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THE SCALE INSECT, A PARAGON OF CONFUSION[1]

by Warren T. Johnson

During the DDT era of pest control, scale insects were just another group of insects subject to DDT's lethal effects. Because of its long residual effects, it was applied in the spring of the year and remained effective for the entire growing season. For control purposes, there was little reason for an arborist to be concerned about life cycles or even identification. Now, it's different with short-life pesticides and a greater emphasis on pest management. Proper identification and a knowledge of biology and life cycle are critical for successful control.

The scale insects are a baffling group of animals. They do not look like the creatures one expects to see. In at least three groups of scales, what one usually sees is not the insect at all, but only a covering, albeit produced by the scale insect. Size is another confusing issue with adults, in some instances, not exceeding 1 mm in length or diameter. Thus, their small size makes a microscope necessary for positive identification. Because of their size, it is common to hear from the frustrated, "they all look alike." The points of confusion about scale insects can be reduced to three: tremendous diversity even among species, bizarre biology and life cycles, and misunderstood pest management techniques.

Diversity

There are about 1,000 described species of coccoid, or scale insects in the United States and Canada (3). More species occur in the south than in the north. Some species are very limited in their distribution, partly because of the distribution of their host plant and climatic conditions.

Even with this large number of species there are several unifying characteristics such as: a) females are "integumental sacs that function as reproductive factories" (7), b) wax secretions are produced in one or more stages of development, functioning to protect the insects or their eggs, c) all species have a crawler stage that facilitates movement and dispersal or location of feeding sites and d) all have mouth parts that consist of four flexible, piercing stylets that interlock to form a salivary tube and a food canal.

There are 16 family groups of scale insects. I have chosen to deal with five families (Table 1) because nearly all of the economically important species belong to these groups. The diversity of form or shape is both bizarre and mind boggling. Sometimes their shape changes to conform to available space. Color and form may also change because of quality and quantity of food.

Armored scales (Diaspididae) are the best known and understood. They are considered to be the most specialized, and with specialization comes a reduction in size. These are the smallest of the scale insects. The name armored scale is used because insects of this group produce a shell called a test, that is separate from their body. The shell is a protective covering made from two moult skins and a quantity of hard wax produced from wax glands. The wax is maneuvered into place by paddle like lobes on the body wall of the insect. There is also a thin layer of wax attaching the test to the plant; thus the armored scale insect is, more or less, loose inside its "shell," attached to the plant only by its mouth parts. Armored insects cannot be positively identified from surface characteristics of the shell although some shell characteristics are useful for tentative field iden-

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tification.

The test of armored scale insects usually varies with the species (Fig. 1, 2, 3). Figures 4, 5 and 6 illustrate the covers of some of the common armored scale insects. The body of a female is illustrated in Figures 7 and 8. When observed under a microscope the insects are sac-like, usually yellowish, wrinkled, without eyes, antennae, legs or other common features associated with insects. With few exceptions, armored scale insects reproduce sexually. Adult males are very small, 1 to 2 mm long, and have the common features of insects, including wings. They are becoming more important as we understand scale insect biology and are being linked to new aspects of control. All female armored scales found in North America have 4 developmental stages; the egg, crawler, 2nd instar immature and adult (Fig. 9).

Table 1. Some common coccoid insects

Armored
white peach scale
latania scale
obscure scale
San Jose scale
elongate hemlock scale
juniper scale
gloomy scale
Soft
E. fruit lecanium
hemispherical scale
calico scale
magnolia
pine tortoise scale
Japanese wax scale
cottony maple scale
Pit
golden oak scale
oleander pit scale
bamboo pit scale
pittosporum scale
Eriococcid
beech scale
azalea bark scale
European elm scale
Margarodid
cottony cuchion scale
Matsucoccus (e.g. red pine scale)
sycamore scale

Soft scale is an accepted but somewhat misleading term used to identify the family Coccidae. It was used primarily as a common name to separate the Diaspididae (armored scales) from

