

APPROVAL SHEET

Title of Thesis: THE GENERA HEMIBERLESIA AND ABGRALLASPIS IN NORTH AMERICA WITH EMPHASIS ON HOST RELATIONSHIPS IN THE H. HOWARDI (COCKERELL) COMPLEX (HOMOPTERA: COCCOIDEA: DIASPIDIDAE)

Name of Candidate: John Angus Davidson, Sr.
Doctor of Philosophy, 1960

Thesis and Abstract Approved:

William E. Bickley

William E. Bickley
Professor
Department of Entomology

Date approved:

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ABSTRACT

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Thesis directed by: ^{Sup.} William E. Bickley
Professor
Department of Entomology

The work reported consists of revisionary studies of Hemiberlesia Cockerell 1897 and Abgrallaspis Balachowsky 1948 in North America. The interpretation of North America is that of Ferris (1937), "all the mainland from the Arctic regions to and including the Panama Canal Zone." According to Ferris (1942), Hemiberlesia contained 15 species. As a result of this study, only eight of these species are here referred to Hemiberlesia. They are: rapax (Comstock), lataniae (Signoret), popularum (Marlatt), ignobilis Ferris, cupressi (Cockerell), diffinis (Newstead), candidula (Cockerell), and palmae (Cockerell). The species H. coniferarum (Cockerell) is newly assigned having previously been placed in Diaspidiotus Berlese and Leonardi, by Ferris. A tenth species, H. pseudorapax McKenzie, was assigned to this genus by its author. Seven of the 15 species have been assigned to Abgrallaspis. Both these genera appear to be North American in origin.

Abgrallaspis was originally created for six species. Three of these occur in North America and were transferred from Hemiberlesia by Balachowsky. They are: palmae (Cockerell), degeneratus (Leonardi), and cyanophylli (Signoret). The last named species was designated as the genotype. Balachowsky (1953) later reassigned palmae to Hemiberlesia

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and transferred four more North American Hemiberlesia species to Abgrallaspis, namely, howardi (Cockerell), comstocki (Johnson), coloratus (Cockerell), and fraxini (McKenzie).

A study of these species in the National Coccoid Collection revealed a complex centering about A. howardi as conceived by Ferris (1938). Usual morphological comparisons of slide mounted adult females failed to yield results, therefore, host transfer experiments were undertaken.

A population of "howardi" of Ferris was secured on pachysandra. A total of 2,700 individual crawler transfers were then made to 20 different host plants. These hosts had been chosen because a preliminary study indicated unusual character variation in specimens collected from them. Fourteen of the test hosts (largely ornamentals) were later found to be infested with 14 to 54 per cent of the transferred crawlers. These crawlers were allowed to mature. Adult females were then collected and mounted for study.

Six host plant species were completely unacceptable to infestation by the transferred crawlers. Five of these were plum, pear, peach, apple, and pine. A. howardi was described from plum in Colorado, and later recorded from such hosts as pear, peach, and apple. A study of the species Ferris synonymized with A. howardi revealed the test population to be A. townsendi (Cockerell), which was described from an unknown host in Mexico, and later recorded from a long list of ornamentals primarily in the southern and eastern United States. This species is redescribed and the name revalidated. A table is presented showing the variations found in salient taxonomic characters of A. townsendi collected from 14 different experimental host plants.

Important variations in the size of the second lobes of A. townsendi were recorded. Second lobe reduction from three-fourths the length of the median lobes to mere hyaline points was observed. Specimens in the last category strongly resemble Diaspidiotus ancylus (Putnam). Aside from these second lobe variations, A. townsendi is a relatively stable species from the standpoint of host determined morphological variables.

Avocado was the sixth test host on which transferred crawlers would not develop. Long series of scales from this host are present in the National Collection. They were collected from avocado fruit in quarantine at Texas, from Mexico. This species, A. perseus Davidson, is described as new herein.

As here understood for North America, Abgrallaspis contains 13 species. Six were placed in this genus by Balachowsky, and seven by the writer. The last are: flabellata (Ferris) from Hemiberlesia; quercicola (Ferris) from Hemiberlesia; mendax (McKenzie) from Hemiberlesia; oxycoccus (Woglum) from Aspidaspis Ferris; ithacae (Ferris) from Aspidaspis; perseus Davidson as a new species; and townsendi (Cockerell) as a revalidated name.

A brief presentation of materials and methods utilized in the host transfer experiments is followed by a discussion of the structural characters used in this work. Descriptions of Hemiberlesia and Abgrallaspis are accompanied by keys and descriptions to all the species in North America. Figures of adult female pygidial characters and scale coverings are provided for all species considered in these two genera.

ACKNOWLEDGMENTS

This work was initiated by Mr. Harold S. McConnell, Department of Entomology, University of Maryland, who directed its course despite failing health, until his untimely death. The author is greatly indebted to Dr. William E. Bickley, Head, Department of Entomology, University of Maryland, who assumed general supervision and gave continual encouragement throughout this study. He also provided the finest optical equipment and made available the coccoid reprints and slide collection of the Department of Entomology.

The invaluable National Coccoid Collection was made available through the courtesy of Dr. Harold Morrison, Entomology Research Division, Agricultural Research Service, U. S. Department of Agriculture. In several instances he also permitted the use of translated foreign articles concerning scale insects, and made many helpful suggestions.

Thanks are due Mrs. Waldo B. Moyers, University Park, Maryland, for graciously allowing a large plot of scale-infested pachysandra to be dug from her beautiful yard.

Mr. Harold L. McKenzie, Department of Agriculture, State of California, Sacramento, contributed type specimens of two species not represented in the National Collection.

Several members of the Biology Department, Washington Missionary College, Takoma Park, Maryland, made substantial contributions in the area of host transfer experiments. They are L. Dickson, A. Fitcher, and D. Lord. Mr. R. Reeder did the photographic work. Mr. Lester E. Harris, Jr., Head of the Department, is to be thanked for providing the laboratory facilities used in the host experiments.

Finally, I wish to thank my wife, Suzonne, for her daily encouragement and patience in typing the many rough drafts necessary to produce a finished product.

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INTRODUCTION AND REVIEW OF LITERATURE

Scale insects have had a close association with man down through the ages. They have long been studied and cultured because of their useful by-products, principally shellac and cochineal. Since the advent of modern synthetic materials, certain beneficial members of this group have become less important in the more advanced areas of the world. As if to compensate for any loss of importance, other members of the superfamily Coccoidea have become well known to man because of their destructiveness to his cultivated crops.

The subfamily Diaspidinae of the family Diaspididae (the armored or diaspid scales) is composed of two tribes: the Diaspidini and Aspidiotini. The latter group contains some of the most destructive members of the Coccoidea. The San Jose scale, Quadraspidiotus (Aspidiotus) perniciosus (Comstock), all but destroyed the fruit industries of several eastern states within 30 years after its introduction in 1886. It was also responsible for the first U. S. laws to quarantine foreign plants. The 1958 and 1959 surveys of Maryland nurseries by personnel of the Department of Entomology, State Board of Agriculture and University of Maryland, revealed that the San Jose scale is still a major pest of nurseries in southern and eastern Maryland. This pest is usually kept under control by the commercial fruit growers due to the rigorous spray programs which must be followed in order to produce fruit of acceptable quality for today's markets.

Related to Q. perniciosus, and still considered part of the old Aspidiotus generic concept by some workers, are several apparently native species of aspidiotines about which the present study is concerned. As a result of this work they are now believed referable to the genus Abgrallaspis Balachowsky 1948, which contains a complex centering around the species howardi (Cockerell) (fig. 17). Although not consistently as destructive as the San Jose scale, these species can build up large populations under certain conditions. At such times they constitute a threat to the viability of their hosts. A brief history of the genus Aspidiotus Bouche 1833 is presented here as a basis for an understanding of the taxonomic problems which have been studied.

The genus Aspidiotus was the second diaspid genus to be described. In the 60 years following its establishment, it gradually was expanded to form the tribe Aspidiotini. During this time only three other aspidiotine genera were created: Chrysomphalus Ashmead 1880, Aonidia Targioni-Tozzetti 1888, and Targionia Signoret 1870. At one time or another, according to Ferris (1941), the genus Aspidiotus contained about 300 species. Although the artificiality of this group has long been recognized, revisionary attempts were slow in appearing and usually of an unsatisfactory nature.

Berlese and Leonardi (1895) and Cockerell (1897) made the earliest attempts at splitting the genus Aspidiotus into several closely related genera, but it was not until the work of Fernald (1903) that a solid foundation was given to coccoid taxonomy. Ferris (1941) wrote concerning this work: "The effect of this catalogue was to fix names to such an extent in the minds of later workers that

even today there is reluctance on the part of some to accept names that were rejected by it or to change names that were accepted by it."

Some 20 years later MacGillivray (1921) attempted to revise the Coccoidea by reviewing the literature without a thorough study of the actual specimens. Apparently throwing all caution to the winds, he proposed some 116 new generic names. Forty-three of these new genera had as their types species which were at one time or another in the genus Aspidiotus. Even more radical proposals were made by Lindinger (1937), who made generic combinations which were more fantastic than MacGillivray's. Fortunately, Lindinger's work was not on as large a scale.

Ferris (1938) began a complete revision of the genus Aspidiotus in North America in an attempt to bring some semblance of order to a poorly defined group. Certain of the genera which Ferris proposed are entirely plausible. The species composing these genera conform to the typological concept as discussed by Brown (1959); each species being morphologically defined, and the degree of morphological difference is the primary criterion for distinguishing different species groups or genera. Other genera fail to conform to typological species concepts as generally understood for this group. One of the latter is the genus Hemiberlesia Cockerell in which Ferris placed the howardi complex.

Hemiberlesia, as conceived by Ferris (1942), contained 15 species which exhibited a very marked cline with regard to diagnostic characters. One species at either end of this character gradient may be shown to be much more variable morphologically than two different species from another presently accepted genus. Also, the character cline of Hemiberlesia, as presented by Ferris, merges into such genera

as Diaspidiotus and Aspidaspis. This makes it difficult to segregate species which have characters applicable to all three generic concepts.

Ferris (1938) stated that the genus Hemiberlesia is chiefly characterized by having a "tendency toward the possession of a conspicuously large anal opening, the small size or even absence of the third lobe, the presence of the intersegmental scleroses and the usually elaborately developed fringe of plates." A good example is the type species H. rapax (Comstock) (fig. 10). In this species only the median lobes are present; lobes two and three are represented by unsclerotized (hyaline) points.

Another species that Ferris also placed in Hemiberlesia, but which is at the opposite extreme regarding these traits, is H. coloratus (Cockerell) (fig. 11). Here the anal opening is very small. Two pairs of lobes and a sclerotized point (regarded by most workers as a reduced third lobe) are present, and the intersegmental paraphyses (scleroses) are reduced. In H. rapax dorsal macroducts are present only on the pygidium from segments eight through five, while in H. coloratus these ducts run forward to prepygidial segment three.

The A. howardi complex lay approximately in the middle of the range of variation for Hemiberlesia with respect to Ferris' definition of the genus. Two pairs of pygidial lobes are usually present, but the second pair is subject to great variations in size, shape, and sclerotization. The intersegmental paraphyses are slightly developed and the fringe of plates moderately so.

It thus appears that Ferris' concept of Hemiberlesia was based mainly upon quantitative rather than qualitative characteristics. This tends to make decisions regarding generic limits and the definition of

species subjective and therefore entirely too arbitrary. For one or more of these reasons, Ferris' keys to this group are largely unworkable.

Balachowsky (1948) created the genus Abgrallaspis for those species of Hemiberlesia found in Europe which usually have numerous dorsal tubular macroducts and anal openings never conspicuously larger than the length of the median lobes and situated at the level of the apical third or fourth of the pygidium. They also have the second pair of pygidial lobes present and well developed. The marginal scleroses are scarcely marked, and the marginal pygidial fringe of plates and barbules (simple plates) are well developed. A. cyanophylli (Signoret) (fig. 13) was designated as the genotype with the following species included in the genus: ephedrarum (Lindinger), seurati (Marchal), insularis (Balachowsky), cyanophylli (Signoret), palmae (Cockerell) (fig. 7), and degeneratus (Leonardi) (fig. 14). Only the last three species have been recorded from North America.

Thus restricted by Balachowsky, members of the genus Hemiberlesia usually have the anal opening situated lower than the apical fourth of the pygidium. The diameter of the anus is greater than the length of the median lobes. The second and third pairs of lobes are degenerate and spiniform. The intersegmental scleroses are stout and recurved. There are few dorsal tubular macropores, and these are usually small and filiform.

In a subsequent work Balachowsky (1953) revised the genus Hemiberlesia for the world. In his key to 14 species, all but one of the ten North American species being considered in this study were presented. No figures of species were included. In the same paper

H. palmae was shifted from Abgrallaspis, in which he first placed it, back to Hemiberlesia, its original assignment by Ferris, and the following species were referred from Hemiberlesia to Abgrallaspis: howardi (Cockerell), coloratus (Cockerell), comstocki (Johnson) (fig. 12), degeneratus (Leonardi), and fraxini (McKenzie) (fig. 16).

Marlatt, in an unpublished note in the U. S. Department of Agriculture files, recognized four species as belonging to the howardi complex; howardi Cockerell, which he believed occurred only in western North America on members of the Rosaceae; comstocki Johnson in the "Middle Atlantic States" on Acer; coloratus Cockerell on Chilopsis in the southwest, and later found on Magnolia and Liriodendron in New York state; and pseudospinosus Woglum from saw palmetto, Florida. Ferris (1938) later made townsendi (fig. 23) and pseudospinosus synonyms of howardi.

To summarize the ideas of Marlatt and Ferris on this subject, we might say that Marlatt tended to split the populations involved. He used host relationships as a basis from which to interpret morphological dissimilarities between various populations. Ferris, on the other hand, tended to lump these populations. He used only morphological comparisons to separate the populations and let host relationships fall where they might. Regardless of the approach, either or both of these concepts may be faulty since no basic, biological experimentation was done to strengthen either viewpoint.

The howardi complex now lies in the center of the Abgrallaspis generic concept. Since Abgrallaspis was derived from Hemiberlesia, they are very closely related. The latter genus has been studied for the world as previously mentioned, but the North American limits of

Abgrallaspis have never been determined. The A. howardi complex presents the most confused taxonomic picture in Abgrallaspis. In considering the problem it was realized that a detailed study of this complex would elucidate the composition of Abgrallaspis in North America, and clarify its relationship to Hemiberlesia.

Hemiberlesia and Abgrallaspis are primarily North American. Ferris' (1937) definition of North America is used throughout this work; "all the mainland from the Arctic regions to and including the Panama Canal Zone." Both genera are closely related since one was derived from the other. Both genera contain actual or potential pests of various aspects of American agriculture. H. lataniae (fig. 6) and H. rapax are greenhouse pests in the north which adapt to a wide range of host plants. A. townsendi and A. ithacae (fig. 18), the Hemlock Scale, are pests of ornamentals. A. howardi prefers such hosts as pear, peach, and plum, and A. perseus Davidson (fig. 21) appears limited to avocado.

The demands on agriculture increase yearly to meet the needs of an exploding population. It is therefore obvious that obtaining detailed information concerning the habits and identities of such pests is a necessary step towards supporting a successful agricultural program in the future.

Therefore, the major objectives of this work have been: (1) a study of Hemiberlesia and Abgrallaspis in North America to determine the number of species now referrable to these genera; (2) the development of new methods for clarifying species boundaries in such confused taxa as the A. howardi complex; (3) the composition of keys to all species placed in these two genera. In order that this might be

accomplished, type species representing eight genera previously separated from Aspidiotus and allied to Hemiberlesia and Abgrallaspis were examined. Taxonomic characters in present use, or of possible future use, were evaluated. Synonymies are not included here because they are readily available in the work of Ferris (1942). Nearly all drawings for the figures included in this work were done from the actual type specimens with the aid of a microprojector. For this reason figures may lack perfect symmetry of outline.

This work was begun under the direction of Mr. Harold S. McConnell (deceased May 11, 1958), Department of Entomology, University of Maryland. About one year was spent examining type material of 47 species representing eight genera closely allied to and including Hemiberlesia and Abgrallaspis. These genera were all split from the genus Aspidiotus by various workers. The intent was to re-examine the type material of involved species and attempt to find new taxonomic characters by which to clarify those specific and generic boundaries obscured at the time.

Paraphyses development as related to age; lobe length as related to age; dermal pockets; patterns of sclerotization; cicatrices; number, type, and distribution of dorsal macroducts and ventral microducts; plate shapes and frequency of occurrence; spiracles and related glands; eye tubercle shapes; setal patterns; and other largely unused characters were studied with the aim of finding new characters upon which to build more stable taxa. On the whole, this work failed to show new relationships.

Next, characters already in use were re-examined to determine the possibility of recombining them in such a way as to develop a more

practical taxonomic concept. This method also failed in its objectives, and the writer was led to seek a different avenue of approach to the revisionary task.

Most taxonomic studies in the Coccoidea have been based mainly on comparisons of morphological characters of slide-mounted adult females. Since this type of work has largely failed to reveal relationships in such confused taxa as the Abgrallaspis howardi complex, it is believed that a new approach is needed involving different methods of comparison. This is not to say that morphological characteristics should be entirely discarded; they may be misleading, however, in the case of very closely related species. The degree of difference may be on the same order of magnitude as occurs normally in polymorphs of other species. It is mainly in the case of sibling or cryptic species and/or polymorphism that the usual morphological comparisons are of less value.

Mayer, Linsley and Usinger (1953) describe five main types of taxonomic characters: (1) morphological, (2) physiological (3) ecological, (4) ethological, and (5) geographical. Morphological studies of this complex have already been discounted as unproductive in themselves. Owing to the minute size of scale insects and their peculiar life histories, ethological characters seem impractical at this time. The geographical distribution of these species is difficult to determine and is without doubt extremely unnatural. The Coccoidea have been widely distributed on plant material, such as ornamentals, which are frequently transported considerable distances by man. This leaves a study of ecological and physiological characteristics as the most promising in obtaining information useful in solving the problem at hand. Adult diaspid s are sedentary obligate plant parasites.

Therefore, it was decided that the simplest of the latter two factors to manipulate in the case of the Coccoidea would be ecological, i.e., the range of host tolerance.

As regards the Homoptera in toto, Brown (1959) wrote, "There is evidence of considerable host specificity in the Homoptera, but the food relationships have received inadequate study and have been neglected by taxonomists." This statement is particularly true when applied to the scale insects. A survey of the coccoid bibliography compiled by Morrison and Renk (1957) revealed approximately 11 articles dealing primarily with biological studies relating to taxonomy. Only eight were considered sufficiently important to mention. This is from a total of about 3,000 entries. The little work which has been done on biological relationships pertaining to taxonomic problems is representative of only three coccoid families: Coccidae, Eriococcidae, and Diaspididae (tribe Diaspidini).

Ebeling (1938) showed that the soft scale Lecanium corni Bouche, when grown on two different hosts, would acquire morphological features characteristic for each host. When allowed to develop on Prunus the insects had large bodies and short appendages. Progeny of this type placed on Photinia developed small bodies and long appendages. The data exhibited a high degree of statistical significance. Ebeling states that "according to conventional standards in taxonomic work, if the sources of the insects were not known, the structural differences between L. corni on Christmas-berry and L. corni on apricot shown by the foregoing data might legitimately be construed to indicate that the insects on these two hosts are distinct species."

Goux (1944) did a comparative study of the hosts of Eriococcus Targioni-Tozzetti and divided the species into two main categories: monophagous (restricted to one genus or botanical family) or polyphagous (not restricted to hosts of a certain genus or family). This work was done mainly by studying collection records. Host transfer experiments were very limited in scope.

Glenn (1920) and Griswold (1922) both reported ecological races of Lepidosaphes ulmi (Linnaeus), the oyster shell scale, from findings based on host transfer work. Suter (1932), working in Germany, made a detailed study of the anatomy and biology of the same insect and as a result recognized five races.

