. Univ. Bul. 18:243.

1937 Diaspis boisduvalii Ferris. Atlas Scale Insects No. Amer. 1:32.

Body conical in shape. Prosoma with a lateral lobe on each side. Pygidium with three pairs of small, well developed lobes.

Median lobes well separated and retracted within the pygidium so that the apices extend barely beyond the apex of the pygidium, inner margins fringed. Dorsal marginal ducts short and very broad; a prominent dorsal duct opens between median lobes. Each perivulvar pore group with 16-20 pores. Lateral spur well developed (Plate II, Fig. B,C).

This scale is a common scale in greenhouses all over the state and when a specimen of Diaspis is taken from palms, orchids, or any other greenhouse plant, and has lateral lobes on the prosoma, the species is D. boisduvalii. Eighty percent of the host plants in Kansas are either palms, cactus, or orchids. Dean recorded this species for the first time in the state on palms in the Kansas State College conservatory.

(B) Diaspis echinocacti Bouché. "Cactus scale".

1851 Diaspis echinocacti Bouche. Stett. Ent. Zeit xii, III.

1883 Diaspis cacti Comstock. 2nd Rpt. Ent. Cornell Univ., p. 91.

1904 Diaspis echinocacti cacti Sanders. Proc. Ohio Acad. Sci. 4, Sp. Papers 8:52.

1917 Diaspis echinocacti cacti Lawson. Kans. Univ. Bul. 18:244.

1937 Diaspis echinocacti Ferris. Atlas Scale Insects No. Amer. 1:36.

Body conical in shape. Lateral lobes absent from prosoma. Median lobes of pygidium small but prominent and not sunken into apex, second and third lobes bilobed and about same size as median lobes. Submarginal dorsal ducts numerous on 4th and 5th abdominal

segments. Each perivulvar group with 13-28 pores. Lateral spur very small.

Wherever the family Cactaceae occurs in Kansas greenhouses the cactus scale, as it is known, is found. All species of cactus are attacked by this scale, and these are the only hosts. This species can be separated from all others by this fact except in rare cases when D. boisduvalii attacks cactus. Dean reported this species for the first time in Kansas on cactus in Kansas State College conservatory (Plate VI, Fig. A).

Genus Lepidosaphes Shimer.

Generic Characters. Body elongated and spindle-shaped. Pygidium with two pairs of well developed lobes, median lobes large and broad, widely separated by two gland spines; second lobes bilobed; third lobes absent or represent merely by a point. Abdominal segments strongly lobed and with sclerotized spurs in between; submarginal ducts numerous and in rows on abdominal segments 1-6. Five groups of perivulvar pores. Anus anterior to vulva.

Key to Species. The following key is for those species of Lepidosaphes found in Kansas.

1. Abdominal segments 2-4 with a sharp sclerotized spur on lateral margins; dorsal side of thorax and anterior abdominal segments heavily sclerotized; median lobes of pygidium notched on each side . . . . . gloverii

Abdominal segments 2-4 without spurs; dorsum membranous; median lobes of pygidium not notched on each side, but triangular in shape . . . . . beckii

(A) Lepidosaphes beckii (Newman). "Purple scale".

1869 Coccus beckii Newman. The Ent. 4:217.

1876 Aspidiotus citricola Glover. Rpt. U.S.D.A., p. 43.

1880 Mytilaspis citricola Comstock. Rpt. U.S.D.A., p. 321.

1903 Lepidosaphes beckii Fernald. Mass. Hatch Expt. Sta. Bul. 88:305.

1917 Lepidosaphes beckii Lawson. Kans. Univ. Bul. 18:254.

1937 Lepidosaphes beckii Ferris. Atlas Scale Insects No. Amer. 1:71.

Body length 3 mm. Median lobes of pygidium large, broad, and triangular shaped. Sclerotized spurs present in lateral lobe angles of the first, second, and fourth abdominal segments. Dorsal macroducts numerous, marginal ducts short and broad, but submarginal ducts are short and slender (Plate IX, Fig. D).

This species is known as the purple scale, a major pest on citrus in Florida and California. It occurs on lemons and oranges in every market in Kansas and was recorded in the state first by Dean on oranges in a Manhattan, Kansas market. It feeds on the bark, leaves, and fruit of citrus in conservatories over the state but is not a serious pest to the floriculturist. Some oranges observed by the author at Manhattan were covered with live young, indicating a definite means of introduction into scale-free areas. Citrus is the only host; although other hosts are recorded in the

literature, these are due to misidentifications (Ferris, 1937), (Plate V, Fig. A).

(B) Lepidosaphes gloverii (Packard). "Glover scale".

1869 Coccus gloverii Packard. Guide to Study of Insects 1:527.

1881 Mytilaspis gloverii Comstock. Rpt. U.S.D.A., p. 323.

1903 Lepidosaphes gloverii Fernald. Mass. Hatch Expt. Sta. Bul. 88:309.

1917 Lepidosaphes gloverii Lawson. Kans. Univ. Bul. 18:255.

1937 Lepidosaphes gloverii Ferris. Atlas Scale Insects No. Amer. 1:74.

Body similar to L. beckii except much slenderer and elongated. Dorsum of prosoma and abdominal segments 1-2 heavily sclerotized; abdominal segments 2-4 with spurs on lateral margins. Median lobes of pygidium rounded and notched on each side. Dorsal ducts more numerous than L. beckii; submarginal ducts in rows on abdominal segments 1-5 (Plate IX, Fig. C).

This species is rare in Kansas and is known as the glover scale. It occurs on citrus and palms in conservatories in rare cases but is found more frequently on grapefruit in markets. Lawson first recorded this scale in Kansas on citrus. L. beckii resembles this species but the sclerotic areas on the prosoma and abdomen identify L. gloverii.

Genus Parlatoria Targioni

Generic Characters. Body circular or broadly oval. Pygidium with three pairs of well developed lobes but not bilobed; median

lobes widely separated by two gland spines; gland spines short and broad (resembling plates). Marginal duct openings bordered by a dark sclerotized area. Four groups of perivulvar pores.

Key to Species. The following key is for those species of Parlatoria found in Kansas.