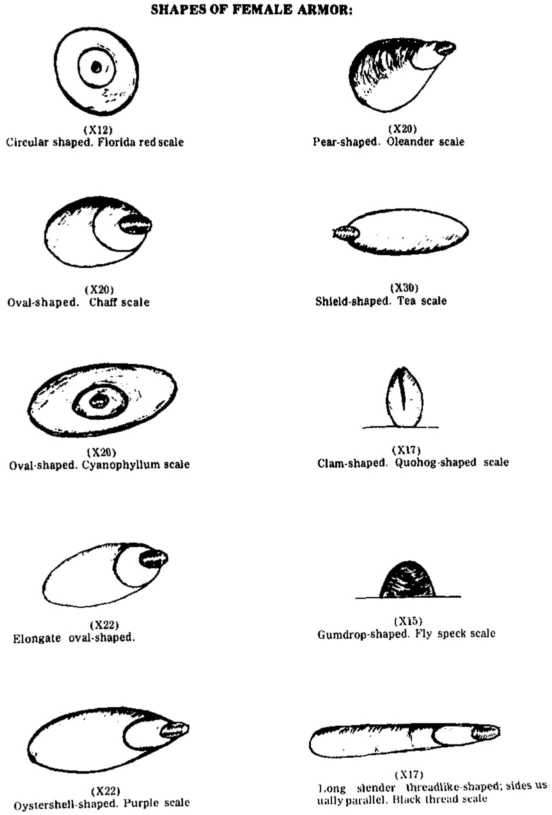

Fig. 1. Tests of female armored scales. Dorsal view. Courtesy G.W. Dekle, Division of Plant Industry, Florida Dept. of Agriculture.

the Coccidae that do not have a test. All scale insects are soft in their immature stages. At maturity, the readily visable portion of the derm or exoskeleton of the soft scale female is dark, except for wax scales, without any of the features usually associated with an insect and just as hard as the test of an armored scale (Fig. 10). If one turns the adult soft scale over (ventral) insect features are readily visible with the aid of a microscope (Fig. 11). They have legs, evidence of segmentation, tiny antennae and thread-like mouth parts. At maturity, the coccid females are much larger than armored scale females. Many species of soft scales reproduce parthenogenetically, thus every individual may be a female capable of producing progeny without fertilization. Tremendous populations can develop during a single growing season.

Soft scales produce copious amounts of

Profile flat. Dictyospermum scale (*Chrysomphalus dictyospermi* (Morgan)

Profile slightly convex. Spinose scale (*Aspidiotus spinosus* Comstock)

Profile moderately convex. Florida red scale (*Chrysomphalus ficus* Ashmead)

Profile highly convex. Latania scale (*Hemiberlesia lataniae* (Signoret)

Fig. 2. Female test profiles. Courtesy G.W. Dekle, Division of Plant Industry, Florida Dept. of Agriculture.

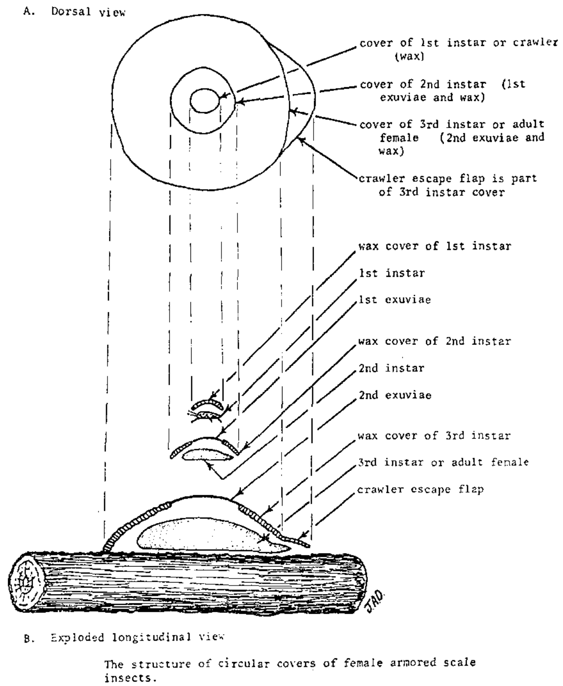

Fig. 3. Diagrammatic description of the development of a female armored scale. Drawing by J.A. Davidson, University of Maryland.

honeydew. They also produce at least one of three kinds of wax; powdery, filamentous or soft dense wax. In cases where coccid biology has been thoroughly studied, investigators are finding four instars rather than three, and some species with two mobile stages rather than one (Fig. 10). Examples of soft scales are illustrated in Figures 12 and 13.