Lupo (1943) and Stafford and Barnes (1948), working in Italy and North America respectively, all came to the same conclusion regarding polymorphism in the fig scale. They discovered that changes in form of this species are host determined, as was the case with Lecanium corni.

Takahashi (1953) studied eight species of Japanese Chionaspis. He noted that in some species of Chionaspis the adult females are dimorphic, the Chionaspis-type and Phenacaspis-type occurring in the same species, even in the same colonies at the same time. The Chionaspis-type tended to occur on the bark in overwintering forms, and the Phenacaspis-type was found only in the summer on leaves. For the most part, specialists working with scale insects have been slow in adopting new techniques and methods of study.

It should be noted at this point that no ecophenotypic work of the type just discussed has been done in the aspidiotine tribe of the Diaspididae, which contains the Abgrallaspis howardi complex.

MATERIALS AND METHODS

In the foregoing introduction it was stated that a major objective of the work reported here was an ecophenotypic study of the Abgrallaspis howardi complex, with the idea that some light might be shed on the scale to scale and host to scale relationships.

The first necessary step in procedure appeared to be the compilation of a list of hosts from which A. howardi had been collected. Accordingly, a study was made of coccoid material in the National Collection, U. S. Department of Agriculture. Scale insects labeled as Aspidiotus [= Hemiberlesia = Abgrallaspis] howardi were recorded from Pyrus (pear, apple), Prunus (peach, plum), Persea (avocado), Ulmus (elm), Liquidambar (sweet gum), Ficus (fig), Acer rubrum (red maple), Hedera (English ivy), Cotoneaster pyracantha (pyracantha), Kalmia (laurel of America), Oxydendrum (sorrel - tree), Smilax (greenbrier), Quercus (oak), and Diospyros (persimmon).

Ferris (1938) listed Hemiberlesia [= Abgrallaspis] howardi as occurring on Rhododendron, Epigea repens (false buckthorn), Magnolia, Ilex (holly), Maclura pomifera (osage orange), Acer saccharum (sugar maple), and Prunus (plum).

In addition to these hosts, an examination of the coccoid collection file, Department of Entomology, University of Maryland, showed Vaccinium (blueberry) and Pachysandra to be susceptible to scales labeled Hemiberlesia [= Abgrallaspis] howardi in Maryland. The works

of Robinson and Fernald (1908) and Benson (1957) were used as aids in the designation of common or scientific names, where this seemed necessary, in the host list just enumerated.

Next, a population of Abgrallaspis howardi as conceived by Ferris (1938) was sought for the transfer work. This was found on September 10, 1958, in the yard of Dr. Waldo B. Moyers, University Park, Maryland, on pachysandra. The plants harboring the most scales were dug up and placed in four flats for removal to the Entomology section of the University of Maryland greenhouses. These plants were allowed to develop in the greenhouse for six months. They were then moved to a well-lighted laboratory room in the Department of Biology, Washington Missionary College, Takoma Park, Maryland. Factors such as light, temperature, and humidity were controlled as much as possible to simulate greenhouse conditions. The plants automatically received ten hours of fluorescent lighting from a timing device and were situated over large, shallow, water-filled trays to keep the humidity high. The temperature was maintained at about 80 degrees Fahrenheit. Fertilizer was not used. The plants usually made a steady rate of growth unless overburdened by scale infestations.

Four to five inch cuttings were then taken from the plants and placed into flats containing 50% sand and 50% mulch (fig. 24). These cuttings were allowed to develop for about one month. At the end of this time the plants were found to be well rooted. They were then transferred into small pots (fig. 25). Flower pots with a diameter greater than four inches were found too unwieldy under the stereoscopic microscope during the delicate task of transferring crawlers.

The infested pachysandra was brought into the greenhouse in September of 1958. The population density of these scales was very low at this time. For this reason, transfers were not practical until the following March. When brought into the greenhouse, the heaviest infestation averaged only six scale insects per leaf. In the laboratory ten months later, the infestation became heavy enough on certain plants to be fatal. From this time on, new cuttings were continually being rooted, potted, and infested to take the place of the dead and dying plants. As many as 100 scales developed on leaves of heavily infested plants (fig. 26).

The tremendous buildup of these scales in the laboratory can probably be attributed to the removal of several factors of natural environmental resistance. Two-spotted spider mites (Tetranychus telarius (Linnaeus)) periodically developed large populations on the pachysandra in both the greenhouse and laboratory. When abundant in great numbers, these mites produced an extensive network of webbing which covered large portions of the plants. This webbing trapped and caused the death of many crawlers. Dimite (Di(p-chlorophenyl) methyl carbinol) was used to control the mites. It had no measurable effect on immature or mature scales.

A mealybug (Planococcus citri (Risso)) also became troublesome under controlled conditions. Adult females secreted large, protective, mealy coverings. These sticky secretions also trapped numerous crawlers. No useful specific chemical control was found. Heavily infested plants were discarded and lightly infested plants hand picked to rid them of mealybugs.

A third contaminant was present in the form of the soft scale, Lecanium persicae (Fabr.) (determined by Dr. Harold Morrison). These scales, which appeared to have a low reproductive potential, never became numerous enough to pose a problem.

Laboratory controlled growing conditions meant that such insect predators as coccinellids, carabids, etc., were not able to deplete the test host population.

The most important limiting factor in rearing A. howardi was the eulophid parasite Aspidiotiphagus citrinus (Craw.) (determined by Dr. B. D. Burks, U. S. National Museum). These minute wasps increased in numbers almost as rapidly as did the scale insects. A survey of parasite escape holes in developing scales revealed as high as 80% parasitism on some of the test plants to which scales had been transferred. Test hosts were kept on opposite sides of the room from the primary infestation on the stock pachysandra. The wasps either flew across the room, or the crawlers were parasitized before being transferred to the previously uninfested test hosts.

Crawlers were transferred with the aid of a stereoscopic microscope and camel's hair brush from which all but one bristle had been removed. Crawlers were most abundant on the under surfaces of leaves. They were easiest to locate on plants laid on their sides to allow leaf manipulation. Once discovered, the crawlers were gently lifted off on the single bristle, and deposited on the desired test host. This was done at a magnification of ten diameters. Other methods of transferring were tried; with minuten nadeln, pins, flotation methods, of egg laden females. These all proved much less practical. Transfers were always made to parts of the test host which had been marked to

make future recognition possible. Notching the tips of test leaves proved the easiest marking method. Approximately 160 hours were spent transferring an average of 135 crawlers to 20 different host plant species. A total of 2,700 crawlers was transferred in the above manner.

The host plants used in this study (several of which may be seen in fig. 27) were avocado, peach, plum, pear, apple, red maple, green-brier, rhododendron, holly, blueberry, oak, persimmon, osage orange, tulip poplar, magnolia, laurel, elm, pine, sweet gum, and pachysandra. The last named plant was used as a control to compare the number of successful transfers to the original host as against successful transfers to the various test hosts. The test hosts were chosen primarily for one of two reasons: (1) a preliminary study of slide material from these hosts seemed to indicate there was a possibility of host determined morphological variation, or (2) they were recorded as hosts for A. howardi by other workers, and the writer questioned the validity of the determinations.

All of the hosts were gathered from various sources in the College Park area except the avocado plants (fig. 28). These were grown from seeds of purchased fruit. The main prerequisite in selecting plants was size. Smaller plants proved easier to handle. Three plants were used to represent each host except avocado. Only two attempts at growing this plant succeeded. It was also found that since the crawlers were not confined, fewer leaves made recovery of transferred scales easier. An attempt was made to force certain crawlers to settle on leaves and others on stems to test the effect of these two environments on development of useful taxonomic characteristics. Materials such as vasoline, mineral oil, a so-called tanglefoot

("Off"), and string were used to bring about this isolation, but they were found impractical because of the high mortality they caused among transferred crawlers. In their natural dispersal over test hosts, some crawlers chose stems while others chose leaves, thus accomplishing the same end by normal activity. However, equal numbers of crawlers never settled on stems and leaves.

The test population was found to have a crawler-to-crawler cycle of three months, on the average, in the laboratory. This study encompassed approximately five generations. Several immature females were allowed to develop in complete isolation from males of their own species. This was brought about by removing all males from a small plant containing immature females which had not completed the final molt. The plant was then moved to a different building. These females lived over four months, but never produced eggs or crawlers. This test was done in order to rule out parthenogenesis as a factor in the production of characteristics in the test populations.

After the test species population had built up sufficiently in the laboratory, host transfers were begun. A period of two months was allowed to elapse from transplant to recovery. This period of time, in the case of pachysandra, was found sufficient to allow maturation of the females without excessive egg production. The latter condition usually interferes with the preparation of good slide mounts. Transferred crawlers were considered "takes" if, after the two month developmental period passed, they were still present and recognizable due to the secretion of a scale-like covering. These individuals were then removed and mounted. The total number of takes could have included immature and/or mature males and females. Of this number, only adult

females were usable for study purposes, and many of these were heavily parasitized and not desirable. The value of immature male and female, and adult male characters has never been fully determined for the species level in this group.

As previously explained, *pachysandra* was the control plant. Accordingly, 135 crawlers were transferred back to three plants which had been carefully examined and found free of infestation. The number of takes on the natural host was used as a standard to compare with the number of takes on the test hosts.

Two types of mounting techniques were used in preparing specimens for study; permanent mounts of fuchsin stained individuals mounted in Canada balsam (filtered and dissolved in xylene), and semipermanent mounts in Hoyer's medium which was ringed with pyroxylin in ethyl acetate. The Hoyer's medium was formulated in the following manner: 30 gm. of gum arabic and 200 gm. of chloral hydrate were dissolved in 50 cc. of distilled water. 20 cc. of glycerine were added. The mixture was then filtered through cellucotton and a drop of hydrochloric acid added to clear the medium.

The fuchsin method, when properly done, undoubtedly yields the best material for study purposes. At the same time, however, it is also the most difficult method to master. A miscalculation in any one of several steps may mean the loss of a good study specimen. The fuchsin method practiced by the writer is as follows:

Step I - The insect is carefully removed from beneath its scale covering by use of a fine probe and placed in a microvial containing a 10 per cent solution of KOH.

Step II - The specimen is heated or soaked until the internal organs disintegrate. Thirty to 60 minutes are usually sufficient for heating. If overheated, the stain retaining ability is often lost. Soaking at room temperature produces the most satisfactory results, but this may require a period as long as two days. Occasionally it is necessary to make a small slit in the derm and tamp eggs, viscera, etc., out of the specimen.

Step III - The specimen is next removed to a clean microdish and washed with water. A drop of dilute HCL is added, and two more water washes applied.

Step IV - The specimen is now transferred into a microvial containing a stain of acid fuchsin (.5 gm. of acid fuchsin to 25.0 cc. of 10 per cent hydrochloric acid and 300 cc. of distilled water). The time required to produce a satisfactory stain may vary from one to 24 hours, depending on whether or not heat is used to speed up the process.

Step V - The insect is then removed to a microdish containing 95 per cent alcohol, for about a 30 minute period.

Step VI - It is then placed in a microdish containing dioxane for about 30 minutes.

Step VII - It is then placed in a microdish containing clove oil for about one hour.

Step VIII - The final step includes placing the specimen on a clean slide, touching a drop of balsam to it, and covering it with a clean coverslip. Approximately 12 armored scale insects can be simultaneously processed in this manner.

Those specimens not mounted by the fuchsin method were mounted in Hoyer's medium. There are two advantages to this method: (1) It is

a one step process; the scales are transferred into the medium, covered with a coverslip, and heated until cleared. Since Hoyer's medium is quite hygroscopic, the coverslip was ringed with pyroxylin in ethyl acetate after the slide had been oven dried. (2) Hoyer's is soluble in water. At any later date the scales may be removed from the medium, washed in water, and run through the more complicated fuchsin process if desired.

There are two major disadvantages in this method: (1) The specimens are not stained, and (2) the mounts are usually not considered permanent due to the instability of the medium. Approximately 200 specimens from the host transfer experiments were mounted on slides using the two methods just discussed.

STRUCTURAL CHARACTERS CONSIDERED

IN THIS STUDY

Ferris (1942) considers the Diaspididae to be composed of two sub-families: the Phoenicoccinae and Diaspidinae. Members of the first tribe are characterized by having a ventral anal opening, sclerotic anal ring, and form no scale covering. Members of the last named tribe have a dorsal anal opening, lack a sclerotized anal ring, and form a scale covering which includes the first and second exuviae.

The two genera about which this work is concerned belong to the tribe Aspidiotini of the subfamily Diaspidinae. The members of this tribe have in common macroducts of the "one-barred" type, second pygidial lobes never bilobulate, fringed plates normally present, gland tubercles usually absent, and anterior spiracles usually without associated disc pores.

The terminology for the taxonomic characters used in this study and the type of illustrations presented are consistent insofar as possible with that employed by Ferris throughout his works on the aspidiotines. Each figure presented herein depicts only the adult female pygidium and appropriate structures, along with the adult female scale covering. Several modern workers in this group habitually figure male scale coverings, adult female body outlines, enlarged drawings of spiracles, antennae, and larval characters. As mentioned earlier, a survey of these, and many other characters in this group, has revealed

them to be of undetermined significance at this time. Therefore, they are not figured.

PROSOMAL SCLEROTIZATION. - The genera in question are, as a rule, without definite sclerotization of the prosomal (cephalothoracic) region. Members of the Abgrallaspis howardi (Cockerell) complex seem most variable with respect to degree of prosomal sclerotization. A comparison of mature eggladen females with mature females not containing eggs has indicated that prosomal sclerotization is progressive with age in many cases. Parasitism may cause extreme sclerotization at any age. Parasitized specimens were not used.

EYESPOTS. - Eyespots may be of some use for specific differentiation. They usually occur on the margins of the cephalothorax lateral to the mouthparts. Although certain species may appear to lack eyespots, if long series are examined, individuals usually are found possessing these structures. They are most pronounced in such species as Abgrallaspis cyanophylli (Signoret) and Hemiberlesia palmae (Cockerell) and usually absent in such species as H. popularum (Marlatt) and H. lataniae (Signoret). Eyespot size may vary intraspecifically, as well as interspecifically. It should be remembered that staining techniques and age of the specimens greatly influence the visibility of such structures.

PERIVULVAR PORES. - The presence or absence of perivulvar pores is the most useful key character for separating large species groups within genera. Those species possessing these pores may often have one or two median pores, but as a rule, only the anterior (front) and posterior (rear) pore clusters are constant in occurrence. The number of perivulvar pores per cluster is highly variable. Usually the anterior

cluster carries one or two pores more than the posterior cluster. In some instances the pores are not grouped into definite anterior and posterior clusters, but run together in a continuous, irregular line. Abgrallaspis coloratus (Cockerell) possesses several supernumerary pores located anterior to the normal anterior perivulvar pore clusters.

MEDIAN LOBES. - The median lobes are mainly useful as specific diagnostic characters. They vary in position from convergent and somewhat appressed as in A. howardi, to vertical and well separated on the pygidial apex, as in H. palmae. Notches of varying sizes on the lateral and mesad aspects of these lobes are usually sufficiently constant to be useful in determining lobe shape. Variation in lobe size and shape is most noticeable in the A. howardi complex. Generally speaking, the characteristic average condition for these lobes is recognizable for each species. Often specimens are found with very rounded median lobes lacking preapical notches. The writer believes this condition to be atypical, and probably the result of wearing.

SECOND LOBES. - The presence or absence of second lobes has proven a useful generic character. Hemiberlesia, as conceived by Ferris, contained individuals with or without second lobes. With the assignment of all species possessing normal second lobes to Abgrallaspis, all species left in Hemiberlesia lack second lobes. In most instances, these second lobes appear as clear (hyaline) points of variable sizes.

THIRD LOBES. - Only one of the species under consideration possesses normal third lobes: Abgrallaspis mendax (McKenzie). In several isolated instances, the derm was found to be sclerotized and projecting in the area of the third lobe. This was always the exception rather than the rule. The third lobe was usually found to be represented by a

small point of variable sclerotization, but usually hyaline.

PLATES. - The genera in question have the plates confined to the pygidial margin. The standard plate formula is two - two - three; two between the median lobes, two between the median and second lobes (or point representing lobe two), and three between lobe two and the point representing lobe three (or the seta marking segment six should the point be lacking). Abgrallaspis usually has four to five plates present anterior to this last point. These are often long and tapering, with several denticles on their lateral aspects. Hemiberlesia usually has but two or three rather simple plates present in this region. Plate width, height in relation to lobe length, and degree of branching is often a useful specific character. The greatest plate development observed occurs in H. palmae.

MACRODUCTS. - Macroducts are usually considered of four types, depending on their location. Those short ducts occurring in groups of one to three along the margin of the prepygidial abdominal segments are considered marginal macroducts. These have proved to be of no value for specific or generic recognition, and are not considered in this work. Any macroducts present on the prepygidial abdominal segments near the margin are usually considered submarginal ducts. One species, A. fraxini (McKenzie), has submedian ducts in addition to submarginal groups. In order to simplify matters, the latter in combination with the fourth type, dorsal macroducts on the dorsum of the pygidium (exclusive of those located in the margin between segments six, seven, and eight), are herein collectively termed dorsal macroducts. Mention will be made in the appropriate cases should any of these ducts be located anterior to the pygidium. Dorsal macroduct

counts are useful specific characters. These counts include only those dorsal macroducts located on the left side of the meson. In addition to the macroducts in the margin between segments six, seven, and eight, one macroduct may or may not be present between the median lobes, depending on the species in question. Hemiberlesia is characterized by long, filiform dorsal macroducts, usually confined to the pygidium, while Abgrallaspis possesses shorter, more numerous macroducts which often continue anteriorly onto prepygidial segments two or three. The number, distribution, and shape of these ducts are valuable for specific determinations.

MICRODUCTS. - Marginal, or submarginal, ventral microducts occur on the pygidium and prepygidial segments. They usually occur in groups and have been found to be extremely variable in number. Here again the question of staining arises as an important adjunct to making these structures apparent to the observer. No importance with regard to the recognition of generic or specific boundaries could be attributed to these ducts.

ANAL OPENING. - The diameter and relative position of the anal opening is quite useful as a key character, especially in separating Hemiberlesia from Abgrallaspis. The former usually has the diameter of the anal opening equal to, or greater than, the width of the median lobes. The post-anal space in such cases is short and often does not exceed the diameter of the anus. Abgrallaspis, on the other hand, has the anal opening usually smaller than the median lobes and the post-anal space very large. The position of the anal opening was found to be most variable in species of the A. howardi complex.

OTHER CHARACTERS. - In isolated cases, such characters as sclerotic patterns, hosts, and distribution must be used to make specific designations more reliable.

GENUS HEMIBERLESIA COCKERELL 1896

The genus Hemiberlesia may be separated from Abgrallaspis because its members never possess typical second or third lobes, usually have very slender dorsal macroducts, well developed paraphyses, and large anal openings. Abgrallaspis species always have the second and possibly third lobes present, usually possess short and wide dorsal macroducts, lack well developed paraphyses, and have anal openings of moderate size.

As presently understood for North America, this genus contains ten species. All but four lack perivulvar pores. The median lobes are usually prominent and closely set, tending to obscure the median plates. A marked exception is H. palmae (Cockerell), which has a pair of large, highly fimbriate plates between the widely separated median lobes. All species here presented lack normal second lobes. In most species, these are replaced by hyaline points of varying lengths. H. diffinis (Newstead) has large, pointed, sclerotized prominences representing lobes two and three. Third lobes are never present, but usually replaced by hyaline points except in the species last mentioned and H. palmae which also has sclerotized points representing the third lobes. The plate formula is usually two - two - three for the intersegmental spaces between segments six, seven, and eight. As a rule, there are but one or two small slender plates present anterior to the seta marking segment six. The exceptions to this are H. palmae, H. diffinis, and H. ignobilis (Ferris). These have three characteristic plates present in

this area which are specific diagnostic characters in each case. The dorsal macroducts are typically long, narrow, opening through orifices located in dermal furrows, and confined to pygidial segments five and six. Exceptions to the normal form of dorsal macroducts are H. cupressi (Cockerell) and H. candidula Ferris, which have short, relatively wide ducts. If the median macroduct is present between the median lobes, it rarely extends anterior to the anal opening. There is generally a pair of distinct paraphyses present between segments six, seven, and eight of the pygidium, with the mesal pair largest. H. palmae lacks these well developed scleroses. The anal opening is characteristically equal to or larger than the median lobes, and placed about its own diameter from the bases of the latter.