1. Fourth pygidial lobe represented by a sclerotized point; dorsal ducts numerous in submarginal areas of pygidium . . . . . pergandii

Fourth lobe not a sclerotized point, but its position represented merely by a seta; dorsal ducts very few . . . . proteus

(A) Parlatoria pergandii Comstock. "Chaff scale".

1880 Parlatoria pergandii Comstock. Rpt. U.S.D.A., p. 327.

1917 Parlatoria pergandii Lawson. Kans. Univ. Bul. 18:248.

1937 Parlatoria pergandii Ferris. Atlas Scale Insects No. Amer. 1:88.

Body length 1.7 mm. Pygidium with three pairs of well developed lobes, the fourth present as sclerotized points; first three pairs of lobes notched on both sides. Gland spines broad, resembling plants. Marginal duct opening sclerotized and occurring from the third abdominal segment to the apex of the pygidium. Anal and vulvar openings coincide in position.

This species is of little importance in the greenhouse. It is known as chaff scale and is a serious pest on citrus in Florida and California. In Kansas greenhouses it has been collected in scattered counties, principally Riley, Douglas, and Wyandotte. It was first recorded in Kansas by Dean on Agava in Kansas State

College greenhouses. Oranges collected in markets of Kansas commonly have this scale on them.

(B) Parlatoria proteus (Curtis).

1843 Aspidiotus proteus Curtis. Gardners' Chronicle, p. 676.

1883 Parlatoria proteus Comstock. 2nd Rpt. Cornell Univ., p. 114.

1917 Parlatoria proteus Lawson. Kans. Univ. Bul. 18:251.

1937 Parlatoria proteus Ferris. Atlas Scale Insects No. Amer. 1:89.

Body broadly rounded. Pygidium with three pairs of well developed lobes, the fourth pair absent; lobes deeply notched on each side. Gland spines beyond third lobes very broad, numerous, resembling plates. Marginal ducts the same as in P. pergandii; submarginal ducts few. Anus and vulva located in middle of pygidium, their positions coinciding (Plate IX, Fig. A).

This species is rare in the state except on oranges at the market. It occurs on citrus, orchids, and Ficus in greenhouses and attacks the bark, leaves, and fruit. Dean first recorded this species in the state on Ficus in Kansas State College greenhouse. The absence of a sclerotized point representing the fourth lobe separates this species from P. pergandii, (Ferris, 1937), (Plate V, Fig. B).

Genus Pinnaspis Cockerell

Generic Characters. Body very long and spindle shaped. Prepygidial abdominal segments very strongly lobed. Median lobes of pygidium fused or slightly separated. Gland spines few but well developed, long. Dorsal ducts few.

Species Description. (A) Pinnaspis aspidistrae (Signoret).

1869 Chionaspis aspidistrae Signoret. Ann. Soc. Ent. Fr. 4(9): 443.

1883 Chionaspis brasiliensis Comstock. 2nd Reg. Dept. Ent. Cornell Univ., p. 109.

1895 Chionaspis aspidistrae Cockerell. U.S. Nat. Mus. Proc. 17:620.

1917 Hemichionaspis aspidistrae Lawson. Kans. Univ. Bul. 18: 258.

1937 Pinnaspis aspidistrae Ferris. Atlas Scale Insects No. Amer. 1:97.

Body length 2.2 mm. Median lobes of pygidium apparently fused together but actually separated by a very narrow space terminating in a common apex to form a triangular structure; second lobes bilobed; third lobes much reduced. Median lobes yoked together at base with a sclerotic plate. Perivulvar pores in five groups. Marginal ducts short and broad. Anal and vulvar openings coincide in middle of pygidium.

The Fern scale, as it is frequently spoken of, is a common species found throughout the state on ferns. Dean first recorded

this species in Kansas on ferns at Manhattan, Kansas. It occurs on many plant species but chiefly on ferns, and can be a serious pest because it is difficult to control. The male scale, which is white, is more easily recognized than the female, which is brown and blends in with the foliage more readily (Plate VIII, Fig. B).

Genus Aonidiella Berlese and Leonardi

Generic Characters. Body circular. Pygidium with three pairs of well developed lobes, the fourth pair indicated by a small point. Slender paraphyses present which terminate at the bases of first to third pygidian lobes. Plates branched profusely. Prosoma and first few abdominal segments swollen and tending to extend back posteriorly, surrounding the sides of the pygidium.

Species Description. (A) Aonidiella aurantii (Maskell).

1878 Aspidiotus aurantii Maskell. N. Z. Ins. Trans. 11:199.

1903 Chrysomphalus aurantii Fernald. Mass Hatch Expt. Sta. Bul. 88:287.

1917 Chrysomphalus aurantii Lawson. Kans. Univ. Bul. 18:210.

1938 Aonidiella aurantii Ferris. Atlas Scale Insects No. Amer. 2:179.

Prosoma extending posteriorly to surround the sides of the pygidium. Pygidium with three pair of well developed lobes and a fourth pair indicated by a sclerotized point. Two plates

separate the median lobes and the median and second lobes; three plates separate the second and third lobes, and also the third lobes and fourth sclerotized points; the plates anterior to the third lobes are divided and notched deeply forming two long, slender, branched processes to each plate. Dorsal ducts very long and slender and present only on pygidium, few in number (Plate IX, Fig. B).

This scale, known as California red scale, was first recorded in Kansas by Dean on Opuntia in the Kansas State College greenhouse. It was introduced into the United States from New Zealand. Citrus is the preferred host but it may occur on any woody plant, attacking leaves, stems, and fruit of trees (Ferris, 1937). The only specimens the author obtained were taken from citrus fruit at the market. In the greenhouse this species is rare, if present at all, and therefore is not a pest to the floriculturist (Plate VI, Fig. B).

Genus Aspidiotus Bouché

Generic Characters. Aspidiotini tribe. Pygidium with three pairs of lobes. Paraphyses not present. Plates well developed and fringed along apex. Dorsum with considerable sclerotization.

Species Description. (A) Aspidiotus hederae (Vallot).

1829 Chermes hederae Vallot. Mem. Acad. Dijon. p. 30.
1880 Aspidiotus nerii Comstock. Rpt. U.S.D.A., p. 301.
1917 Aspidiotus hederae Lawson. Kans. Univ. Bul. 18:223.