Pit scales (Asterolecanidae) could be called soft scales were it not that the term is reserved for the family Coccidae. They are small, 1 to 3 mm in diameter and somewhat flattened. All members of the family when fully grown have a thin wax membrane on the dorsal surface that imparts a yellowish to greenish color. Many species have a fringe of white filamentous wax around the periphery. The wax membrane can be removed with difficulty (Fig. 14).

There are no males; reproduction is accomplished by parthenogensis. The females give birth to living young allowing for a rather long period when crawlers can be found. All pit scales feed on shoots or one and two-year old twigs. Most of the destructive species inject a plant growth regulating chemical that retards cellular growth at the site where their stylets penetrate the plant. The plant cells in the immediate vicinity are stimulated to excessive growth resulting in a wall around the scale. In some plants the pit and surrounding walls are described as warts, in other plants the bark only appears rough (Plate 1, E).

When the adult female is removed from the plant and her ventral surface examined through a microscope, one will find no distinguishable legs, antennae or segmentation. Pit scales, like armored scales, remain affixed to the place selected by the crawler for the remainder of their lives.

The **erioccids** have many features reminiscent of mealybugs, but most noticeable is the mealy, powdery wax. There are only three important economic species in the U.S. but none of the three has adult features that lead the uninformed

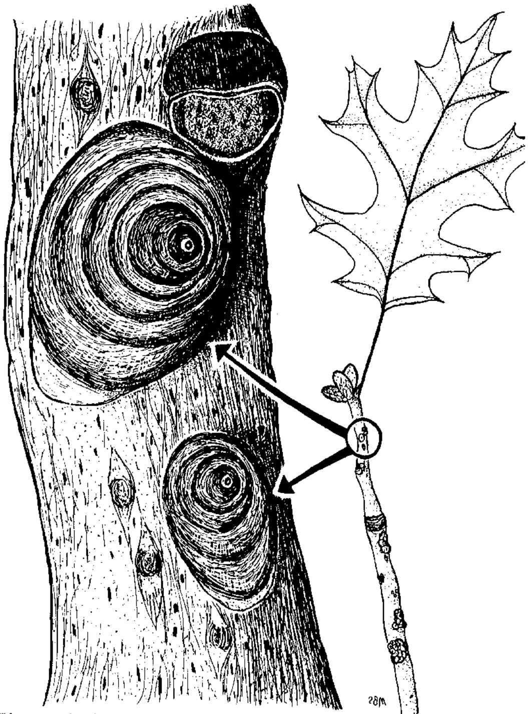

Fig. 4. A drawing of the female obscure scale, *Melanaspis obscura*, armor. By J.A. Davidson, University of Maryland.

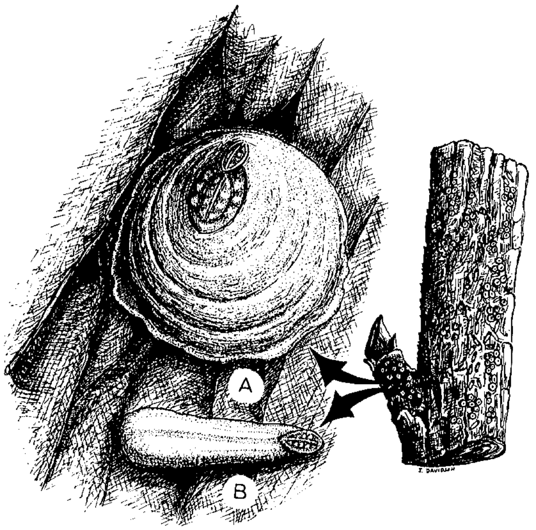

Fig. 5. A drawing of the (A) adult female and (B) male armor of white peach scale *Pseudaulaspis pentagona*. Note the two cast skins on the female armor. By J.A. Davidson, University of Maryland.

to an understanding of their close relationship to the immature form. In at least one stage, they all have a cocoon-like covering over their bodies. Some investigators have described the covering as a felted test. Except for the beech scale, they produce large quantities of honeydew. Manna, used as food by the children of Israel, is hardened honeydew and was produced by an eriococcid scale that fed on the Tamarix.