Balachowsky (1953) stated that "although the area of distribution of the genus now known embraces all the regions of the globe, it seems that the majority of species have an American origin." In addition to the ten species representing this genus in North America, Balachowsky listed four other Hemiberlesia species as occurring in other parts of the world. They are H. implicatus Maskell, H. loranthi Laing, H. manengoubae Balachowsky, and H. ziziphi Hall. Only the first named species was seen by the writer.

KEY TO THE NORTH AMERICAN SPECIES

OF HEMIBERLESIA COCKERELL

1. Perivulvar pores present - - - - - 2
 Perivulvar pores absent - - - - - 5
2. Second lobe represented by an elongate, lanceolate, hyaline point
 equal to or larger than the length of the median lobes;
 plates highly fimbriate, the largest three located anterior
 to the seta marking segment six; median lobes usually
 separated by about the width of one lobe - - - - -
 - - - - - H. palmae (Cockerell)
 Second lobes replaced by a small hyaline or sclerotized point,
 if represented at all; plates slightly or normally
 fimbriate, those present anterior to the seta marking
 segment six usually much reduced; median lobes usually
 placed less than the width of one lobe apart - - - - - 3
3. Plates present in the normal two - two - three formula, with the
 anterior three largest and heavily fimbriate; anal opening
 larger than the median lobe length, removed about one times
 its diameter from the latter's base; about ten elongate
 dorsal macroducts present in two narrow dermal furrows - - -
 - - - - - H. lataniae (Signoret)
 Plates usually present in an irregular formula (not two - two -
 three) and atypical in size and fimbriation; anal opening

equal to or slightly greater in diameter than the length of the median lobes, placed more than one times this diameter from the latter's bases; dorsal macroducts short, numerous (more than 20), opening in wide dermal furrows, or elongate, broad, less than ten in number and not opening in furrows - - - - - 4

4. Dorsal macroducts short, slender, more than 20, opening in broad dermal furrows; plates usually in a two - two - two formula, these reduced in size and fimbriation, equal in size or shorter than the median lobes, apically branched - - - - - H. popularum (Marlatt)

Dorsal macroducts elongate, broad, numbering less than ten, never opening in conspicuous dermal furrows; plate formula usually greater than two - two - three, these generally longer than the median lobes, tapering toward the apex - - - - - H. candidula Ferris

5. Second and third lobes represented by large, broad, sclerotized points - - - - - H. diffinis (Newstead)

Second and third lobes represented only by hyaline points, if at all represented - - - - - 6

6. Second and third lobes represented by elongate, slender, hyaline points about equal in length to the median lobes; dorsal macroducts very thread-like; anal opening removed by more than two times its diameter from the bases of the median lobes - - - - - H. ignobilis Ferris

Second and third lobes usually represented by small hyaline points; dorsal macroducts not thread-like, typical for

the genus; anal opening placed two or less times its own
diameter from the bases of the median lobes - - - - - 7

7. Dorsal macroducts much wider and shorter than those of the
genotype; median lobes small, separated by about the
width of one lobe, plainly exhibiting the median plates;
anal opening laterally expanded and situated in a
definite, circular, sclerotized area - H. cupressi (Cockerell)

Dorsal macroducts all slender, elongate, similar to those
of the genotype; median lobes large, rather closely
appressed, separated by less than the width of one
lobe, tending to obscure the median plates; anal open-
ing circular, not situated in a definite, circular,
sclerotized area - - - - - 8

8. Anal opening diameter equal to, or smaller than, the median
lobe length, always placed more than its own diameter
from the bases of the median lobes; plate formula
typically two - two - two, these at times very reduced,
normally never longer than the median lobes; one macro-
duct present between the median lobes - - - - -
- - - - - H. coniferarum (Cockerell)

Anal opening usually greater in diameter than the median lobe
length, never placed more than its own diameter from the
bases of the median lobes; plate formula two - two -
three, these often longer than the median lobes with
well developed fimbriation; macroduct absent between
the median lobes - - - - - 9

9. Lobes two and three represented by hyaline points; usually less than ten short, dorsal, pygidial macroducts present; two tall, slender plates usually present beyond the seta marking segment six; plates between segments six, seven, and eight coarsely fimbriate - - - - - H. rapax (Comstock)

Lobe three absent, not represented by a hyaline point; usually more than 25 elongate, dorsal pygidial macroducts present; long slender plates normally not present beyond the seta marking segment six; plates between segments six, seven, and eight regularly fimbriate - - - H. pseudorapax (McKenzie)

Hemiberlesia candidula (Cockerell) 1900

(Fig. 1)

Type material from Prosopis velutina, Tucson, Arizona, was examined. It has also been recorded from Yucca sp., Todos Santos, Southern District, Baja California, Mexico, by Ferris (1938). Scale of the female whitish, flat, circular, exuviae subcentral.

Adult female. - Length about 1 mm. Cephalothoracic derm slightly sclerotized at maturity. Eyespots absent. Perivulvar pores present in four clusters of three to seven pores each. Median lobes prominent, well separated, their apices angled back toward the meson, slightly rounded, with very slight subapical notching on their mesal aspects, and somewhat more pronounced notching on their lateral aspects. Second lobes absent, apparently not even replaced by hyaline points. Third lobes also completely without representation. Plates all characteristically elongate, slender, tapering toward the apex, very slightly laterally serrate and apically fimbriate. Two or three reduced plates present anterior to the seta marking segment six. Macroducts all elongate, with wide diameters. One macroduct present between the median lobes, extending to about the top of the anal opening. Two macroducts usually present between segments seven and eight and one macroduct between segments six and seven. Dorsal macroducts usually numbering less than ten, all confined to segments five and six of the pygidium, with two or three usually located on the margin anterior to the seta marking segment six. Anal opening slightly greater

in diameter than the length of the median lobes, and removed by about three times this diameter from the base of these lobes. Paraphyses are most pronounced between segments seven and eight, and only slightly so between six and seven.

Notes. - The illustration accompanying this description differs radically from that of Ferris (1938). Ferris' drawing was made from topotype material, and shows very rounded median lobes, low anal opening, and indistinct median macroduct between the median lobes. The writer believes that median lobe rounding is usually the result of wearing and is not typical for most species.

This species seems to have some characters common to both Hemiberlesia and Diaspidiotus, but its generic assignment is not challenged here. It is easily recognized by the anal opening being well removed from the median lobes, characteristic type of plates, median lobe shape, and few but wide dorsal macroducts.

Hemiberlesia coniferarum (Cockerell) 1898

(Fig. 2)

Three type specimens from Pinus ponderosa, Organ Mountains, New Mexico, were examined. Additional material was seen from such hosts as cedar, cypress, juniper, pines, and Libocedrus. Scale of the female circular, flat, whitish with yellowish submarginal exuviae.

Adult female. - Length about 1 mm. Cephalothoracic sclerotization absent. Eyespots absent. Perivulvar pores absent. Median lobes prominent, quite convergent, notched primarily on their lateral margins, lateral margins sloping back toward the meson. Second lobes usually replaced by minute points. Third lobes absent. Only two plates seen

between segments six and seven, and seven and eight. These reduced in size and fimbriation. One or two slender, pointed plates usually present anterior to the seta marking segment six. One macroduct present between the median lobes, extending to about the top of the anal opening. Three macroducts present between segments seven and eight. One macroduct present between segments six and seven. Between 15 and 30 dorsal macroducts present on segments four, five, and six of the pygidium. Most of these usually opening in two irregular, broad, dermal furrows. All macroducts elongate and slender. Paraphyses well developed between segments six, seven, and eight. Anal opening diameter slightly larger than the length of the median lobes, and placed about two times this diameter from the latter's bases.

Notes. - This species was placed in Diaspidiotus by Ferris (1938). His figures were from topotype material which had been compared by him with specimens from the type lot. The type material seen by the writer differs in several respects from Ferris' figure of this species. The anal opening appeared larger than the length of the median lobes and placed closer to their bases, definite plates were present between segments six, seven, and eight, the dorsal macroducts were much more numerous and elongate, a macroduct was present between the median lobes, and dorsal macroducts were present on segment four of the pygidium.

In the light of these facts, this species is here referred to Hemiberlesia and not Diaspidiotus. It very closely resembles H. popularum, but lacks perivulvar pores.

Hemiberlesia cupressi (Cockerell) 1899

(Fig. 3)

Several type specimens were examined from Cupressus species, collected in Toluca, Mexico. This species is known only from the original collection record. Scale of the female flat, white, varying from circular to slightly oval, exuviae central or slightly subcentral.

Adult female. - Length about .8 mm. Cephalothorax tending to be slightly sclerotized in the marginal areas. Small tubercle-like eyespots present. Perivulvar pores absent. Median lobes prominent, well separated, relatively small, somewhat wider than long, subapically notched on both lateral and mesal aspects, apices broadly rounded, tending to be slightly tilted away from the meson. Second and third lobes replaced by sharp hyaline points about equal to, or shorter than, the length of the median lobes. Plates present in the two - two - three formula, but much reduced, often slender, laterally serrate, and lacking typical expanded fimbriate apices. One or two slender plates usually present anterior to the seta marking segment six. No median macroduct seen between the median lobes. One macroduct present between segment six and seven, and two between segments seven and eight. Dorsal macroducts grouped in a rather narrow area, confined to segments five and six of the pygidium, very short and relatively wide, numbering from ten to 16. Anal opening laterally expanded, its longitudinal diameter greater than the length of the median lobes, placed slightly more than its own diameter from the bases of these lobes, located in a distinct circular sclerotized area.

Notes. - This species is easily recognized by the absence of perivulvar pores, laterally expanded anal opening, low and widely separated median lobes, and short but wide dorsal macroducts.

Hemiberlesia diffinis (Newstead) 1893

(Fig. 4)

Four type specimens were examined from Demerara, British Guiana, on an undetermined host. Other material was available from such hosts as magnolia, Louisiana; plum, Mexico; and several hosts from South America. Scale of the female gray, elongate, oval, quite convex, with large marginal exuviae at the anterior end.

Adult female. - Length about 1 mm. Cephalothoracic derm membranous at maturity. Eyespots represented by small sclerotized buttons. Perivulvar pores absent. Median lobes about equal in height and width, close set, with lateral margins sloping back toward the meson, and bearing a distinct preapical notch relatively far from their rounded apices. Second and third lobes represented by low, pointed, sclerotized points, the first pair largest, usually bearing a large notch on their lateral aspects. Plates present in the normal two - two - three formula, elongate, only slightly fimbriate. Three large, broad plates always present anterior to the seta marking segment six. Usually two or three small, slender, pointed plates present anterior to the seta marking segment five. One long, slender macroduct present between the median lobes, usually extending slightly beyond the anal opening. One macroduct present between segments six and seven, and three usually present between segments seven and eight. Ten to 20 dorsal macroducts confined to segments five and six of the pygidium, often opening in faintly marked dermal furrows. All macroducts long and slender. Paraphyses well developed between segments six, seven, and eight. Anal opening diameter somewhat greater than the length of the median lobes, placed about twice this diameter from the bases of these lobes.

Notes. - This species most closely resembles H. rapax but is immediately separable because it possesses sclerotized rather than hyaline points representing lobes two and three. Ferris' (1938) illustration of this species fails to depict the macroduct present between the median lobes seen in the type specimens and other material examined.

Hemiberlesia ignobilis Ferris 1941

(Fig. 5)

Three type specimens were examined. This species was originally described from Ficus species, Chirique Province, Republic of Panama. Although never recorded from Mexico, it is probably present in much of the southernmost area covered by this study. Scale of the female white, circular, moderately convex, exuviae centrally placed.

Adult female. - Length about 1 mm. Cephalothorax tending to be lightly sclerotized on the margins. Eyespot present in the form of a low, blunt tubercle. Perivulvar pores lacking. Median lobes large, with deep mesal and lateral subapical notches equidistant from their prominent, rounded apices. Second and third lobes replaced by slender, acute, elongate, hyaline points equal in length to the median lobes. Plates present in the two - two - three formula, but with greatly reduced fimbriation, often merely simple acute points. Three characteristic plates present anterior to the seta marking segment six. These elongate, acute, with one large mesal notch half way to the apex. One macroduct present between segments six, seven, eight, and the median lobes. Five to seven dorsal macroducts confined to segments five and six of the pygidium, widely scattered. All macroducts of extremely slender diameter and elongate. Anal opening about equal in diameter to the length of the median lobes,

removed from the latter's bases by about three times this diameter. Paraphyses are moderately developed between segments six, seven, and eight. A very large, oval, dorsal, sclerotic patch was noticed in the anterio-lateral area of pygidial segment five. The body form of all three specimens was quite turbinate. Anal opening situated in a rather distinct, circular, sclerotic area.

Notes. - Because of the peculiar thread-like dorsal macroducts, long slender hyaline points replacing lobes two and three, and characteristic plates present anterior to the seta marking segment six, this species cannot be confused with other members of the genus. Ferris' (1938) figure of this species fails to show the median macroduct present between the median lobes, quite evident in the type specimens.

Hemiberlesia lataniae (Signoret) 1869

(Fig. 6)

Type material was not available, but authentic specimens determined by Signoret were seen. This species was examined from a long series of hosts in the southern states. It is common in tropical and subtropical areas. According to Ferris, its host range may include all but oaks and certain conifers. Scale of the female circular, convex, gray to white, exuviae submarginal.

Adult female. - Length about 1 mm. Cephalothorax membranous at maturity. Perivulvar pores present in four clusters of two to nine pores each. Median perivulvar pores usually absent. Median lobes prominent, close set, and tending to obscure the slender median plates, slightly convergent, wider than long, lateral margins sloping back toward the meson, subapically notched on both lateral and mesal aspects. Second lobes

absent, replaced by small hyaline points. Third lobes also replaced by hyaline points, usually smaller than the preceeding pair. One slender, elongate macroduct present between the median lobes, extending to the top of the anal opening. Two similar ducts usually present between the median lobes and segment seven, one such duct between segments six and seven. Dorsal macroducts numbering from ten to 24, confined to the pygidium, usually opening in narrow dermal furrows. Anal opening diameter somewhat greater than the length of the median lobes, placed slightly more than one times this diameter from the bases of these lobes.

Notes. - This species is very similar to H. rapax and H. pseudorapax except for the presence of perivulvar pores, which immediately distinguishes it from the preceeding two. Ferris' (1938) drawing of this species was based on specimens from Hypericum species, San Gabriel, California. The illustration does not show the median duct between the median lobes which was evident in the material determined by Signoret. In all other respects the figures are quite similar.

Hemiberlesia palmae (Cockerell) 1893

(Fig. 7)

Type specimens from coconut palm in Jamaica were examined. Additional material was available from Mangifera, Citrus, avocado, mango, and banana. Scale of the female slightly oval, convex, white, with dark submarginal exuviae.

Adult female. - Length about .7 mm. Derm of cephalothorax usually unsclerotized at maturity. Strongly sclerotized, spur-like eyespots present. Perivulvar pores present in four rather irregular clusters of three to seven pores each. Median perivulvars rarely present. Median lobes

large, slightly longer than wide, widely separated, with distinct sub-apical notches on both mesal and lateral aspects equidistant from their rounded apices. Second lobes represented by slender, lanceolate structures, about equal in length to the median lobes, completely lacking sclerotization, and therefore resembling a type of pygidial plate. Third lobes represented by strongly sclerotized, tooth-like projections. Plates present in the normal two - two - three pattern, with the addition of three, constant in number and appearance, anterior to the seta marking segment six. All plates longer than the lobes, showing much branching, and highly fimbriate. One macroduct present between the median lobes, extending well beyond the anal opening. Two macroducts present between segments six and seven, and seven and eight. Four to nine dorsal macroducts confined to pygidial segments five and six. All macroducts very elongate and moderately wide in comparison to those of the genotype. Paraphyses not as strongly developed as in most members of the genus. Anal opening diameter greater than the length of the median lobes, usually placed less than one times this diameter from the bases of these lobes.

Notes. - This species is probably the most easily identified of the genus. The highly developed fringe of plates, clear lanceolate second lobes, large anal opening, and very elongate dorsal macroducts are excellent key characters.

This species does pose a slight problem of generic placement. The reduced paraphyses, the presence of second lobes even though unsclerotized, and well developed fringe of pygidial plates seem indicative of association with Abgrallaspis. The very large anal opening and its closeness to the apex of the pygidium are equally important for use in showing relationship to Hemiberlesia. The writer accepts Balachowsky's assignment of this species to Hemiberlesia.

Hemiberlesia popularum (Marlatt) 1908

(Fig. 8)

Four type specimens were examined from Populus species, Deming, New Mexico. Additional material was seen from apple, New Mexico. Ferris also records this species from Salix species, Glenn Springs, Texas. Scale of the female oval, whitish, very convex, exuviae marginal on the anterior end.

Adult female. - Length about 1 mm. Cephalothorax membranous at maturity. Eyespots absent. Perivulvar pores present in four loosely arranged clusters with five to eight pores per cluster. Median perivulvar pores were not seen. Median lobes prominent, close set, wider than long, slightly convergent, subapically notched primarily on their lateral margins, broadly rounded. Lobe two and possibly three represented by a minute hyaline point. Plates present in a two - two - two formula. The median pair nearly obscured by the median lobes, slightly fimbriate apically. Second pair of plates about equal in length to the median lobes, moderately wide and fimbriate. Third pair of plates about equal in size and shape to the second pair. One or two very small pointed plates may be present anterior to the seta marking segment six. One macroduct present between the median lobes, extending into the region of the anal opening. Four to 12 macroducts usually present between segments seven and eight. One macroduct present between segments six and seven. Twenty to 40 dorsal macroducts confined to segments four, five, and six. These opening in two wide dermal furrows. Anal opening diameter greater than the length of the median lobes, placed about one and one half times this diameter from the bases of these lobes.

Notes. - This species is most similar to H. lataniae, but can be distinguished by the numerous dorsal macroducts, minute points replacing lobes two and three, and great reduction in size and number of the pygidial plates. The type material seen possessed median lobes quite different from those illustrated by Ferris (1938) for this species. In addition, a macroduct was present between the median lobes which Ferris did not indicate in his drawing.

Hemiberlesia pseudorapax McKenzie 1951

(Fig. 9)

This species was described from Abies species, originating from Santa Rita, New Mexico, and intercepted in quarantine at Hemet, Riverside County, California. Only the holotype was seen. Scale of the female slightly oval, grayish, with dark, reddish-brown, submarginal exuviae.

Adult female. - Length of adult female about 1 mm. Cephalothorax membranous at maturity. An eyespot-like, unsclerotized tubercle present midway between the anterior and posterior spiracles on the margin of the cephalothorax. Perivulvar pores absent. Median lobes prominent, lateral aspects sloping back toward the meson, subapically notched on both mesal and lateral aspects, with the lateral notch the largest, close set with a tendency to obscure the median plates. Second lobes replaced by small hyaline points. Third lobes absent. Pygidial plates present in the normal two - two - three formula and typically fimbriated. One or two very short, simple plates present anterior to the seta marking segment six. No macroduct present between the median lobes. Three macroducts present between segments seven and eight. Two or three macroducts present between segments six and seven. Dorsal macroducts relatively numerous (27 in the holotype),

rather elongate, often in furrows and confined to segments five and six of the pygidium. Intersegmental paraphyses well developed between pygidial segments six, seven, and eight. Anal opening somewhat larger than the length of the median lobes and removed from the latter's base by slightly more than one times its own diameter.