1938 Aspidiotus hederae Ferris. Atlas Scale Insects No. Amer. 2:192.

Body nearly circular. Pygidium with three pairs of well developed lobes, the median lobes notched on both sides near apex; second and third lobes same shape as median lobes, but smaller. Median lobes separated by two narrow plates and median and second lobes also separated by two narrow plates; three plates separate the second and third lobes; anterior to the third lobes are 4-6 plates. Dorsal ducts short, broad, submarginal, and extending from the apex of the pygidium to the third abdominal segment. Perivulvar pores present in four groups.

This species, known as oleander scale, is one of the most common scales in Kansas greenhouses. It feeds on the stems and leaves of the host plants. There are a wide range of hosts, some of the more common being oleander, English ivy, asparagus, fern, and lemon. It was first recorded in Kansas by Hunter on oleander (Plate VIII, Fig. B).

Genus Chrysomphalus Ashmead

Generic Characters. Pygidium with three pairs of well developed lobes, the fourth pair indicated by a point. Marginal sclerotic area present anterior to the fourth pair of lobes. Plates between third and fourth lobes club-shaped. Slender, long paraphyses arising from bases of median, second, and third

lobes. Dorsal ducts very long and slender, arranged in rows.

Key to Species. The following key is for those species of Chrysomphalus found in Kansas.

1. With a cluster of macroducts on the second abdominal segment . . . . . ficus

Without clusters of macroducts on any abdominal segments . . . . . .dictyospermi

(A) Chrysomphalus dictyospermi (Morgan). "Dictyospermum scale".

1889 Aspidiotus dictyospermi Morgan. Ent. Month. Mag. 25:352.

1903 Chrysomphalus dictyospermi Fernald. Mass. Hatch Expt. Sta. Bul. 88:289.

1917 Chrysomphalus dictyospermi Lawson. Kans. Univ. Bul. 18:213.

1938 Chrysomphalus dictyospermi Ferris. Atlas Scale Insects No. Amer. 2:200.

Pygidium with three pairs of lobes, the fourth pair represented by a sclerotized point; first three pairs of lobes well developed and notched on the anterior margin. Three pairs of paraphyses arising from the bases of the first three pairs of lobes. Two slender plates present, separating the median lobes and the median and second lobes. Four groups of perivulvar pores with two to four in each group. Thoracic spur small and fringed.

The common name of this species is dictyospermum scale. It was first recorded in Kansas by Dean on palm in Manhattan. This species is very common all over the state and occurs on a wide range of plants, the more common being palms, lemon, English ivy,

Ficus, and asparagus. It is not present in sufficient numbers to be a serious pest. This species is recognized by having plates beyond the third pygidial lobes bearing a single club and fringed on the anterior side.

(B) Chrysomphalus ficus Ashmead. "Florida red scale".

1880 Chrysomphalus ficus Ashmead. Amer. Ent., p. 267.

1917 Chrysomphalus aonidum Lawson. Kans. Univ. Bul. 18:214.

1938 Chrysomphalus ficus Ferris. Atlas Scale Insects No. Amer. 2:201.

A sclerotized spur or point present on each side of thorax. Pygidium with three pairs of well developed lobes, the fourth pair indicated by a rounded sclerotized area; lobes all the same size, notched on each side; two broad plates present, separating the median lobes and the median and second lobes; three plates present separating the second and third lobes; beyond the third lobes are two plates, each divided into two club-shaped processes and not fringed. One row of dorsal ducts present at base of third lobes and one row at base of fourth, extending along the lateral margin to the anterior margin of the pygidium; three ducts opening between the median and second lobes. Perivulvar pores present in five groups and each group with 3-5 pores.

This species, known as Florida red scale, is one of the chief pests in Florida on citrus. It has been recorded on an endless number of hosts but the more common ones in Kansas are palms, English ivy, oleander, orange, and rubber plant. Dean first recorded this species in Kansas on palms in Kansas State

College greenhouses. It is a common insect all over the state but is only a serious pest on palms and oleander. The distinguishing character is the dorsal, submarginal cluster of ducts on the second segment of the pygidium (Plate VII, Fig. A).

Genus Hemiberlesia Cockerell

Generic Characters. Perivulvar pores occasionally present. Pygidium with median lobes well developed and second and third lobes represented only by points or small lobes. Plates well developed and variable in shape. Dorsal ducts few, slender, and long. Anal opening large.

Key to Species. The following key is for those species of Hemiberlesia found in Kansas.

1. Perivulvar pores absent . . . . . rapax
Perivulvar pores present 2

2. Second lobes present only as non-sclerotized points . . . . . lataniae
Second lobes developed and resembling the median lobes, but smaller . . . . . cyanophylli

(A) Hemiberlesia cyanophylli (Signoret).

1869 Aspidiotus cyanophylli Signoret. Ann. Soc. Ent. Fr. 4(9): 119.

1917 Aspidiotus cyanophylli Lawson. Kans. Univ. Bul. 18:222.

1938 Hemiberlesia cyanophylli Ferris. Atlas Scale Insects No. Amer. 2:237.

Pygidium with median lobes large and notched on either side; second lobes similar to median lobes, well developed but much smaller; third lobes represented by small sclerotized points. Two plates separating the median lobes and median and second lobes; three plates separating the second and third lobes. A seta is present at the base of each lobe on the dorsal side. Dorsal ducts few, slender, and long. Perivulvar pores in four groups and each group with 3-6 pores.

This scale insect is present only in scattered counties of the state, these being Edwards, Shawnee, and Riley, and is not a serious pest in these areas. Dean recorded this pest for the first time in Kansas on palm. It has a limited number of hosts in Kansas and has been collected on palms, Ficus, and umbrella tree. I collected it on bananas only in a Manhattan Market. The character that separates this species from others is the row of four or five submarginal ducts originating at the second incision (between second and third lobes) (Plate VIII, Fig. A).

(B) Hemiberlesia lataniae (Signoret).