Notes. - This species most closely resembles the genotype, H. rapax. It differs by possessing more numerous, elongate, dorsal macroducts, lacks a hyaline point replacing lobe three, has more typically fimbriated plates, and has the anal opening further removed from the bases of the median lobes.

Hemiberlesia rapax (Comstock) 1881

(Fig. 10)

This species was originally described from "various trees and shrubs in California and Florida." It occurs throughout the United States, with the possible exception of extreme northern states. It apparently can exist on any woody plant. Numerous specimens were examined from such hosts as Citrus, Prunus, Vaccinium, Persea, Eucalyptus, and Maranta. Scale of the female very convex, grayish, rather oval, exuviae marginal and usually at the apex of the convexity.

Adult female. - Length about 1 mm. Cephalothoracic derm membranous at maturity. Eyespots present as low, sclerotized buttons, often with three or four papillae-like projections. Perivulvar pores absent. Median lobes very prominent, wider than long, tending to be convergent, close set, blunt, subapically notched on both mesal and lateral aspects with the latter most conspicuous. Second and third lobes replaced by conspicuous hyaline points. Plates present in a two - two - three formula,

not highly but coarsely fimbriated. The median pair slender and somewhat obscured by the median lobes. Two very slender plates usually present anterior to the hyaline point representing lobe three. No macroduct present between the median lobes. Three macroducts present between the first and second hyaline point. Between six and 12 small, slender dorsal macroducts present, confined to pygidial segments five and six. Paraphyses well developed between segments five, six, and seven. Anal opening extremely large, greater in diameter than the length of the median lobes, and usually placed less than its own diameter from the bases of these lobes. Derm immediately about the spiracles usually possessing a distinctive sclerotic pattern of circular, broken striations.

Notes. - There is much nomenclatural confusion concerning this species. Various authors claim Signoret recorded Aspidiotus camelliae for this species and attributed the name to Boisduval. It would be necessary to examine Signoret's specimens, and accept his determination before any displacement of Comstock's rapax could be accomplished. Since these are not available, the latter name is maintained in this work. This species is the genotype and vividly depicts Hemiberlesia characters as defined for the group in this work. The large anal opening, coarsely fimbriated plates, reduced number of dorsal macroducts, and absence of perivulvar pores sets this species off as distinct. It is most similar to H. pseudorapax (McKenzie) and H. lataniae (Signoret). The first lacks a hyaline point representing lobe three, possesses many more and longer dorsal macroducts, and appears to lack long, slender plates beyond the second hyaline point. It can be separated from H. lataniae because the latter possesses perivulvar pores.

GENUS ABGRALLASPIS BALACHOWSKY 1948

All North American species of this genus possess normal second lobes. Certain specimens representing the species A. howardi (Cockerell) and A. townsendi (Cockerell) may have the second lobes reduced down to small hyaline points. The dorsal macroducts are typically short, relatively wide, never open in distinct dermal furrows, are often present on segments three and four, and are quite numerous in comparison to Hemiberlesia species. Intersegmental paraphyses are always very reduced and often unrecognizable. The diameter of the anal opening is typically equal to, or less than, the length of the median lobes, and the anal opening is usually removed two or more times its diameter from the bases of the median lobes.

As presently understood for North America this genus contains 13 species. Only A. quercicola (ferris) lacks perivulvar pores. They usually have the median lobes well developed, well separated allowing the median plates to be easily observed, about as wide as long, and subapically notched on both mesal and lateral aspects equidistant from their rounded apices. An exception is A. quercicola, which has the median lobes apically truncate. All species here presented possess normal second lobes. The third lobe is usually replaced by a small hyaline point, or represented by a low sclerotized prominence. Only A. mendax (McKenzie) has normal third lobes. The plate formula is two - two - three for the intersegmental spaces between segments six, seven, and eight. As a rule there are four or five slender, simple, or laterally

serrate (or fimbriate) plates present anterior to the seta marking segment six. The exception to this, A. quercicola, completely lacks typical inter-segmental plates. One macroduct is usually present between the median lobes, but this rarely extends anterior to the anal opening.

Six other species have been recorded for this genus outside North America by Balachowsky (1953). They are A. ephedrarum (Lindinger), A. flarida DeLotto, A. furcillae (Brain), A. insularis (Balachowsky), A. sewiatii (Marchal), and A. rhodesiensis (Hall). Only the last named species was seen by the writer.

This genus is definitely American in origin and is represented by greater numbers of species here than is Hemiberlesia.

KEY TO THE NORTH AMERICAN
SPECIES OF ABGRALLASPIS BALACHOWSKY

1. Perivulvar pores absent - - - - - 2
 Perivulvar pores present - - - - - 3
2. Median lobes not rounded, apically truncate; dorsal macroducts
 present on abdominal segments two and three; lobe three
 not represented; plates usually present only between the
 median lobes - - - - - A. quercicola (Ferris)
 Median lobes low, broadly flabellate, but with rounded apices;
 dorsal macroducts confined to segments five and six of
 the pygidium; lobe three represented by a prominent
 sclerotized process lacking distinct subapical notches;
 plates present in the normal two - two - three formula - - - -
 - - - - - A. flabellata (Ferris)
3. Third lobes similar in shape to the second lobes but smaller;
 anal opening laterally expanded; plates between the
 median lobes with distinctly expanded apices; dorsal
 macroducts unusually elongate - - - - - A. mendax (McKenzie)
 Third lobes, if present, never similar in shape to the
 second lobes; anal opening usually oval, not laterally
 expanded; plates between the median lobes lacking
 greatly expanded apices; dorsal macroducts usually not
 markedly elongate - - - - - 4

4. Two or three submedian dorsal macroducts present on segments
 one, two, three, and four - - - - - A. fraxini (McKenzie)
 Submedian dorsal macroducts absent - - - - - 5
5. Submarginal dorsal macroducts always present in definite series
 on the third and fourth abdominal segments; usually more
 than 20 dorsal macroducts present - - - - - 6
- Dorsal macroducts normally confined to pygidial segments five
 and six; one or two submarginal ducts occasionally
 present on segment four; usually less than 20 dorsal
 macroducts present - - - - - 9
6. Two to six supernumerary perivulvar pores normally present - - - - -
 - - - - - A. coloratus (Cockerell)
 Supernumerary perivulvar pores absent - - - - - 7
7. Pygidium quite acute, elongate; anal opening removed from the
 bases of the median lobes by more than three times its
 own diameter; principle host cranberry - A. oxycoccus (Woglum)
 Pygidium apically blunt; anal opening placed about twice its
 own diameter from the bases of the median lobes;
 principle hosts not including cranberry - - - - - 8
8. Third lobe replaced by a small hyaline point; second lobes
 subapically notched only on their lateral aspects;
 known only from coniferous hosts - - - - - A. ithacae (Ferris)
 Third lobe represented by a sclerotized prominence often
 bearing lateral serrations; second lobes subapically
 notched on both lateral and mesal aspects; known
 from camellia and ornamentals other than conifers - - - - -
 - - - - - A. degeneratus (Leonardi)

9. Eyespots well developed, sclerotized, pointed; usually less than ten dorsal macroducts present; female scales elongate oval; third lobe a narrow, sclerotized point - - - -
 - - - - - A. cyanophylli (Signoret)
 Eyespots short, lightly sclerotized, blunt; usually more than ten dorsal macroducts present; female scale circular; third lobe replaced by a hyaline point, or represented by a low, broad, sclerotized process - - - - - 10
10. Third lobes represented by a low, broad sclerotized process; both median and second lobes about as wide as long; dorsal macroducts extremely wide; macroduct between the median lobes with a sclerotized orifice, and the width of this duct usually equal to or wider than the anal opening diameter; known only from avocado - - - - -
 - - - - - A. perseus Davidson
 Third lobes usually replaced by a hyaline point, never a sclerotized process; median and/or second lobes longer than wide; dorsal macroducts of normal width; macroduct between the median lobes lacking a sclerotized orifice and never equal in width to the diameter of the anal opening - - - - - 11
11. Second pair of pygidial lobes elongate, normally longer than the median pair; usually less than ten dorsal macroducts present; preferred host maple - - A. comstocki (Johnson)
 Second pair of pygidial lobes never longer than the median pair, possibly reduced to hyaline points; usually more than ten dorsal macroducts present; preferred host Prunus or ornamentals such as holly and rhododendron - - - - - 12

12. Median lobes arising vertically from the pygidial apex, about as wide as long, widely separated, not obscuring the plates located between them; an inverted U-shaped pattern of sclerotization recognizable in freshly stained specimens, the ends of the U-arms usually reaching the bases of the median lobes; known mainly from the East on rhododendron, holly, and other perennial ornamental plants - - - - - A. townsendi (Cockerell)

Median lobes tending to be convergent, longer than wide, closely opposed, often obscuring the median pair of plates; normally no U-shaped sclerotization pattern present; known mainly from the West on members of the genus Prunus - - - - - A. howardi (Cockerell)

Abgrallaspis coloratus (Cockerell) 1893a

(Fig. 11)

Several type specimens from Chilopsis linearis, New Mexico, were examined. Additional material from the same species in Texas was also examined. Scale of the female circular, rather flat, white, with central exuviae.

Adult female. - Length about 1 mm. Slight cephalothoracic sclerotization was observed in some specimens. Eyespots are small and very spine-like. Perivulvar pores in four normally positioned clusters of three to eight pores each. Median perivulvar pores may be present. Two to nine supernumerary pores usually present. The latter occur on what appears to be the fourth segment. Median lobes slightly broader than long as a rule, and tending to expand toward the meson. Second lobes present, about half the size of the median pair, but usually not similar in shape. Third lobes replaced by small, often sclerotized, basally broad points which usually bear one or two minute lateral serrations. Fimbriated plates present in the formula two - two - three. Four or five more slender plates usually present anterior to the third pair. One macroduct present between the median lobes, usually extending to the level of the anal opening. Three macroducts normally present between the median and second lobes. An irregular pattern of dorsal macroducts present on all pygidial segments. A distinct submedian group present on abdominal segment three. A total of 30 to 50 dorsal macroducts usually present. They are all relatively short, and of intermediate width.

Intersegmental scleroses usually not recognizable. Median lobe length normally equal in size to the anal opening diameter. Anal opening diameter usually slightly greater than the length of the median lobes, and removed about twice this diameter from the latter's bases.

Notes. - Except for a few minor variations, the above description agrees rather closely to that set forth by Ferris (1938). The supernumerary perivulvar pores, the low serrate point representing lobe three, and continuation of the dorsal macroducts to the third abdominal segment, set this species off as quite distinct from its congeners. It appears restricted to Chilopsis.

Abgrallaspis comstocki (Johnson) 1896

(Fig. 12)

Fifteen type specimens in rather poor condition were examined. These were all from sugar maple, Illinois. Additional material on maple from Georgia and Ohio was available. Scale of the female circular, unless appressed against a leaf vein, whitish, exuviae submarginal.

Adult female. - Length about .8 mm. Derm of the cephalothorax may be lightly sclerotized. On well stained specimens a small eyespot may be seen. Perivulvar pores occur in four clusters of three to six pores per cluster. One or two median perivulvar pores may be present. Median lobes typically longer than wide, somewhat convergent toward the meson, tending to obscure the slender pair of plates between them, notched primarily on their lateral aspects. Second lobes, as a rule, distinctly longer than the median lobes, bluntly rounded apically, and arising vertically from the pygidial apex in contrast to the convergent median lobes. A minute, hyaline point may be present representing lobe three.

Typical fimbriate plates present in the normal two - two - three formula. Four or five slender plates usually present anterior to the seta marking segment six. One macroduct present between the median lobes, extending to about the top of the anal opening. One or two similar ducts located between the median and second lobes. The majority of dorsal macroducts confined to pygidial segments five and six. These usually number about 15, are typical for the genus being moderately short and broad, and do not open in definite dermal furrows. Paraphyses slightly developed between the median and second lobes. Anal opening slightly smaller than the median lobe length and placed about twice its diameter from the bases of the median lobes.

Notes. - Should the second lobes of this species be reduced in size, it would become indistinguishable from A. howardi. The relatively constant second lobe size and host preference seem to indicate this species to be valid. It can be best recognized by the unusually large second lobes.

Abgrallaspis cyanophylli (Signoret) 1869

(Fig. 13)

The type material of this species was from Cyanophyllum magnificum in France. It has since been determined from a long list of hosts in the tropics. It occurs out of doors in Florida, Texas, Mexico and Southward into the tropics. It occurs in greenhouses in the North. Specimens were examined from Phoenix, Euphorbia, Cereus, Cactus, Pilocereus, Pereskia, and Mammillariid. The latter three hosts were from Mexico. Scale of the female elongate oval, flattened, exuviae centrally placed.

Adult female. - Length about .8 mm. No cephalothoracic sclerotization was observed. Eyespots appear as heavily sclerotized, spine-like structures. Perivulvar pores occur in four rather scattered clusters, usually three to six pores per cluster. A median perivulvar pore may be present. Median lobes well developed, arising vertically, well separated, notched on both lateral and mesal aspects at distances equidistant from their apices. Second lobes very slender, about one half to three fourths the length of the median pair. Third lobe a pointed, sclerotized process, about one half the length of lobe two. Plates of the normal two - two - three pattern. Three to seven slender plates may be present anterior to lobe three. One macroduct present between the median lobes, usually extending to the top of the anal opening. One or two macroducts between the median and second lobes. A similar number between lobes two and three. Dorsal macroducts confined to pygidial segments five and six. These all very elongate, quite broad, numbering from seven to 15, and not opening in dermal furrows. Paraphyses only slightly developed. Anal opening relatively large, usually equal in diameter to the length of the median lobes, and removed by about one and one half times its diameter from the bases of these lobes. Ventral derm of the pygidial apex usually bearing a pair of narrow sclerotic patches arising near the bases of the second lobes.

Notes. - This species can be recognized by its three pairs of distinctive lobes, large anal opening, and few but large dorsal macroducts. This is the type species of the genus as described by Balachowsky. Type material was not available. Some variability was noted in the shape and size of the second lobes. This was never sufficient to cause concern in identifying this species.

Abgrallaspis degeneratus (Leonardi) 1897

(Fig. 14)

Numerous specimens examined from Camellia species taken at quarantine from Japan. Several specimens also seen from holly, palms, laurel, and Odontoglossum. Ferris records it from Tulare County, California. Additional material was also seen from Mexico. Scale of the female circular, brownish, with exuviae central or subcentral.

Adult female. - Length about .9 mm. Cephalothoracic sclerotization normally absent. Eyespots may be seen in well stained specimens as low, pointed, tooth-like projections. Perivulvar pores present in four irregular clusters, reduced in number with two to four pores per cluster. Median perivulvar pores usually absent. Median lobes low, broad, well separated, arising vertically from the pygidial apex, subapically notched on mesal and lateral aspects. Second lobes nearly as large as the median pair, somewhat similar in shape, but narrow and lacking the mesal expansion of the median lobes. Third lobes represented by a pair of sclerotized points usually bearing minute serrations on their lateral aspects. Typical plates present in the two - two - three formula. Three or four slender plates usually present anterior to lobe three. One macroduct present between the median lobes, extending to about the top of the anal opening. Three present between the median and second lobes. Two present between the second and third lobes. Between 20 and 30 dorsal macroducts usually present, including distinct submarginal groups of two or three on all prepygidial segments, and pygidial segment four. Paraphyses may be slightly developed. Anal opening relatively small, about equal in diameter to the width of a median lobe, and removed about three times this diameter from the latter's base.

Notes. - The small but distinct pygidial lobes, in combination with the submarginal groups of macroducts extending to the first abdominal segment, set this species off quite well from other members of the genus.

Abgrallaspis flabellata (Ferris) 1938

(Fig. 15)

One paratype specimen was seen. This species was described from Pinus species, Hacienda La Providencia, near Acapulco, Mexico. Scale of the female circular or oval, slightly convex, whitish, exuviae sub-central.

Adult female. - Length about .8 mm. Derm of the cephalothorax heavily sclerotized at maturity. Eyespots absent. Perivulvar pores absent. Median lobes characteristically flabellate, much wider than long, deeply notched on both mesal and lateral aspects, well separated. Second lobes smaller, narrow, notched primarily on their lateral aspects, well sclerotized. Third lobes about one half the size of the second pair, laterally serrate, well sclerotized. Typical plates present in the usual two - two - three formula. Four or five simple, slender plates usually present anterior to the seta marking segment six. Macroduct between the median lobes absent. Four macroducts usually present between segments seven and eight, and two between segments six and seven. Approximately 15 dorsal macroducts present on segments five and six of the pygidium. Paraphyses slightly developed. Anal opening somewhat laterally expanded, nearly equal in horizontal diameter to the width of a median lobe, placed about one and one half times this diameter from the bases of the median lobes.

Notes. - The flabellate median lobes of this species make it easily separable from other members of this genus.

Abgrallaspis fraxini (McKenzie) 1944

(Fig. 16)

According to McKenzie (1943), type and paratypes were collected from Fraxinus velutina, Arizona ash, Riverside County, California, and were observed on the leaves "causing noticeable injury by removing the chlorophyll from the leaf tissue." Only the holotype and its scale covering were seen. Female scale circular, whitish, exuviae submarginal.

Adult female. - Length about 1 mm. Cephalothorax membranous at maturity. Eyespot a small, pointed tubercle. Perivulvar pores present in four rather loose clusters, with three to ten pores per cluster. Median, second, and third lobes present. The median pair largest notched on their mesal and lateral aspects. Lobe two similar but smaller. Lobe three a small sclerotized projection tending to be serrate on its lateral aspect. Typical plates present in the normal two - two - three formula. Three or four simple plates usually present anterior to the seta marking segment six. One macroduct present between the median lobes. Four between the median and second lobes. Three between the second and third lobes. Thirty to 40 dorsal macroducts present, including submedian groups on abdominal segments one, two, and three, and submarginal groups on segments three and four. Anal opening diameter usually slightly smaller than the median lobe length, and placed about three times its diameter from the bases of these lobes. Paraphyses moderately developed.

Notes. - This species is very closely related to Abgrallaspis coloratus (Cockerell) but can be differentiated because it lacks

supernumerary perivulvar pores. Also, A. coloratus lacks submedian dorsal macroducts on the first three abdominal segments.

Abgrallaspis howardi (Cockerell) 1895

(Fig. 17)

Fourteen type specimens in very poor condition were examined. The best material found for this study was taken from Bumelia, Oklahoma. The section treating host transfer work deals in more detail with the host range of this species. Type specimens were taken from plum in Colorado. Scale of the female usually circular, whitish, exuviae yellowish and subcentral.

Adult female. - Length about .8 mm. Cephalothorax tending to be lightly sclerotized at maturity. Very small, pointed eyespots may be seen in well stained specimens. Perivulvar pores present in four irregular clusters of four to ten pores each. One or two median pores may be present. Median lobes longer than wide, slightly convergent, tending to obscure the pair of thin plates between them. Second lobes grading down in size from normal lobes shorter than the median pair to small hyaline points. Whenever present, they are usually sclerotized only on their outer margins. Third lobes usually represented by an elongate hyaline point. Plates present in the normal two - two - three formula. Four or five slender plates usually present anterior to the seta marking segment six. One macroduct present between the median lobes, usually extending beyond the anterior limits of the anal opening. Two macroducts usually present between the median and second lobes, and one between the second lobe and point representing lobe three (or seta marking segment six should the point be lacking). Dorsal macroducts varying from 15

to 30 in number, mostly confined to segments five and six of the pygidium. One to three may occur on segment four. Paraphyses may be slightly developed. Anal opening diameter usually smaller than the median lobe length, removed by at least twice its diameter from the latter's base.