1869 Aspidiotus lataniae Signoret. Ann. Soc. Ent. Fr. 4(9):124.

1880 Aspidiotus cydoniae Comstock. Rpt. U.S.D.A., p. 295.

1917 Aspidiotus lataniae Lawson. Kans. Univ. Bul. 18:230.

1938 Hemiberlesia lataniae Ferris. Atlas Scale Insects No. Amer. 2:241.

Pygidium with median lobes very large and notched on both sides, appearing almost as one except that there is a narrow space between, with two hair-like plates; second and third lobes

represented by non-sclerotized points. Two branched plates separating the median and second lobes and three plates separating the second and third lobes. Dorsal ducts long and very slender, arranged in two submarginal, diagonal rows; microducts on the ventral side numerous and marginal. Anal opening large and near apex of pygidium. Perivulvar pores present in four groups of 5-7 each.

This species occurs on all woody plants in the tropical regions of the world but it occurs over the entire state of Kansas only in the greenhouse. It infests many plants but is found most commonly on date palm, trailing vinca, and yucca. It is not present in sufficient numbers to be a serious pest in this state. Dean recorded this species for the first time in Kansas on palm. This species and H. rapax are often confused and the character that separates H. lataniae is the presence of perivulvar pores.

(C) Hemiberlesia rapax (Comstock).

1880 Aspidiotus rapax Comstock. Rpt. U.S.D.A., p. 307.

1896 Aspidiotus camelliae Green. Coccidae Ceylon 1:60.

1917 Aspidiotus rapax Lawson. Kans. Univ. Bul. 18:238.

1938 Hemiberlesia rapax Ferris. Atlas Scale Insects No. Amer. 2:244.

Perivulvar pores absent. Pygidium with median lobes very large and notched only on the outer margin. A pair of slender hair-like plates present between median lobes; second and third lobes represented by small, non-sclerotized points; two plates separating the median and second lobes, three plates separating

the second and third lobes. A seta is present at the base of each lobe. Dorsal macroducts few (10-15), long, very slender, and in two groups; ventral microducts numerous. Anus large and close to apex of pygidium.

This species is sometimes referred to as the greedy scale. It is a very common scale in the warmer regions of the United States but in Kansas it is rare, where it occurs on citrus in the greenhouse. This scale insect is common on oranges in the market, on which Dean first recorded this insect in Kansas.

CONCLUSIONS

The scale insects, as a group, are of great importance in the greenhouse. The injury inflicted by scales is frequently underestimated and at times overlooked until the plants are badly infected. Because of the tropical environment maintained in the greenhouse, a large number of scale insect species is found.

Professor George A. Dean of Kansas State College presented a check list of scales in Kansas in 1903 and listed the following nineteen scale species present in greenhouses: Coccus hesperidum, Coccus elongatus, Saissetia hemisphaerica, Saissetia oleae, Pseudococcus citri, Pseudococcus adonidum, Diaspis boisduvalii, Diaspis echinocacti, Pinnaspis aspidistrae, Aspidiotus hederae, Hemiberlesia cyanophylli, Hemiberlesia lataniae, Hemiberlesia rapax, Chrysomphalus ficus, Chrysomphalus dictyospermi, Aonidiella aurantii, Lepiodsaphes beckii, Parlatoria pergandii, Parlatoria proteus. Dr. Paul B. Lawson, in 1917, published his taxonomic paper, "The Coccidae of Kansas." He included the nineteen species which Dean had listed and added Lepidosophes gloverii to the list of scale insects present in Kansas greenhouses.

This paper includes the 20 species of Dean and Lawson and one species, Orthezia insignis, reported for the first time in Kansas. Orthezia insignis Douglas is one of the few scale insects that is active during its entire life. It has long legs, the body is covered with heavy white, waxy lamellae, and the posterior lamellae overhangs a marsupium or pouch. This insect

is very destructive to coleus, Lantana, Verbena, and Chrysanthemum.

Several species listed by Dean and Lawson now appear under new genera, and some have a new species name. This is due to the classification presented by Ferris in his "Atlas of Scale Insects of North America." Diaspis echinocacti cacti, appearing in the papers of Dean and Lawson, is now Diaspis echinocacti. Ferris states that there is great variability in this species but there is no justification for a subspecies cacti. Hemiberlesia lataniae replaces the species Aspidiotus lataniae and Aspidiotus cydoniae of Lawson's and Dean's papers. Hemichionaspis aspidistrae has taken a position in the genus, Pinnaspis, by Ferris. The species, Chrysomphalus aurantii of Dean and Lawson, is now Aonidiella aurantii. Chrysomphalus ficus Ferris replaces Chrysomphalus aonidum. The genus Hemiberlesia by Ferris replaces the genus Aspidiotus of A. rapax and A. cyanophylli.

Of the 21 species reported in this paper, only eight are common in Kansas greenhouses and of any economic importance. Pseudococcus citri, the "citrus mealy bug," is probably the most common member of the scale family in Kansas greenhouses. It is a serious pest on coleus, fuchsia, cactus, croton, fern, gardenia, begonia, and geranium. Coccus hesperidum, the "soft scale," is found on over 75 plant species, but is only injurious to rubber plants, oleander, citrus, English ivy, and ferns. A black fungus feeds on the honey dew excreted by C. hesperidum and causes plants to become unsightly. Saissetia hemisphaerica,

the "hemispherical scale," is very common but does not cause enough injury to be of economic importance except for outbreaks on ferns, chrysanthemums, and oleanders. Diaspis boisduvalii is a very common scale but eighty percent of the hosts are represented by palms or orchids. The serious pest of ferns is Pinnaspis aspidistrae, "fern scale." It is present wherever ferns are grown. Aspidiotus hederae, the "oleander scale," becomes a serious pest on oleander, English ivy, fern and lemon. Chrysomphalus dictyospermi, the "dictyospermum scale," is a very common scale on palms, lemon, English ivy, Ficus and asparagus. It is never present in large enough numbers to become serious. Florida red scale, Chrysomphalus ficus, is recorded on a large number of hosts but is only serious on palms and oleander.

The other 13 species of no economic importance in the state have limited plant hosts and are therefore limited in their infestation and population. The greater majority of these species are limited to citrus and therefore are found only in conservatories where citrus is present.

SUMMARY

No group of insects is of greater importance as pests of greenhouse plants than those specialized members of the superfamily Coccoidea commonly called scale insects and mealy bugs. Because of the warm, humid conditions of the greenhouse, these insects find conditions at an optimum for their development.

This paper is the first of its type in the State of Kansas in which a small group of scale insects is studied because it occupies a certain ecological niche. The State of Kansas has had several workers with the superfamily Coccoidea. The most important papers are those of Dean, "Coccidae of Kansas", and Lawson, "The Coccidae of Kansas."

The resume of the world literature on Coccoidea starts with the earliest paper Targioni Tozzetti (1868) and progresses, reviewing the more important workers and their papers up to the present time. The most recent work is the classical monograph of G. F. Ferris, "Atlas of Scale Insects of North America."

The Diaspididae or armored scales are oviparous and ovoviviparous. The adult females are unable to move from the point of attachment on the plant. All male scales of the superfamily Coccoidea are winged. The mealy bugs, Pseudococcidae, are both oviparous and ovoviviparous. The soft scales, Coccidae, are oviparous. Both the mealy bugs and the soft scales are active when adults.

Control of scales can be accomplished if a routine program is set up. The best control for a few plants is by washing or scrubbing the scales from the plants. Sprays (oils, nicotine sulfate, thiocyanate) are successful, but many plants are injured by these toxic sprays. Fumigation is the best control for a large number of plants. Calcium cyanide (1/4 - 1/3 oz. per 1,000 cu. ft.) or parathion give good control.

Scale insects must be cleared and stained before mounting them on slides. The method published by William P. Nye (1947) is used except for a few modifications. This procedure employs about twelve steps and requires about two hours to complete. The structures used in the keys and descriptions of this paper are discussed and defined. The pygidium and its various structures are covered in detail because the classification of the armored scales, Diaspididae, is based on these structures. The antennae, anal cleft, and anal plates are discussed as characters for classification of the soft scales, Coccidae. The anal ring and lobes are discussed as structures of classification for mealybugs.

The scales in Kansas greenhouses are members of four families: Orthoziidae, Pseudococcidae, Coccidae, and Diaspididae. The following 21 species make up the four families: Orthezia insignis, Pseudococcus citri, Pseudococcus adonidum, Coccus hesperidum, Coccus elongatus, Saissetia hemisphaerica, Saissetia oleae, Diaspis boisduvalii, Diaspis echinocacti, Lepidosaphes beckii, Lepidosaphes gloverii, Parlatoria pergandii, Parlatoria proteus, Pinnaspis aspidistrae, Aonidiella aurantii, Aspidiotus hederae, Chrysomphalus dictyospermi, Chrysomphalus ficus, Hemiberlesia cyanophylli, Hemiberlesia lataniae, and Hemiberlesia rapax. Orthezia insignis is reported for the first time in the State of Kansas.

A field key is presented which makes use of the color, shape, and size of the scale insect. The taxonomic part of the paper

discusses each family separately. The generic character of each genus is discussed in brief. Keys to species are given. An incomplete synonomy is listed under each species and a description of the most important taxonomic charactes follows the synonomy. Following this a short paragraph on the occurrence of this species in Kansas, and host plants, is given.

Of the twenty-one scales present in Kansas greenhouses, only eight, Pseudococcus citri, Coccus hesperidum, Saissetia hemisphaeriea, Diaspis boisduvalii, Pinnaspis aspidistrae, Aspidiotus hederae, Chrysomphalus dictyospermi, and Chrysomphalus ficus are common and of any serious nature to plant hosts. The other 13 have a limited number of hosts, which prevents their spread or injury.

ACKNOWLEDGMENT

The writer wishes to acknowledge his indebtedness to Dr. Howard E. Evans, under whose direction this work was undertaken, for his guidance, technical advice, and constructive criticisms in the preparation of this paper; to Dr. Roger C. Smith, Head of the Department of Entomology, for suggesting the problem and providing personal suggestions from time to time.

Also deep appreciation is expressed to Kenneth D. Havel, Assistant State Entomologist, for his aid in collecting some of the material used; to Dr. Charles D. Michener, University of Kansas, Kansas; to Floyd J. Hanna, for the photographs used in this thesis.

BIBLIOGRAPHY

Boudeaux, Bruce H.
A technique for mounting aphids and other soft bodied insects on slides. Jour. Econ. Ent. 42:846-847. October, 1949.

Bourne, A. J., and F. R. Shame.
Control of black scale (Saissetia olea) on gardenias in commercial greenhouses. Jour. Econ. Ent. 40:429-430. June, 1947.

Britton, W. E.
The Hemiptera or sucking insects of Connecticut. Conn. Nat. Hist. Surv. Bul. 34(4):346-382. 1923.

Cockerell, T. D. A.
A check-list of the Coccidae. Ill. State Lab. Nat. Hist. Bul. 4:318-339. 1897.

Comstock, J. H.
Reports on scale insects. In U. S. Dept. Agr. Rpt. 1880. p. 276-350. 1881.

Cooley, R. A.
The Coccid genera Chionaspis and Hemichionaspis. Mass. Hatch Agr. Expt. Sta. Spec. Bul. 57 p. 1899.

Dean, Geo. A.
Coccidae of Kansas. Kans. Acad. Sci. Trans. p. 265-275. 1909.

Dietz, Harry F., and Harold Morrison.
The Coccidae or scale insects of Indiana. In Rpt. State Ent. p. 195-321. 1916.

Essig, E. O.
Mounting aphids and other small insects on microscopic slides. Pan-Pacific Ent. 24(1):9-22. Jan. 1948.

Fernald, Maria E.
A catalogue of the Coccidae of the world. Mass. Hatch Agr. Expt. Sta. Bul. 88:360 p. 1903.

Ferris, G. F.
Atlas of the scale insects of North America. Stanford University, Stanford University Press. 4 v., 444 p. 1937-1942.

Gage, J. H.
The staining of coccids. Ent. News 30:142-143. 1919.

Green, H. A.
The Coccidae of Ceylon. London 4v., 344 p. 1896-1909.