Notes. - As discussed in the section on host transfer work, this species is not synonymous with A. townsendi (Cockerell) as stated by Ferris. Intermediate forms may be found in which certain characters become less easily distinguishable, making separation of the two species difficult. As a rule, A. howardi may be separated from A. townsendi by its elongate, close set, convergent lobes, somewhat longer dorsal ducts (especially the median duct which extends anterior to the anal opening), preference for hosts of the genus Prunus, primarily western distribution, and tendency to have the cephalothoracic derm sclerotized at maturity. This species is also closely related to A. perseus Davidson, and A. comstocki (Johnson). A. perseus has very wide dorsal macroducts, a broad sclerotized point representing lobe three, and is known only from avocado in Mexico. A. comstocki typically has the second lobes distinctly longer than the median pair, and prefers hosts of the genus Acer.

Abgrallaspis ithacae (Ferris) 1938

(Fig. 18)

The type was described from Abies canadensis, Ithaca, New York. Mr. Charles McComb, Department of Entomology, University of Maryland, has collected this species from Tsuga canadensis in several localities in Maryland. Scale of the female circular, convex, gray, exuviae centrally placed.

Adult female. - Length about .75 mm. Derm usually membranous at maturity. Eyespots absent. Perivulvar pores present in four clusters of four to 14 pores each. One or two median perivulvar pores may be present. Median lobes prominent, well separated, about equal in height and width, notched on both mesal and lateral aspects equidistant from their rounded apices. Second lobes similar in shape to the median pair but only half as large and notched mainly on their lateral aspects. Third lobes replaced by small hyaline points. Plate formula two - two - three. All plates relatively low, broad and apically fimbriate. Several slender, slightly fimbriate plates usually present anterior to the seta marking segment six. One macroduct present between the median lobes, extending to the bottom of the anal opening. Three to five macroducts present between segments seven and eight. One or two macroducts present between segments six and seven. Forty to 55 rather short, wide, dorsal macroducts usually present. These extend in rather irregular rows to abdominal segment three. Paraphyses slightly developed. Anal opening diameter equal to the width of a median lobe, placed about two times this diameter from the latter's bases.

Notes. - The shape of the median and second lobes and size and location of the anal opening indicate definite relationship to Abgrallaspis. Therefore this species is here transferred from Aspidaspis Ferris 1938. This species is similar to A. townsendi but can be easily recognized by the numerous dorsal macroducts and preference for coniferous hosts.

Abgrallaspis mendax (McKenzie) 1943

(Fig. 19)

The holotype and one paratype were seen. These were taken in quarantine at Los Angeles from orchid, Guatamala. Additional material was available from Odontoglossum laevi and O. grande, also taken at quarantine in San Francisco, from Guatamala. Scale of the female circular, reddish-brown, with black, subcentral exuviae.

Adult female. - Length about 1.5 mm. Cephalothorax unsclerotized at maturity. Structures resembling eyespots present, each bearing three or four minute, apical, papillae-like projections. Perivulvar pores in four clusters of two to six pores per cluster. Median perivulvar pores may be present. Median lobes prominent, well separated, notched on both lateral and mesal margins equidistant from their apices. Second and third lobes similar, but each progressively smaller, with the lateral notches tending to be most prominent. Plates present in the normal two - two - three formula. The median pair are rather large in comparison to other members of the genus, longer than the median lobes with the apical margins expanded and deeply fimbriate. Four long, slender, occasionally fimbriate plates usually present anterior to the third lobe. One or two macroducts present between the median and second, and second and third lobes. Dorsal macroducts confined to segments five and six of the pygidium, usually numbering from 15 to 27. Paraphyses very slightly developed. Anal opening large, tending to be laterally expanded, about one and one half times greater in horizontal diameter than the median lobe length, and removed from the latter's base by about twice this diameter.

Notes. - This species has been recorded only from Guatamala. It most closely resembles the genotype, but can be separated from

A. cyanophylli because it has more numerous dorsal macroducts, blunt eyespots bearing papillae-like projections, broad second and third lobes, and much reduced paraphyses.

Abgrallaspis oxycoccus (Woglum) 1906

(Fig. 20)

Much material was available from cranberry collected primarily in New Jersey, Massachusetts, and Connecticut. Ferris records it from cranberry taken at quarantine in California, from Oregon and Washington. No type material was seen. Scale of the female flat, circular, gray, exuviae subcentral.

Adult female. - Length about .8 mm. Cephalothoracic region membranous at maturity. Eyespots very flat circular structures, when recognizable. Perivulvar pores present in four large clusters, usually six to twelve pores per cluster. Median perivulvar pores may be present. Median lobes well developed, well separated, arising vertically from the pygidial apex, preapically notched on both mesal and lateral aspects equidistant from their rounded apices. Second lobes about one half as large at the median pair, usually lacking the mesal subapical notch. Third lobes replaced by a minute hyaline point. Plates present in the normal two - two - three formula. All typically low, rarely longer than the median lobes. The second and third pair about as wide as the second lobes. From four to eight slender plates may be present anterior to the seta marking segment six. One macroduct present between the median lobes, usually not reaching the anal opening. Four loosely associated macroducts present between the median and second lobes, extending to the level of the anal opening. Two macroducts usually present between the

second lobe and hyaline point replacing lobe three. Thirty to 40 dorsal macroducts present, extending to segments two or three in submarginal groups. Paraphyses usually not distinguishable. Anal opening approximately equal in diameter to the length of the median lobes, and removed from the latter's base by about three and one half times its own diameter.

Notes. - Although type material was not seen, all the material examined was obviously conspecific with the drawings of Ferris, who had seen several type specimens. The difficulty here is not with species recognition, but generic placement. Presumably, the main reason for its assignment to Aspidaspis was the absence of paraphyses. This has proven to be a very unstable character, however, and in all other respects this species conforms to the pattern of Abgrallaspis. A. oxycoccus is morphologically similar to A. ithacae, but is distinct because of the submarginal macroducts present on the second and third abdominal segments, and the relatively great distance the anal opening is removed from the bases of the median lobes. A. oxycoccus appears confined to hosts of the genus Vaccinium, while A. ithacae prefers conifers such as Tsuga and Abies.

Abgrallaspis perseus, new species

(Fig. 21)

Type material from avocado fruit taken in quarantine at Brownsville, Texas, from Mexico. A long series collected through several months at Brownsville, Texas, 1941, is present in the National Coccoid Collection. Additional material was available from quarantine, Laredo, Texas, 1940. This species is known only from the type host. Scale of the female circular, light brown, exuviae subcentral. Known only from the fruits taken in quarantine.

Adult female. - Length about .8 mm. Derm of the cephalothorax membranous at maturity. Eyespots present in the form of low, pointed tubercles. Perivulvar pores always present in four clusters with normally five to 11 pores per cluster. One or two median perivulvar pores may be present. Median lobes arising vertically from the pygidial apex, normally wider than long, distinctly notched preapically on both lateral and mesal aspects. Second lobes similar but smaller. Third lobes represented by a low, sclerotized prominence, often bearing one or two lateral serrations. Plates present in the normal two - two - three formula, with three to five present anterior to the seta marking segment six. One macroduct present between the median lobes, opening through a sclerotized orifice, its width usually more than half the anal opening diameter. Three similar macroducts between the median and second lobes, and one or two between lobes two and three. Dorsal macroducts all relatively large, confined to the fifth and sixth pygidial segments, and usually 15 to 25 in number. Paraphyses are very small, but usually distinguishable. Anal opening somewhat greater in diameter than the length of the median lobes, and removed about twice its own diameter from the base of these lobes.

Notes. - This species can easily be confused with A. townsendi. It is separable from the latter because of the extremely wide ducts and lobes it possesses, and sclerotized prominence representing lobe three. Host transfer work has shown A. townsendi to be incapable of development on avocado.

Types. - The holotype female, No. 43-69, is present in the National Coccoid Collection, U. S. Department of Agriculture, Washington, D. C. Fifteen additional specimens in the same collection were designated as paratypes.

Type host. - Avocado.

Type locality. - Taken in quarantine in 1941 on avocado fruit, Brownsville, Texas, from Mexico.

Abgrallaspis quercicola (Ferris) 1941

(Fig. 23)

Ten specimens were examined from preparations made from type material obtained through the courtesy of Mr. Howard L. McKenzie, Department of Agriculture, State of California. The type specimens were collected from Quercus englemanni, at Banner, San Diego County, California. Paratypes were from Quercus species, between San Marcial and Hot Springs, New Mexico. Most specimens were found deeply buried in cracks in the bark. Scale of the female whitish, basically circular, exuviae submarginal and yellowish.

Adult female. - Length about 1 mm. Slight cephalothoracic sclerotization may occur at maturity. Eyespots absent. Perivulvar pores absent. Median lobes very short and truncate. Second lobes represented by low, rounded, convergent prominences. Third lobes absent. Plates may be present in the form of low, broadly tapering, hyaline points between the median and second lobes. No plates present anterior to the second lobes. One macroduct present between the median lobes, one between the median and second lobes and two just anterior to the second lobes. Fifteen to 20 dorsal macroducts present, extending to the third abdominal segment. Those macroducts on the two prepygidial segments much reduced in size. Paraphyses scarcely distinguishable. Anal opening diameter about equal to the width of a median lobe. A pair of sclerotic patches present on each side of the meson on the apex of the pygidial venter.

Notes. - The peculiar truncate median lobes and absence of typical fimbriate plates sets this species off from all other members of the genus. The generic placement of this species is questionable, but the writer can see no other alternative at this time.

Abgrallaspis townsendi (Cockerell) 1896

(Fig. 22)

Five adult female paratypes were examined. Abundant material of this species is present in the National Coccoid Collection. It has been most often collected from holly and rhododendron. Although originally described from an unknown host in Mexico, it appears to be distributed primarily east of the Mississippi. Additional hosts are discussed in the section on host transfer work. Scale of the female circular, whitish, exuviae subcentral.

Adult female. - Length about .9 mm. Cephalothorax normally unsclerotized. Eyespots recognizable as very small, pointed tubercles. Perivulvar pores present in four clusters of three to ten pores per cluster. One or two median perivulvar pores may be present. Median lobes prominent, arising vertically from the pygidial apex, well separated, about as long as wide, subapically notched on both mesal and lateral aspects equidistant from their rounded apices. Second lobes extremely variable. Type material with second lobes about one half as large as the median pair, but these may grade down in size, and possibly be replaced by hyaline points. Lobe three replaced by a hyaline point. One macroduct present between the median lobes, extending into the anal opening area. Two macroducts usually present between the median and second lobes, and two between the second lobes and point replacing

lobe three. Dorsal macroducts typical in length and width for the genus, numbering from ten to 30, usually confined to pygidial segments four, five, and six, but may occur anteriorly to segment two or three of the abdomen. Paraphyses very lightly developed. Anal opening usually about equal in diameter to the length of the median lobes, and removed from one to three times its own diameter from the bases of the latter. Ventral derm of the pygidial apex usually bearing a peculiar inverted U-shape pattern of sclerotization. The legs of the U usually reach the bases of the median lobes.

Notes. - Although considered synonymous with A. howardi by Ferris, host transfer studies have shown this species to be a distinct biological entity. It most closely resembles A. howardi and A. perseus. It can best be distinguished from the former by the vertically arising, widely separated, broad median lobes, peculiar U-shaped sclerotic pattern of the ventral pygidial derm, preference for ornamental hosts, especially holly and rhododendron, and inability to develop on members of the genus Prunus. It can be distinguished from A. perseus by the more narrow median and second lobes, the hyaline point representing lobe three, the macroducts of normal width, and inability to develop on avocado.

Should the second lobes of A. townsendi become elongated, this species would closely resemble A. comstocki. When dorsal macroducts are present on the second or third abdominal segments, it resembles A. oxycoccus. The latter is still distinct because of the great distance the anal opening is removed from the pygidial apex. A. townsendi also may resemble A. ithacae, but again transfer studies have shown that it does not develop on coniferous hosts.

All things considered, the above species can, under circumstances such as character variation, prove difficult to separate solely on the

basis of morphological characters. In such instances these specimens might be considered sibling species. At such times data concerning hosts and distribution are necessary adjuncts to reliable determinations of species in this complex.

RESULTS OF HOST TRANSFER EXPERIMENTATION

The population of "howardi" from pachysandra referred to in the section on Materials and Methods was used in the host transfer experiments. Two thousand seven hundred crawlers were individually transferred to 20 different host plant species, and 14 of these plants (Table I) were found to be acceptable to different degrees of infestation by the test scale insect population. The percentages of "takes" ranged from 14 to 54. Adult female scale insects recovered from the infested test hosts were mounted on slides and a comparative analysis of salient taxonomic characters made to determine the extent of host determined morphological variations.

The most striking variation in an important taxonomic character was the reduction in size, and change in form, of the second lobes. From all but three of the test hosts (pachysandra, blueberry, red maple), the majority of recovered females had the second lobes reduced to small, unrecognizable, unsclerotized prominences, or hyaline points.

This lobe reduction is significant for two reasons: (1) specimens lacking the second lobes superficially resemble members of the genus Diaspidiotus Berlese and Leonardi which have only the median lobes present, and (2) the type specimens of the test scale insect species possessed normal second lobes.

Variation was also observed in the form of the median lobes. The normal median lobe of "howardi" is about as long as wide, arising

vertically from the pygidial apex, notched on both mesad and lateral aspects, and apically rounded. In two cases, laurel and sweet gum, the majority of specimens varied in one or more of the characters just discussed. Since only 12 females were involved in this comparison (four normal and eight abnormal), the data are probably insufficient from which to draw further conclusions.

The number of perivulvar pores present in the anterior clusters was higher, on the average, than the number present in the posterior clusters. In addition, the numbers of pores present in anterior or posterior clusters was never constant on specimens collected from different hosts. These differences appear to be well within the normal range of variation known for this character.

The number of dorsal pygidial macroducts varied from 11 to 17 among specimens taken from the different test hosts. This also appears to be within the range of variation for this character in this species.

Eye tubercles were not seen in the individuals taken from four hosts. Most of these individuals had recently molted. It is probable that the eye tubercles had not become sclerotized enough to be seen in Hoyer's mounts, or to take enough stain to make them visible in fuchsin preparations.

Prosomal sclerotization was encountered several times. Almost without exception, this condition occurred in specimens which had been parasitized. It is known that parasitism may cause excessive sclerotization and other abnormalities. For this reason, parasitized specimens were not used to study morphological characters. The four remaining characters, plate formulae, paraphyses, antennae, and spiracles, did not exhibit any unusual variations.

The scale insects used in the host transfer experiments qualified as Abgrallaspis /Hemiberlesia/ howardi (Cockerell) as this species was understood by Ferris (1938). A. howardi was described from plum in Colorado, and later recorded from several hosts including pear, peach, and apple. The six hosts on which the test species would not develop were: plum, pear, peach, apple, avocado, and pine. This evidence clearly indicates that the test species was not A. howardi as conceived by Ferris.

Ferris made three species synonyms of A. howardi: townsendi Cockerell 1896, epigaeae Marlatt 1908, and pseudospinosus Woglum 1906. A re-evaluation of the type specimens representing these names was made. As a result, the writer believes these three species to be synonymous with each other, but distinct from Abgrallaspis /Hemiberlesia/ howardi. Therefore, the test species is believed to be A. townsendi, since this name has priority.

In the National Coccoid Collection there are several lots of specimens resembling A. townsendi which were taken from avocado fruit at quarantine in Texas, from Mexico. In the host transfer experiments A. townsendi failed to develop on avocado. This indicated a third species population was involved. An examination was made of long series of specimens from avocado. As a result the writer believes the avocado population to be a valid species separable from A. howardi and A. townsendi on the basis of morphology as well as host specificity. This species, A. perseus Davidson, is described as new herein.

Pine was used in the host transfer experiments because a population of scale insects resembling the diaspid form of A. townsendi (having the second lobes replaced by hyaline points) was found by the writer on the University of Maryland campus. Host transfer experiments proved pine

to be unacceptable. The species in question is now believed to be Diaspidiotus ancylus (Putnam).

More transferred crawlers developed on pachysandra than any other host. The 72 scales (54%) recovered from these transfers indicated: (1) the original host on which the test population, A. townsendi, occurred in nature was most acceptable or preferred, and (2) the transfer methods would not be at fault should any negative results be obtained from crawler transplants.

Holly and rhododendron appeared to be the second and third most preferred hosts with 68 and 67 (50%) adults recovered respectively. This is in complete accord with collection data examined by the writer. The frequency with which A. townsendi has been collected on these two hosts may be in proportion to the plants' popularity with buyers, and therefore growers, rather than strict host preference per se.

The fact that only second instars were recovered from osage orange and persimmon seems to indicate a slower rate of growth on less preferred hosts, with more than three months necessary for a complete life cycle. Since the first molts were completed on these two hosts, it is assumed that the individuals would have developed to maturity if given enough time. Therefore, these hosts are considered acceptable and listed in the table.

As a general rule, there was a high ratio of maturing males to females of A. townsendi on all hosts. This condition was most pronounced on the less accepted hosts. The outstanding example was white oak, where 20 males developed but no females were found in any stage. This suggests that males are more adaptable to new host plants than females.

Only two host species exhibited noticeable reactions to infestation by test insects. All greenbrier plants developed light brown spots

wherever the crawlers settled. These spots appeared to grow in size as the scales matured, but no effect was noticeable on the general growth and vigor of the three plants. All tulip poplar plants reacted much more severely. A black necrosis developed immediately around all the developing scales. The young plants failed to show any growth during the experiment and were continually troubled by fungus growths on the leaves.

Experimental host plants	Total "takes"	Percentage of "takes"	Adult females examined	Salient taxonomic characters								Eye tuber- cles	Plate form.	Prosona	Paraphyses	Antennae	Spiracles
				Second lobes		Median lobe shape		Perivulvar pores per cluster		Dorsal pygidial macro- ducts							
				Present	Absent	Normal	Abnormal	"Front"	"Rear"								
Pachysandra	72	54	26	15	11	19	7	8	4	14	present	2-2-3-4	Usually membranous	Only slightly developed	Normal	Normal	
Holly	68	50	25	4	21	24	1	6	5	12	present						
Rhododendron	67	50	19	6	13	19	0	7	5	11	present						
Blueberry	54	40	18	10	8	18	0	8	5	13	present						
Greenbrier	45	33	25	7	18	24	1	6	5	17	present						
Laurel	33	24	9	1	8	3	6	7	5	12	absent						
Red maple	32	24	7	4	3	5	2	7	5	14	absent						
Magnolia	29	21	11	3	8	9	2	8	6	16	present						
Tulip poplar	29	21	3	0	3	3	0	7	5	15	absent						
Osage orange	27	20	0	---	---	---	---	---	---	---	---						
Elm	23	17	13	0	13	10	3	7	5	11	absent						
Sweet gum	20	14	3	1	2	1	2	7	5	13	present						
White oak	20	14	0	---	---	---	---	---	---	---	---						
Persimmon	19	14	0	---	---	---	---	---	---	---	---						

Table I.-The preference of Abgrallaspis townsendi (Cockerell) for 14 different host plants, and the effect of these hosts on the development of salient taxonomic characters.

CONCLUSION

This study has resulted in the clarification of generic and specific relationships of two coccoid genera. Twenty-three species of aspidiotines are ~~here~~ recognized as representing Hemiberlesia and Abgrallaspis in North America. These genera are primarily tropical or subtropical in origin and present distribution. Relatively few species occur outside greenhouses in the temperate areas of North America. Those that do, such as A. howardi (Cockerell), A. townsendi (Cockerell), and A. comstocki (Johnson), are usually very widespread and morphologically variable. These species form a complex difficult to separate by taxonomic methods presently used in studies of this group.

The host transfer experiments completed in this work clearly indicate the extent of morphological variation possible in the A. howardi complex. This becomes important when one considers the many other scale insect taxa which present difficult taxonomic problems, and yet whose biologies have received little or no attention from workers in the Coccoidea.

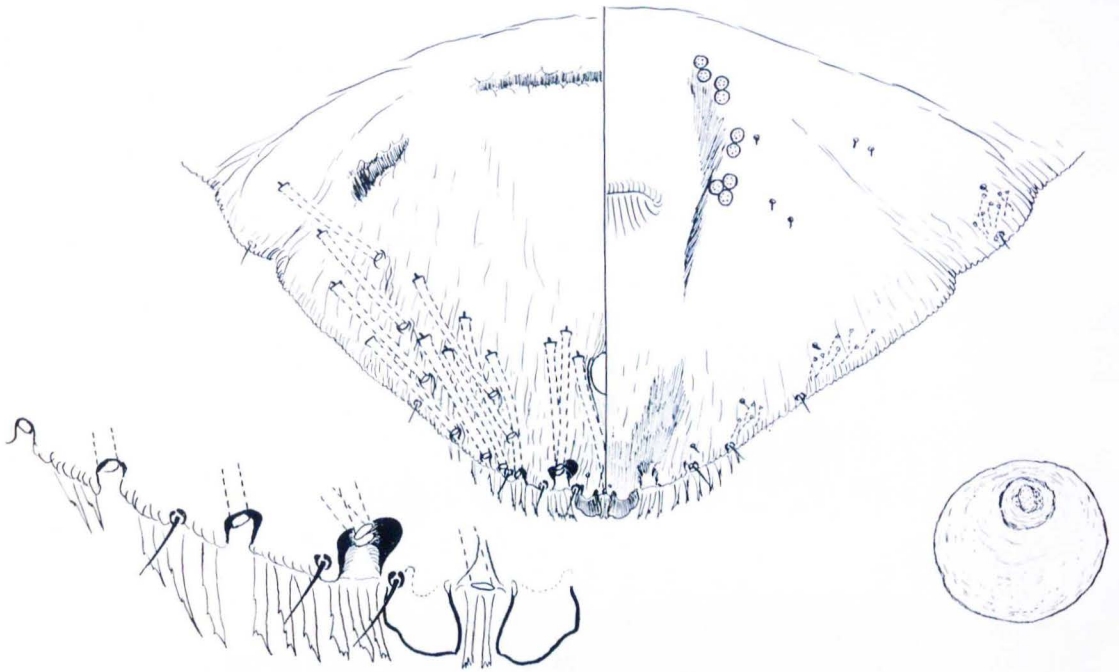


Fig. 1.-Hemiberlesia candidula (Cockerell)

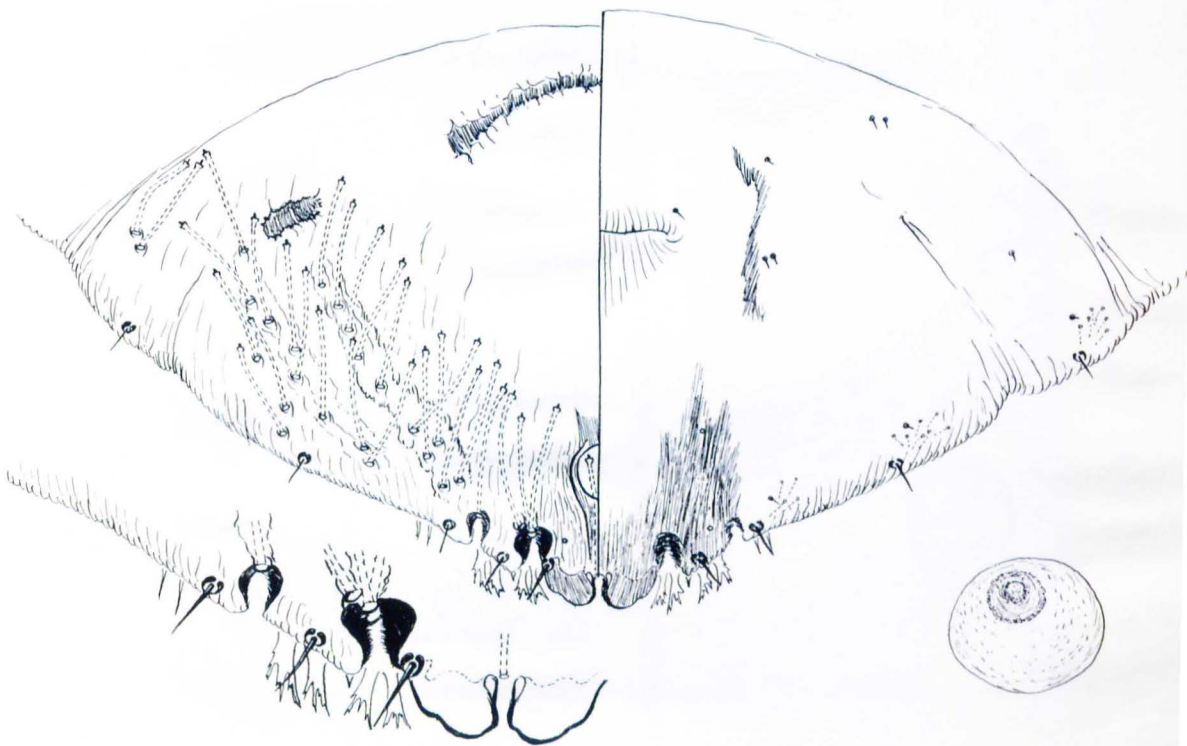


Fig. 2.-Hemiberlesia coniferarum (Cockerell)

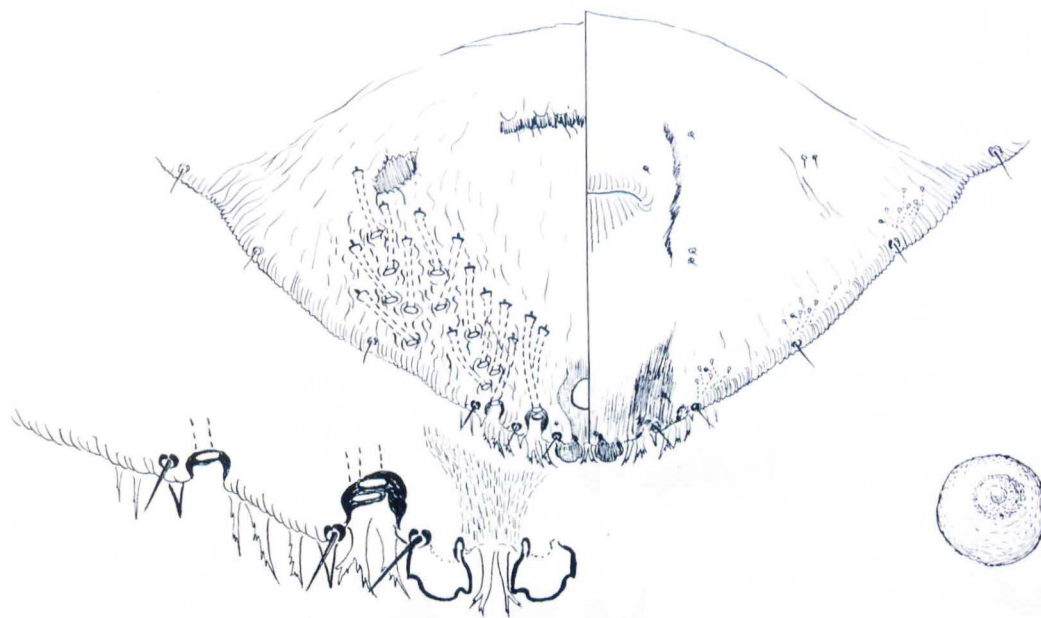


Fig. 3.-Hemiberlesia cupressi (Cockerell)

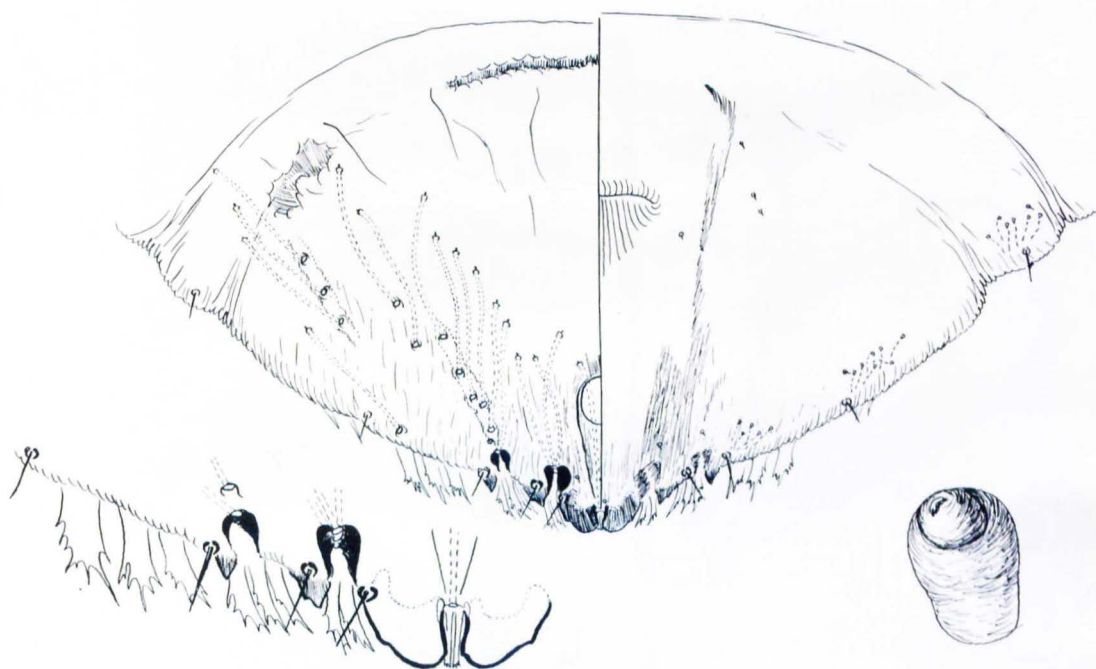


Fig. 4.-Hemiberlesia diffinis (Newstead)

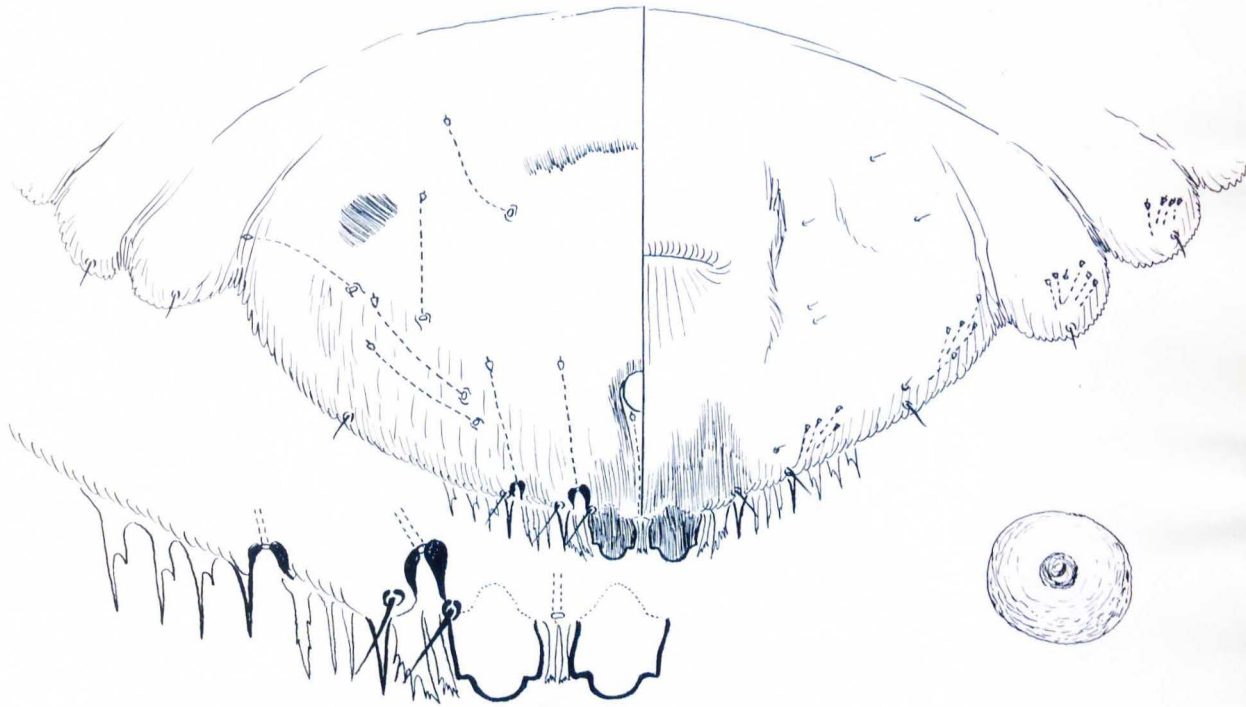


Fig. 5.-Hemiberlesia ignobilis Ferris

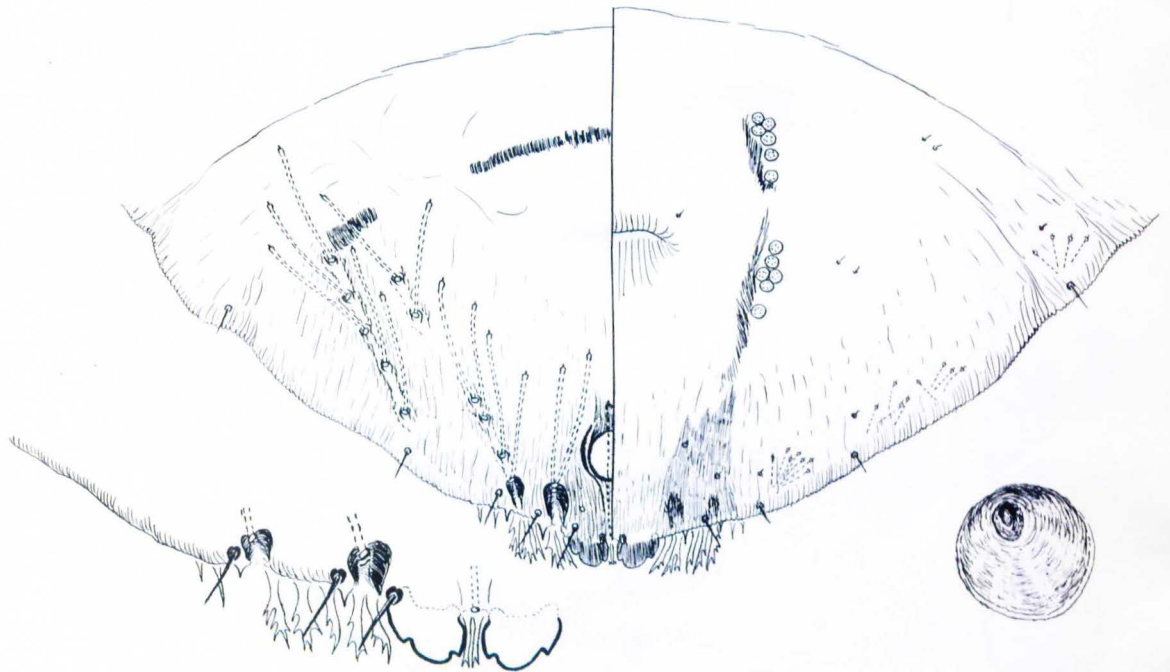


Fig. 6.-Hemiberlesia lataniae (Signoret)

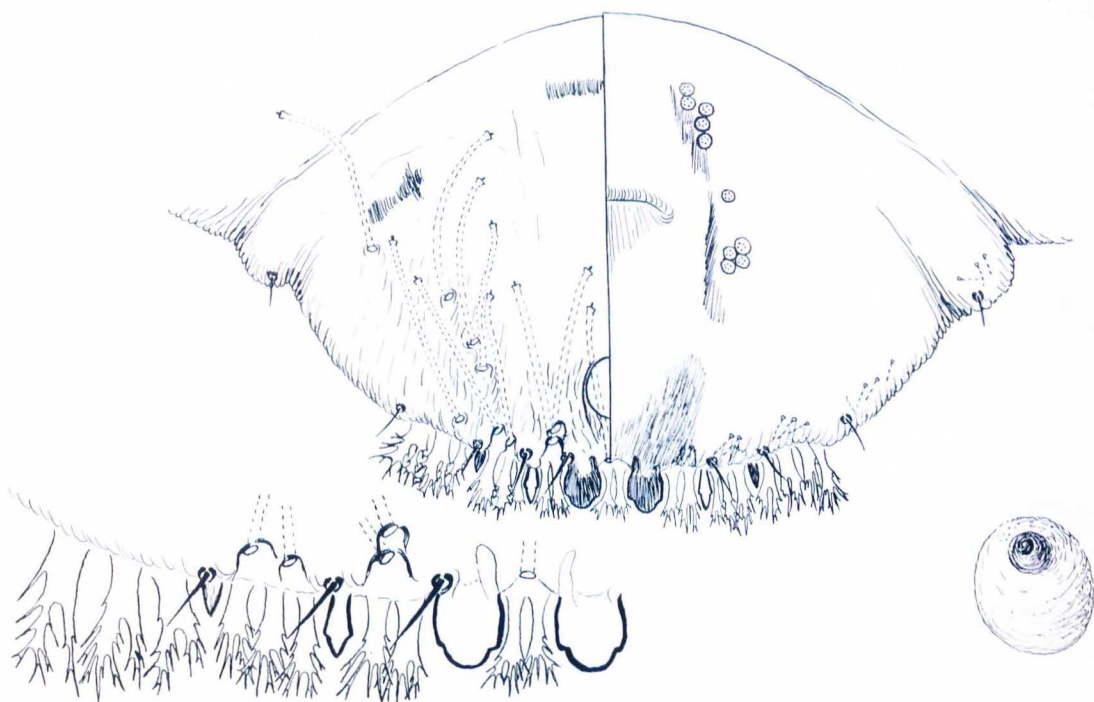


Fig. 7.-Hemiberlesia palmae (Cockerell)

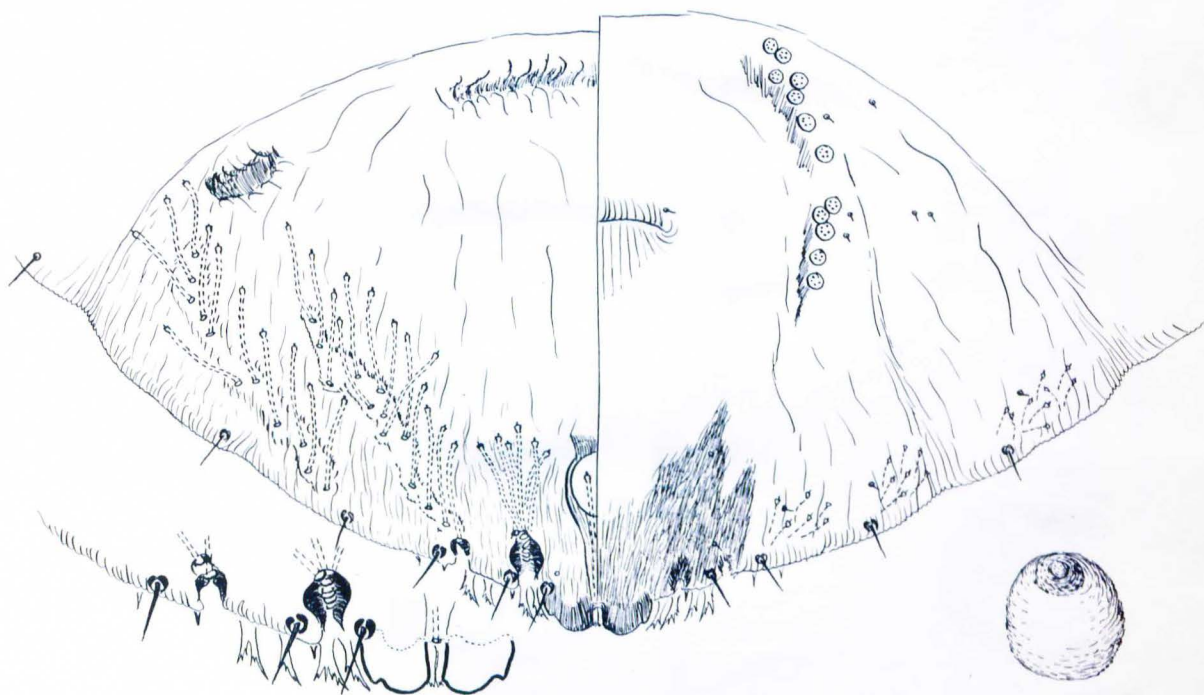


Fig. 8.-Hemiberlesia popularum (Marlatt)