Herrick, Glenn W.
Some scale insects of Mississippi with notes on certain species from Texas. Miss. Agr. Expt. Sta. Tech. Bul. 2:78 p. 1911.

Hollinger, A. H.
Scale insects of Missouri. Mo. Agr. Expt. Res. Bul. 58. 71 p. 1923.

Hunter, S. J.
The Coccidae of Kansas. Kans. Univ. Quarterly 8(1):67-77. 1899; 9(3):101-107. 1900; 10(4):17-145. 1901.

Keifer, H. H.
Isopropyl alcohol and phenol used in entomological microtechnique. Jour. Econ. Ent. 39(5):665-666. 1946.

Lawson, P. B.
The Coccidae of Kansas. Kans. Univ. Sci. Bul. 18(1):161-279. 1917.

Lindinger, L.
Die Schildläuse. Stuttgart. 388 p. 1912.

MacGillivray, Alex D.
The Coccidae. Illinois, Scarab Press. 502 p. 1921.

Marlatt, C. L.
The national collection of Coccidae. U. S. Dept. Agr. Bul. Ent. Tech. Ser. 16(1):1-10. 1908.

Maskell, W. M.
On some Coccidae in New Zealand. Trans. New Zealand Inst. 11:187-228. 1879.

Metcalf, C. L., and W. P. Flint.
Destructive and useful insects. New York: McGraw-Hill, p. 739-745. 1939.

Miles, Herbert W., and Mary Miles.
Insect pests of glasshouse crops. London, Crosby Lockwood. p. 130-140. 1948.

Morrison, Harold
Classification of the scale insects of the subfamily Orthezziinae. Jour. Agr. Res. 30:97-154. 1925.

_____ Taxonomy of some scale insects of the genus Parlatoria encountered in plant quarantine inspection work. U. S. Dept. Agr. Misc. Pub. 344:1-34. 1939.

Newstead, Robert
A monograph of the Coccidae of the British Isles. London. Ray Society. 2 v., 490 p. 1901-1903.

Nye, William P.
A simple method of mounting aphids. Pan-Pacific Ent. 23(2): 73-74. April, 1947.

Palmer, Miriam A.
On the dorsal glands as characters of constant specific value in the coccid genus Parlatoria. Kansas Univ. Sci. Bul. 3: 129-146. 1905.

Parrot, P. J.
Scale insects from Kansas grasses. Kans. Agr. Expt. Sta. Bul. 98:133-146. 1900.

Sanders, J. G.
Catalogue of recently described Coccidae. U. S. Dept. Agr. Bur. Ent. Tech. Ser. 12 and 16. 1906-1909.

_____ Coccidae of Ohio. Ohio State Acad. Sci. Proc. 4:25-82. 1904.

_____ The identity and synonomy of some of our soft scale insects. Jour. Econ. Ent. 2:428-448. 1909.

Sasscer, E. R.
Catalog of recently described Coccidae. Wash. Ent. Soc. Proc. 17:25-38. 1915.

Signoret, V.
Essai sur les Cochinelles (Homcpteres-Coccides). Ann. Soc. Ent. Fr. 5(5):428 p. 1875.

Smith, Floyd B., P. H. Lung and R. A. Fulton.
Parathion in aerosols for control of pests on greenhouse ornamentals. U. S. D. A. Bur. of Ent. and Plant Quaran. E-759. 8 p. 1948.

Stafford, E. W.
Studies in Diaspinae pydigia. Ent. Soc. Amer. Ann. 8:67-73. 1915.

Targioni Tozzetti, A. L.
Introduzione alla seconda Memoira per gli studj sulle Cocciniglie, e Catalogo dei generi e delle specie della famiglia dei Coccidi rivista e ordinata. Atti della Soc. Ital. delle Sci. Nat. 11:694-738. 1868.

Trimble, F. M.
Scale insects injurious in Pennsylvania. Penn. Dept. Agr. Bul. 398:1-22.

Thro, William C.
Distinctive characteristics of the species of the genus Lecanium. Cornell Agr. Expt. Sta. Bul. 209:205-221. 1903.

APPENDIX

EXPLANATION OF PLATE I

Fig. A. Ventral side of anal plates, Coccus hesperidum Linn. X190.

Fig. B. Antenna of Coccus elongatus Signoret. X110.

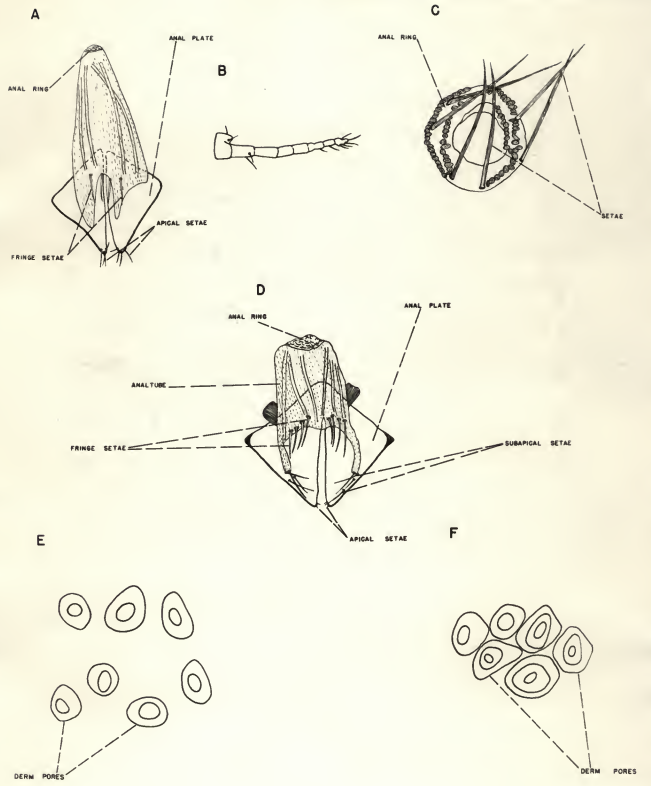
Fig. C. Anal ring of Pseudococcus citri Risso. X300.

Fig. D. Ventral side of anal plates, Coccus elongatus Signoret. X190.

Fig. E. Portion of derm showing derm pores, Saissetia hemisphaerica Targ. X160.

Fig. F. Portion of derm showing derm pores, Saissetia oleae Bernard. X160.

PLATE I


A
ANAL PLATE
ANAL RING
APICAL SETAE
FRINGE SETAE
B
C
ANAL RING
SETAE
D
ANAL RING
ANAL PLATE
ANAL TUBE
FRINGE SETAE
SUBAPICAL SETAE
APICAL SETAE
E
DERM PORES
F
DERM PORES

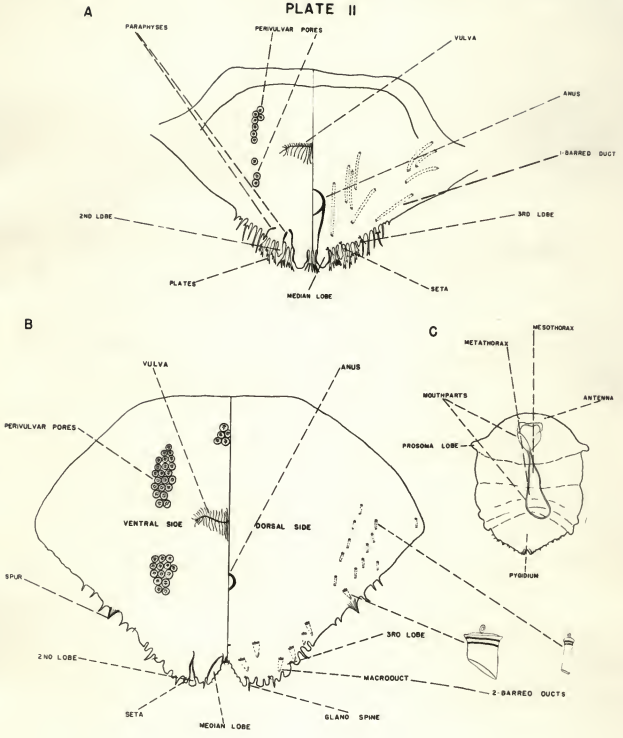
EXPLANATION OF PLATE II

Fig. A. Pygidium of adult female, Hemiberlesia cyanophylli Signoret.

Fig. B. Pygidium of adult female, Diaspis boisduvalii Signoret.

Fig. C. General features of adult female, D. boisduvalii Sign.

PLATE II


A
PARAPHYSES
PERIVULVAR PORES
VULVA
ANUS
1-BARRED DUCT
2ND LOBE
3RD LOBE
PLATES
SETA
MEDIAN LOBE
B
VULVA
ANUS
PERIVULVAR PORES
VENTRAL SIDE
DORSAL SIDE
SPUR
3RD LOBE
2ND LOBE
MACRODUCT
2-BARRED DUCTS
SETA
MEDIAN LOBE
GLAND SPINE
C
MESOTHORAX
METATHORAX
MOUTHPARTS
ANTENNA
PROSOMA LOBE
PYGIDIUM

EXPLANATION OF PLATE III

Fig. A. Pseudococcus citri Risso on ivy.

Fig. B. Orthezia insignis Douglas on coleus.

PLATE III

Fig. A.

Fig. B.

EXPLANATION OF PLATE IV

Fig. A. Saissetia hemisphaerica (Targ.) on ivy.

Fig. B. Coccus hesperidum Linn. on oleander.

PLATE VI

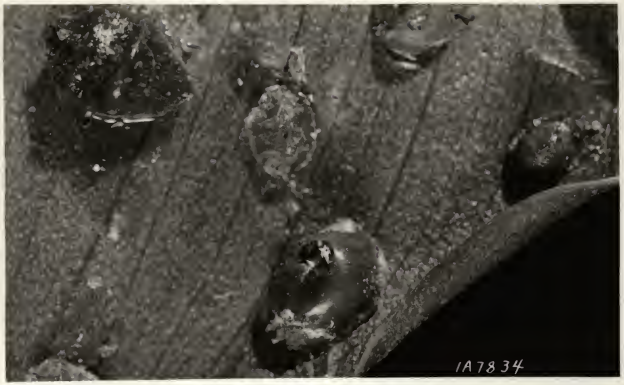


Fig. A.

Fig. B.

EXPLANATION OF PLATE V

Fig. A. Lepidosaphes beckii (Newman) on orange fruit.

Fig. B. Parlatoria proteus (Curtis) on orange leaf.

Fig. A.

Fig. B.

EXPLANATION OF PLATE VI

Fig. A. Diaspis echinocacti Bouche. The elongated scales are males and the round scales are females. The host is cactus.

Fig. B. Aonidiella aurantii (Maskell) on yew.

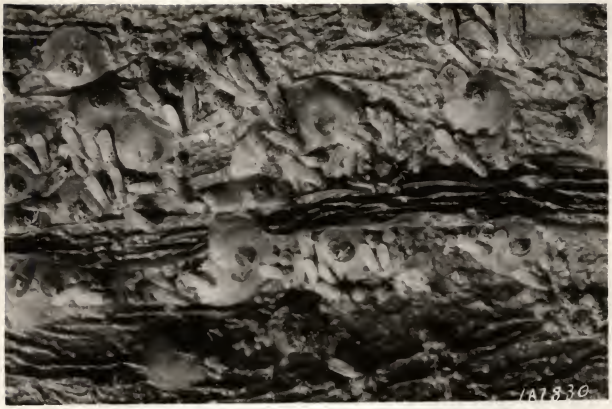


Fig. A.

Fig. B.

EXPLANATION OF PLATE VII

Fig. A. *Chrysomphalus ficus* Ashmead on ivy.

Fig. B. *Aspidiotus hederae* (Vall.) on *Hedera*.

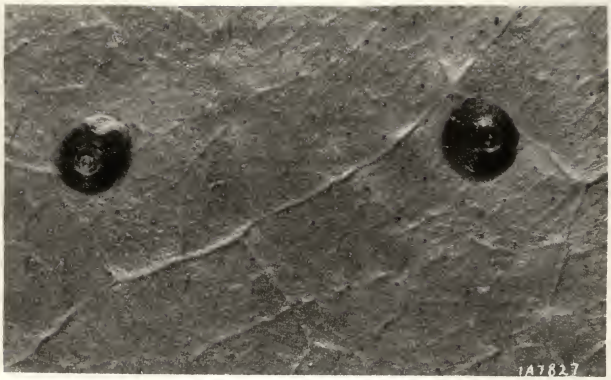


Fig. A.