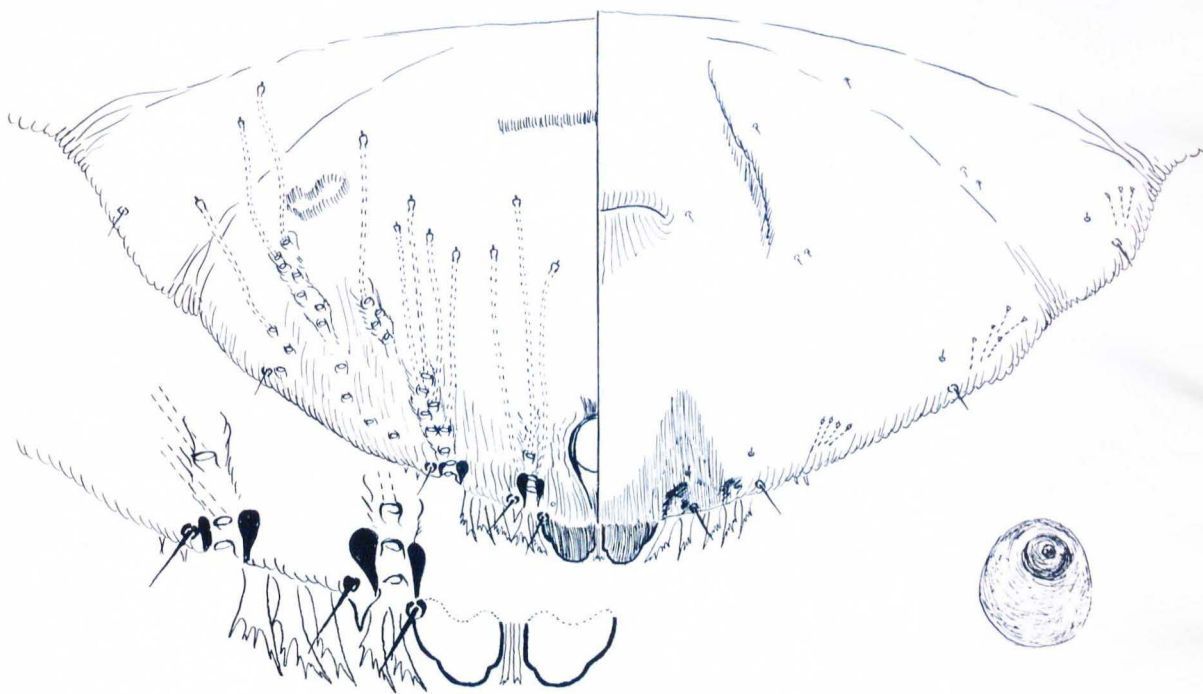


Fig. 9.-Hemiberlesia pseudorapax McKenzie



Fig. 10.-Hemiberlesia rapax (Comstock)

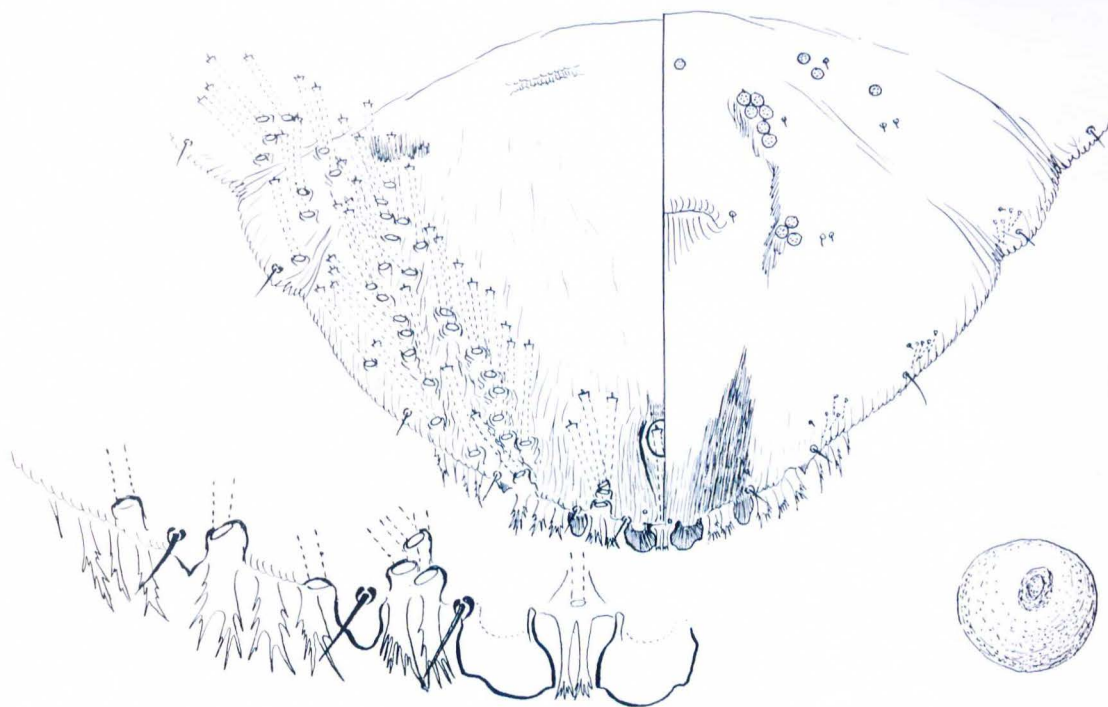


Fig. 11.-Abgrallaspis coloratus (Cockerell)

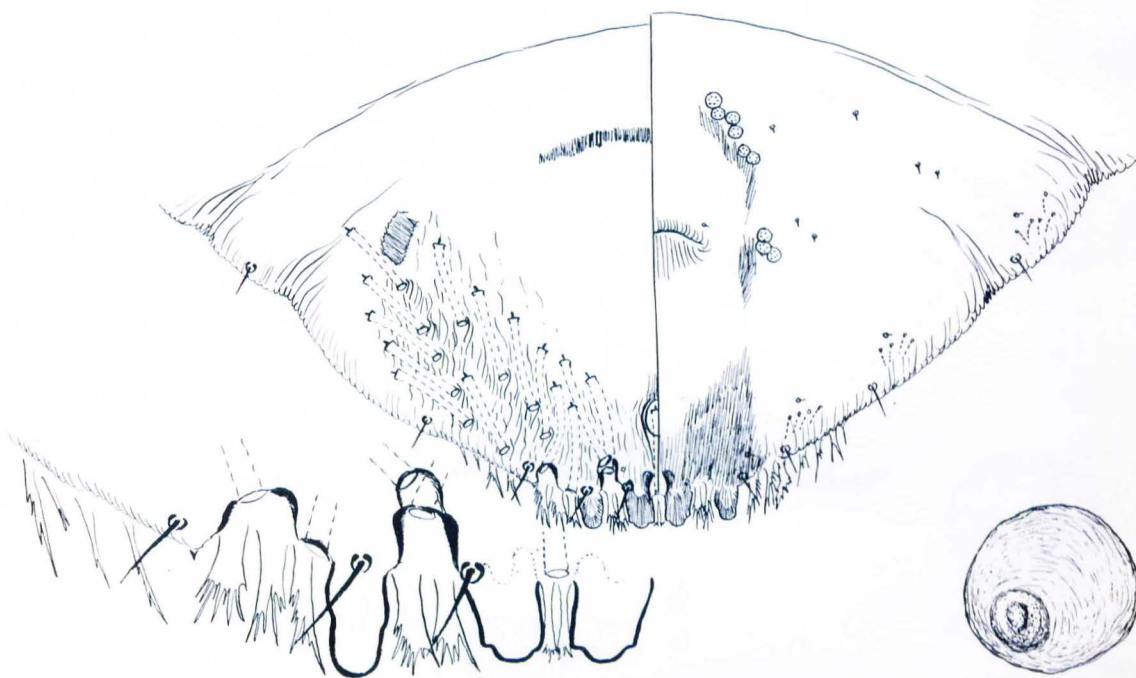


Fig. 12.-Abgrallaspis comstocki (Johnson)

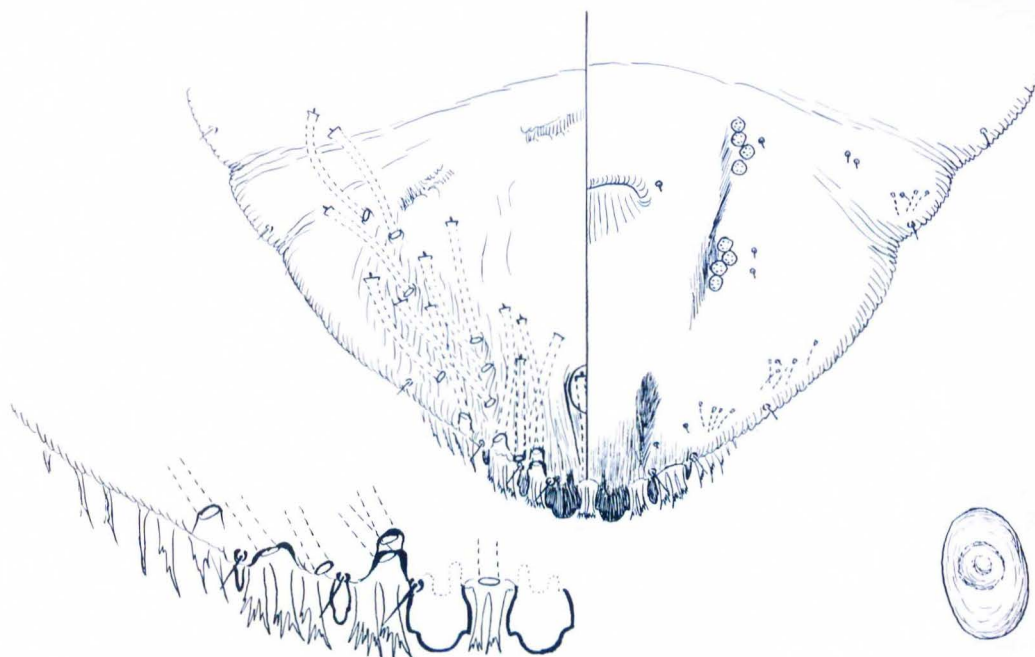


Fig. 13.-Abgrallaspis cyanophylli (Signoret)

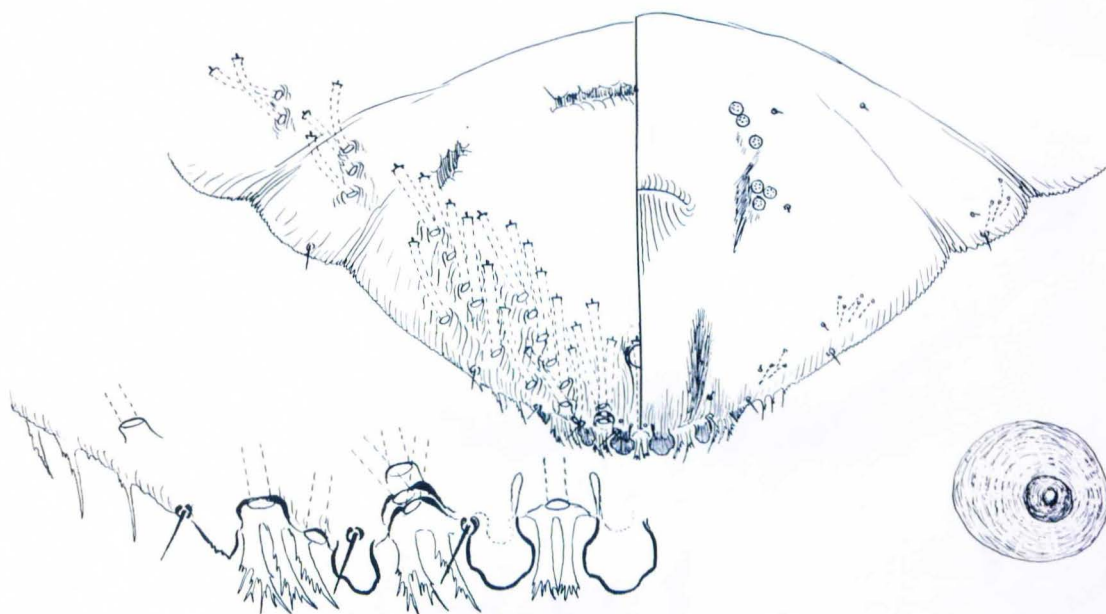


Fig. 14.-Abgrallaspis degeneratus (Leonardi)

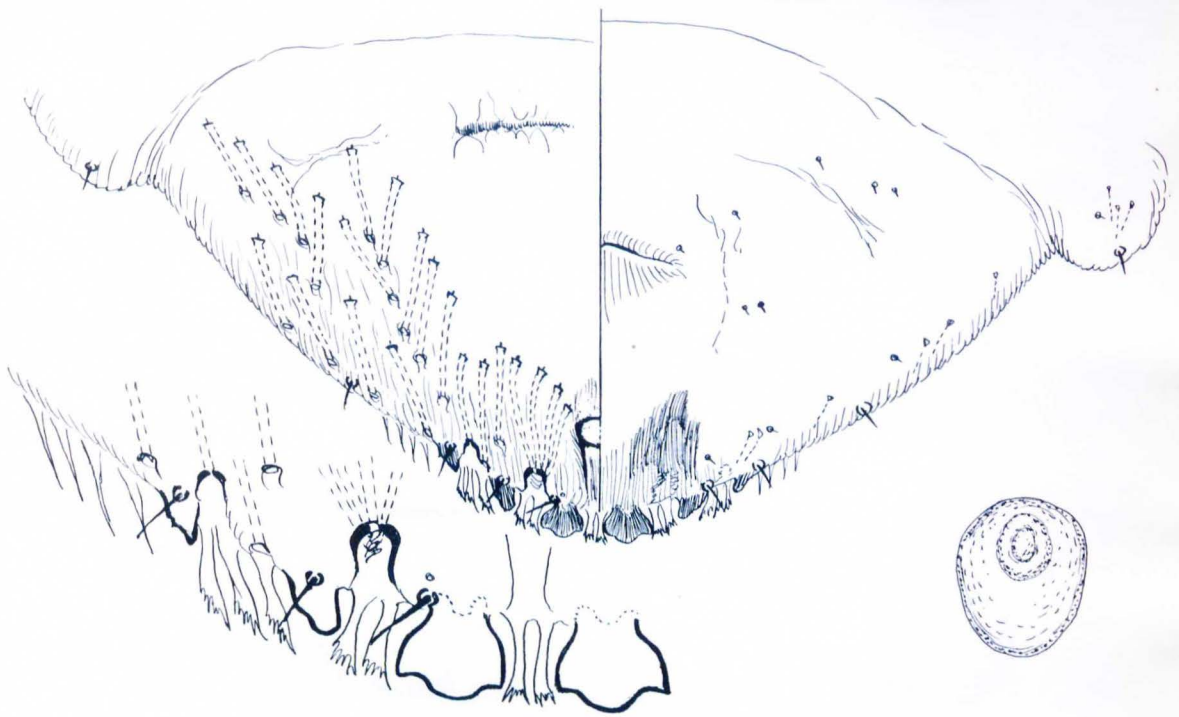


Fig. 15.-Abgrallaspis flabellata (Ferris)

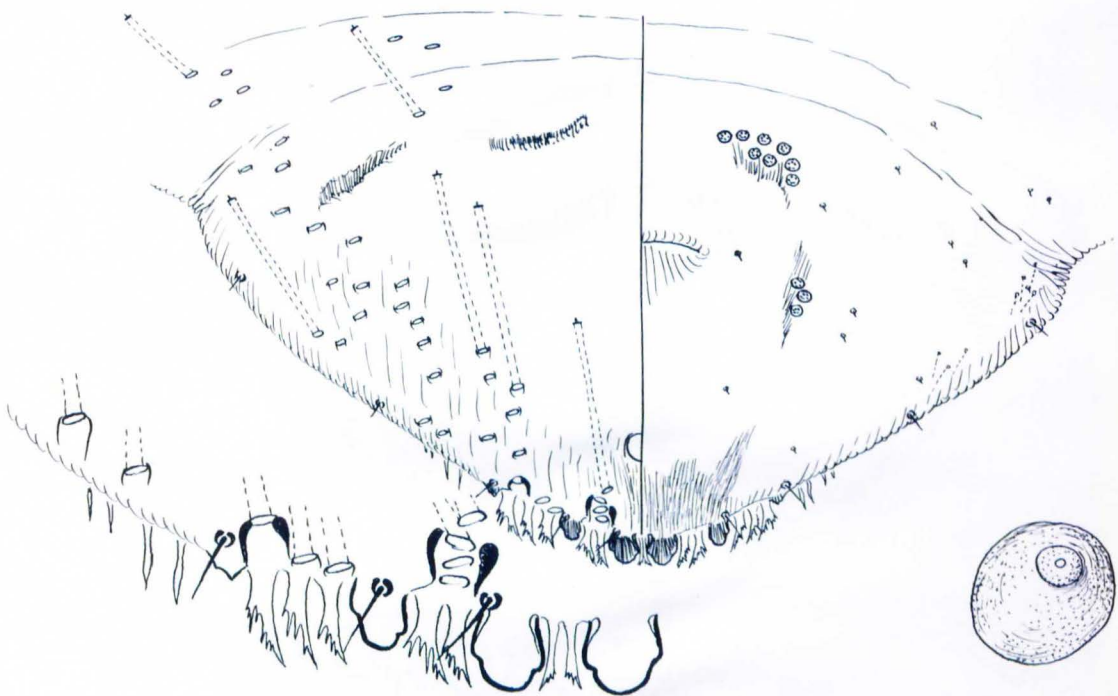


Fig. 16.-Abgrallaspis fraxini (McKenzie)

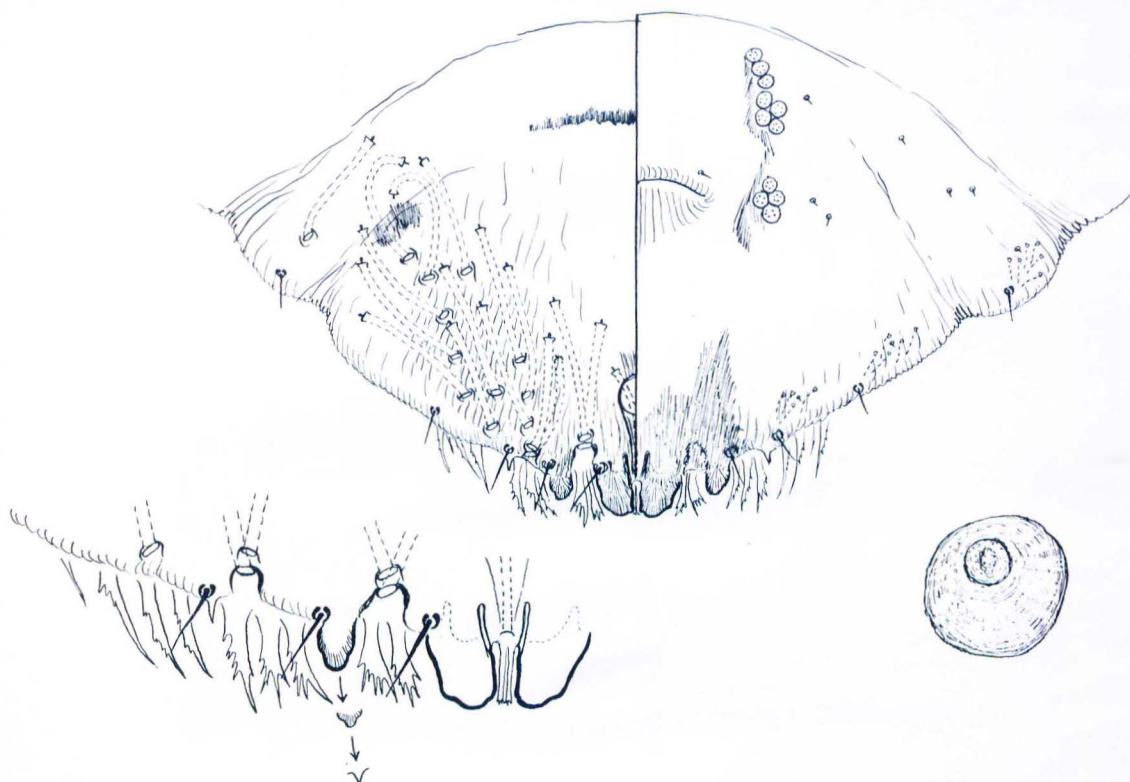


Fig. 17.-Abgrallaspis howardi (Cockerell)

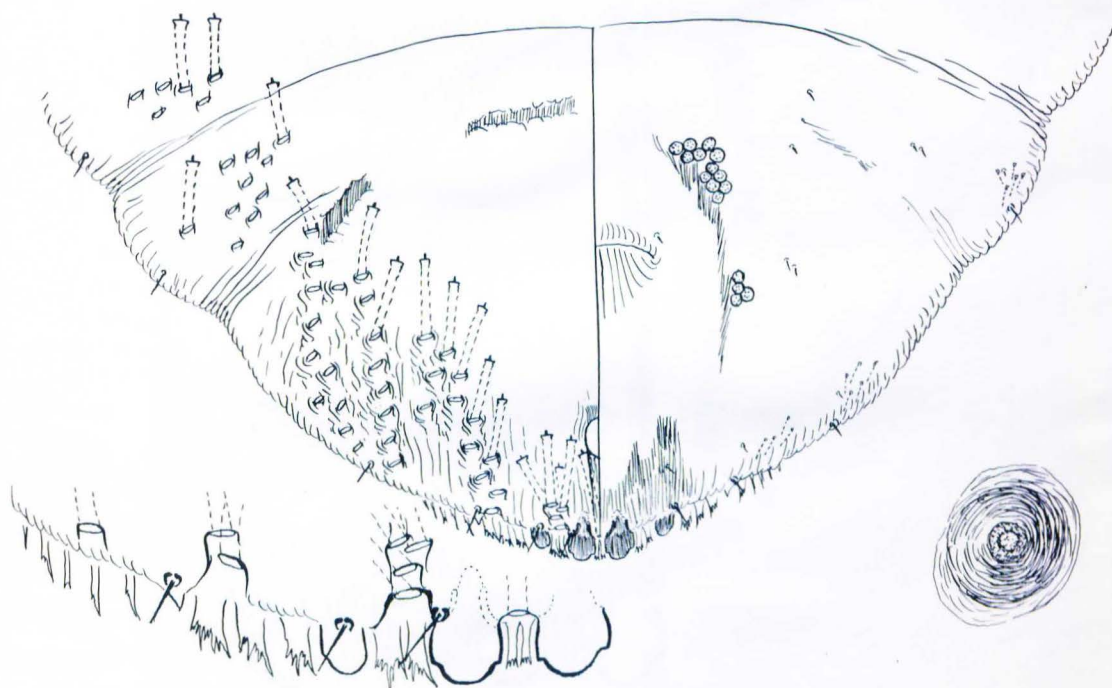


Fig. 18.-Abgrallaspis ithacae (Ferris)

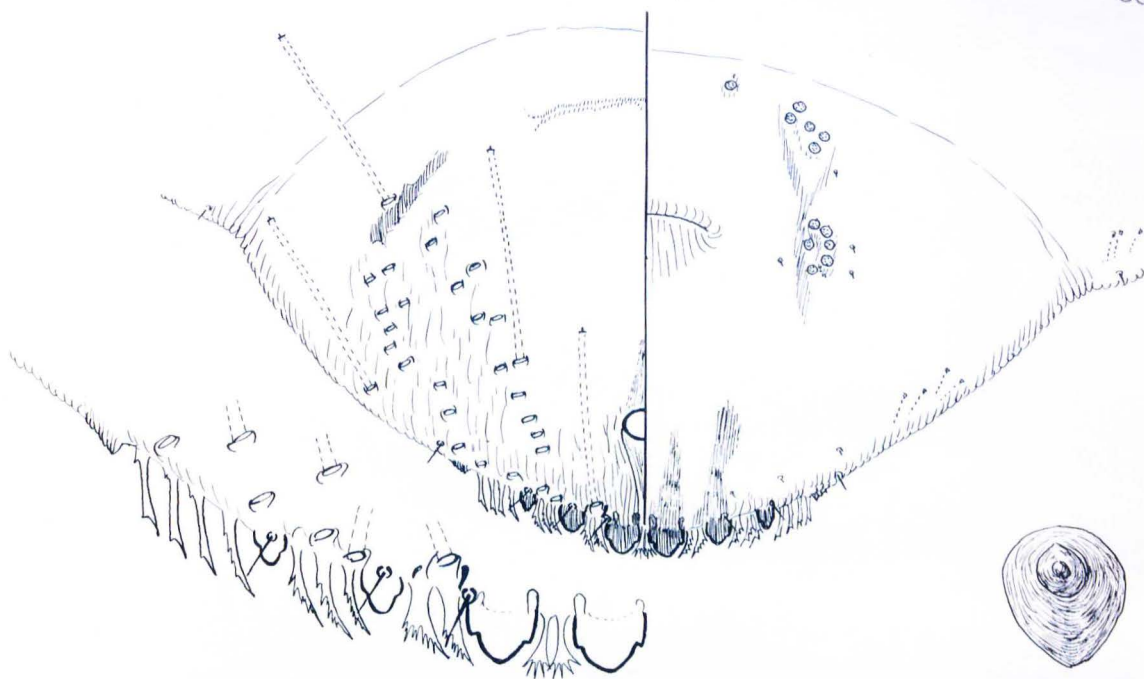


Fig. 19.-Abgrallaspis mendax (McKenzie)

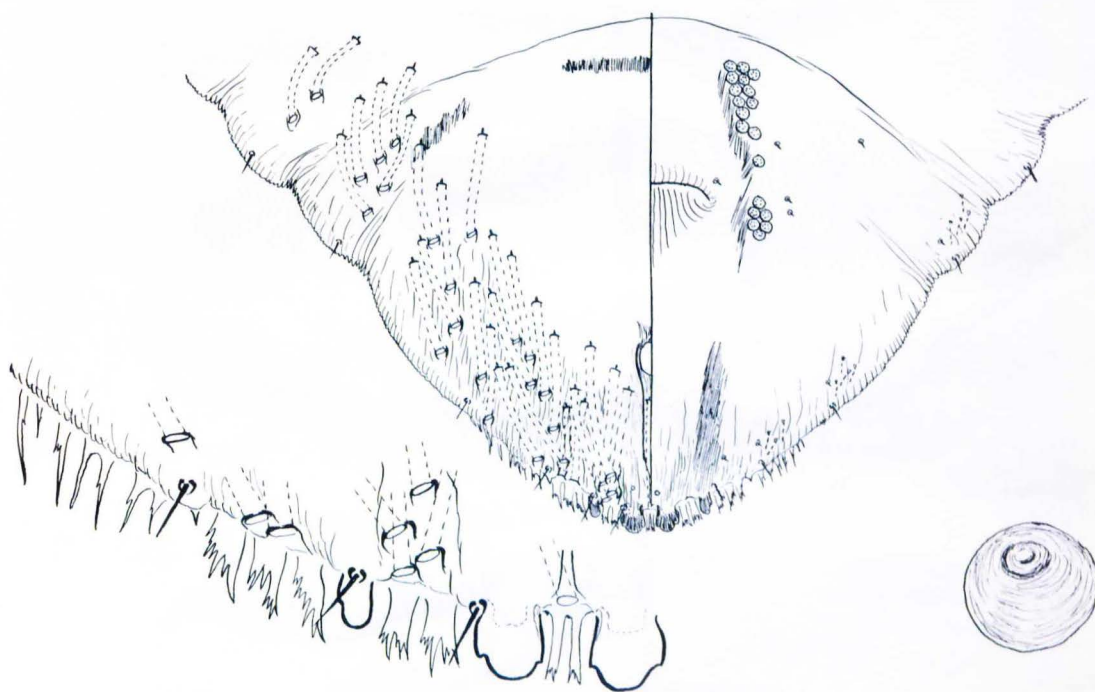


Fig. 20.-Abgrallaspis oxycoccus (Woglum)

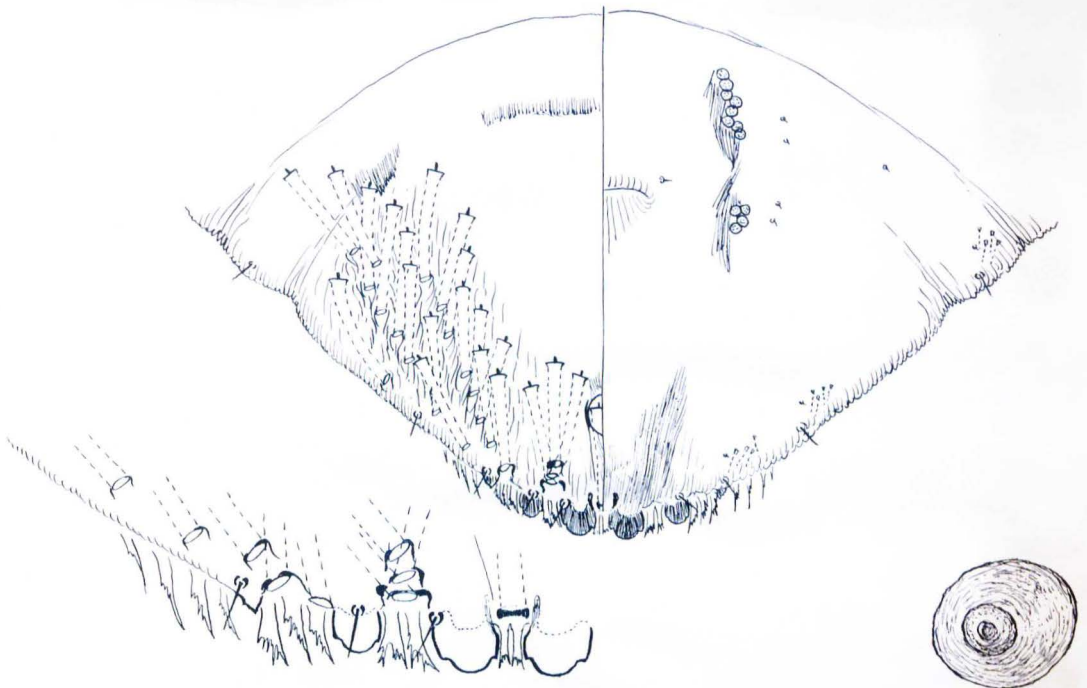


Fig. 21.-Abgrallaspis perseus Davidson

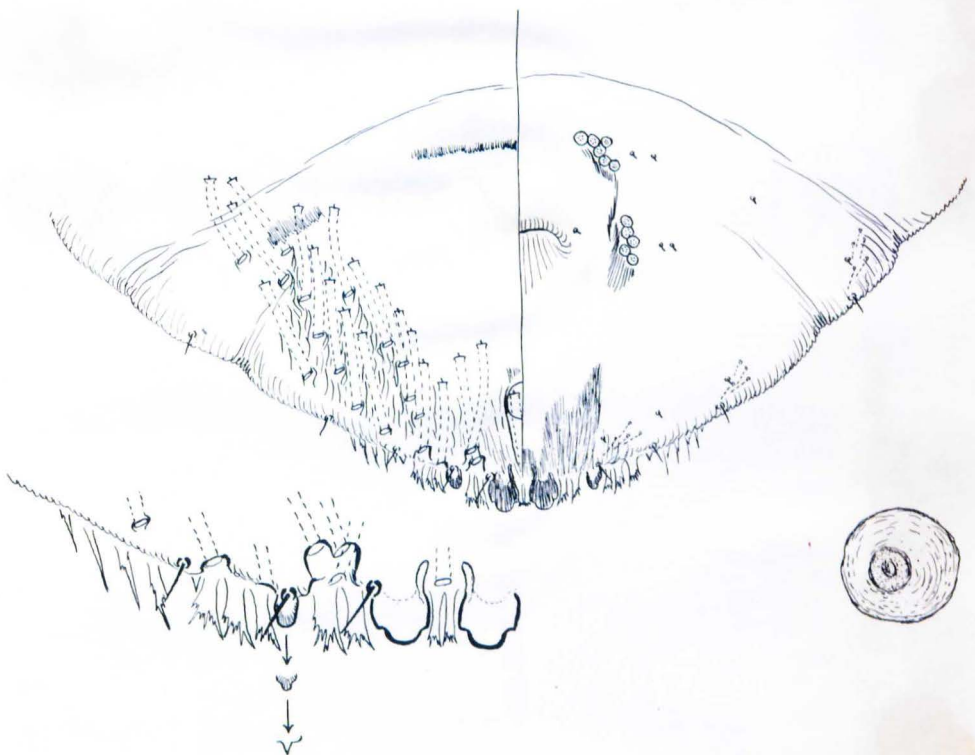


Fig. 22.-Abgrallaspis townsendi (Cockerell)

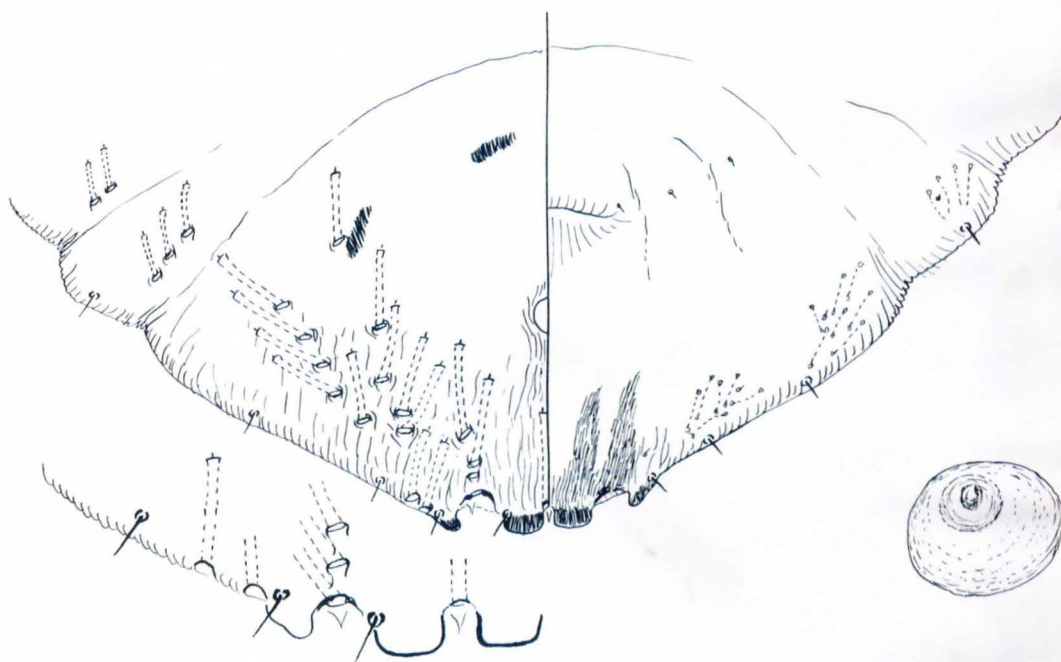


Fig. 23.-Abgrallaspis quercicola (Ferris)

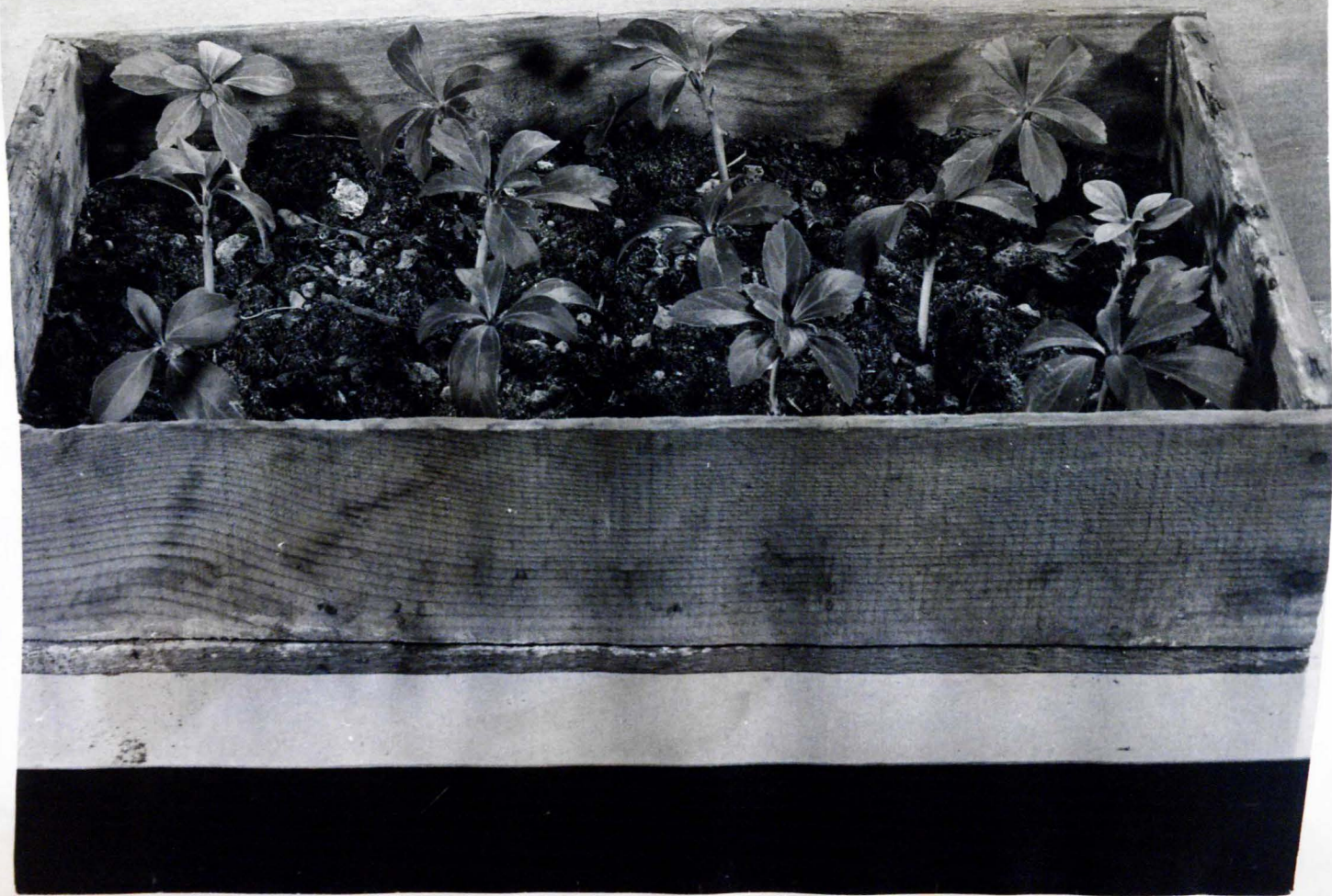


Fig. 24.-Flat containing pachysandra cuttings.



Fig. 25.-Rooted pachysandra cuttings in pots.



Fig. 26.-Pachysandra plant showing a heavy laboratory infestation of Abgrallaspis townsendi (Cockerell).



Fig. 27.-Nine experimental host plants including: oak, holly, red maple, rhododendron, blueberry, sweet gum, tulip poplar, greenbrier, and laurel.



Fig. 28.-Potted avocado plant.

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