Fig. B.

EXPLANATION OF PLATE VIII

Fig. A. Hemiberlesia cyanophylli (Sign.) on Ficus.

Fig. B. Pinnaspis aspidistrae (Sign.) on fern. The white scales are males and the brown scales are females.

Fig. A.

Fig. B.

EXPLANATION OF PLATE IX

Fig. A. Parlatoria proteus (Curtis) mounted on a slide and photographed through a microscope. X100.

Fig. B. Aonidiella aurantii (Mask.) mounted on a slide and photographed through a microscope. X40.

Fig. C. Lepidosaphes gloverii (Packard) mounted on a slide and photographed through a microscope. X40.

Fig. D. Lepidosaphes beckii (Newman) mounted on a slide and photographed through a microscope. X40.

Fig. A.

Fig. B.

Fig. C.

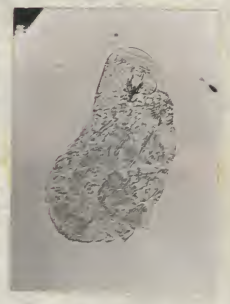


Fig. D.

EXPLANATION OF PLATE X

Fig. A. Pseudococcus citri Risso male. X80.

Fig. B. Coccus elongatus (Sign.) showing the mouth-parts, legs, anal plates, and cleft. X45.

PLATE X

Fig. A.

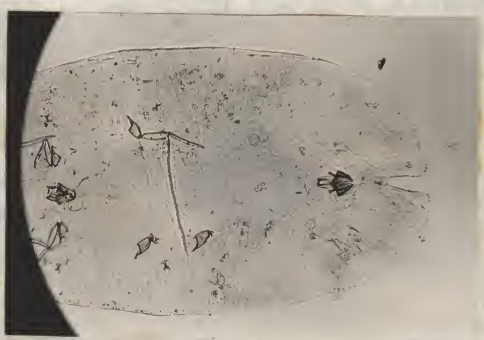


Fig. B.

SCALE INSECTS (HOMOPTERA, COCCOIDEA) IN KANSAS GREENHOUSES

by

EUGENE HOMER DAVIDSON

B. S., Colorado State College
of Agriculture and Mechanic Arts, 1950

AN ABSTRACT

of

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1951

ABSTRACT

No group of insects is of greater importance as pests of greenhouse plants than those specialized members of the superfamily Coccoidea commonly called scale insects and mealy bugs. Because of the warm, humid conditions of the greenhouse, these insects find conditions at an optimum for their development.

This paper is the first of its type in the State of Kansas in which a small group of scale insects is studied because it occupies a certain ecological niche. The State of Kansas has had several workers with the superfamily Coccoidea. The most important papers are those of Dean, "Coccidae of Kansas," and Lawson, "The Coccidae of Kansas."

The resume of the world literature on Coccoidea starts with the earliest paper Targioni Tozzetti (1868) and progresses, reviewing the more important workers and their papers up to the present time. The most recent work is the classical monograph of G. F. Ferris, "Atlas of Scale Insects of North America."

The Diaspididae, or armored scales, are oviparous. The adult females are unable to move from the point of attachment on the plant. All male scales of the superfamily Coccoidea are winged. The mealy bugs, Pseudococcidae, are both oviparous and ovovivivaparous. The soft scales, Coccidae, are oviparous. Both the mealy bugs and the soft scales are active when adults.

Control of scales can be accomplished if a routine program is set up. The best control for a few plants is by washing or

scrubbing the scales from the plants. Sprays (oils, nicotine sulfate, thiocyanate) are successful, but many plants are injured by these toxic sprays. Fumigation is the best control for a large number of plants. Calcium cyanide (1/4 - 1/3 oz. per 1,000 cu. ft.) or parathion give good control.

Scale insects must be cleared and stained before mounting them on slides. The method published by William P. Nye (1947) is used except for a few modifications. This procedure employs about twelve steps and requires about two hours to complete. The structures used in the keys and descriptions of this paper are discussed and defined. The pygidium and its various structures are covered in detail because the classification of the armored scales, Diaspididae, is based on these structures. The antennae, anal cleft, and anal plates are discussed as characters for classification of the soft scales, Coccidae. The anal ring and lobes are discussed as structures of classification for mealybugs.

The scales in Kansas greenhouses are members of four families: Ortheziidae, Pseudococcidae, Coccidae, and Diaspididae. The following 21 species make up the four families: Orthezia insignis, Pseudococcus citri, Pseudococcus adonidum, Coccus hesperidum, Coccus elongatus, Saissetia hemisphaerica, Saissetia oleae, Diaspis boisduvalii, Diaspis echinocacti, Lepidosaphes beckii, Lepidosaphes gloverii, Parlatoria pergandii, Parlatoria proteus, Pinnaspis aspidistrae, Aonidiella aurantii, Aspidiotus hederae, Chrysomphalus dictyospermi, Chrysomphalus ficus,

Hemiberlesia cyanophylli, Hemiberlesia lataniae, and Hemiberlesia rapax. Orthezia insignis is reported for the first time in the State of Kansas.

A field key is presented which makes use of the color, shape, and size of the scale insect. The taxonomic part of the paper discusses each family separately. The generic character of each genus is discussed in brief. Keys to species are given. An incomplete synonomy is listed under each species and a description of the most important taxonomic characters follows the synonomy. Following this a short paragraph on the occurrence of this species in Kansas, and host plants, is given.

Of the twenty-one scales present in Kansas greenhouses, only eight, Pseudococcus citri, Coccus hesperidum, Saissetia hemisphaerica, Diaspis boisduvalii, Pinnaspis aspidistrae, Aspidiotus hederae, Chrysomphalus dictyospermi, and Chrysomphalus ficus are common and of any serious nature to plant hosts. The other thirteen have a limited number of hosts, which prevents their spread or injury.