The beech scale (Plate 1, B) is an aberrant form. It neither looks like a mealybug nor reproduces sexually. All beech scales seen in North America are females and produce filamentous wax covers that look somewhat like tiny puffs of cotton. Their bodies are yellow and somewhat spherical. This scale insect may occur in enormous numbers on the bole as well as branches of beech trees. Because of the wax, conventional spray mixes will not penetrate and contact the scale.

The azalea bark scale looks like a pink mealybug about 2-3 mm long (Plate 1, C) in its 2nd instar. The cocoon-like covering develops in the adult stage. Young scales are most always found on azalea twigs. They are capable of movement in all stages but the female does not move after she begins to lay eggs (*see plate*).

The European elm scale also looks like a small pink mealybug during the summer. The crawlers move from the bark to their feeding sites on the undersides of leaves during the spring and remain there till late summer. After completing their summer activities they move to bark, often congregating at the base of twigs and small branches. Upon moulting to the adult stage in the autumn, the cast skin breaks away from the mid-dorsum and slides to the sides. This makes a white fringe along the periphery in contrast to the black body.

There are numerous species of **margarotid scales** including sycamore, *Matsuccocus* and *Xylococculus*. None is of widespread importance. They are so aberrant in form that it is difficult to make general statements about the group. There are always 2 mobile stages and they all produce white to yellow filamentous wax in one or more stages. Other than these features, they go their own way in development.

The sycamore scale, *Stomacoccus platani*, is limited to sycamore species growing in California

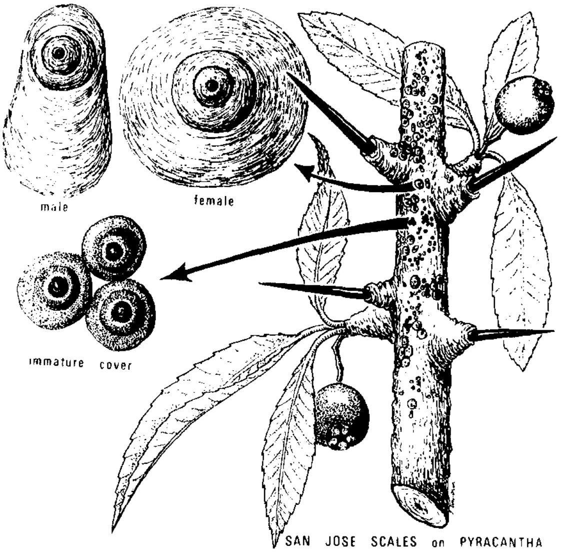

Fig. 6. A drawing of San Jose scale covers as commonly seen on immatures; male and female. By J.A. Davidson, University of Maryland.

and Arizona. Immatures, as well as adult females are yellow and may reach 3 mm in length. They remain mobile throughout their life. The immatures feed on the leaves. Adults apparently do not feed and most frequently move back to bark to lay their eggs and cover them with a mass of white waxy threads. There are three to five generations per year.

Female cottony cushion scales are big, about 12 mm long. They, like the female sycamore scales, remain mobile until they begin to lay eggs. Look for the immature stages on leaves. The crawlers are orange. The wax covering produced by the immatures is yellow with a felt-like appearance. It is possible to confuse the adult stage of the cottony maple scale with the cottony cushion scale but they are only distant relatives.

The most aberrant form of all scales belongs to the genera *Matsucoccus* and *Xylococculus*. *Matsucoccus* scales (Plate 1, A) are found only on conifers and probably only on pine. There is a geographical pocket of red pine scale specific to red pine, *Pinus resinosa,* and Japanese red pine, *Pinus densiflora,* found in Connecticut and southeastern New York State. This insect kills trees. In the west, the ponderosa pine twig scale, *Matsucoccus bisetosus* is rated as the most damag-

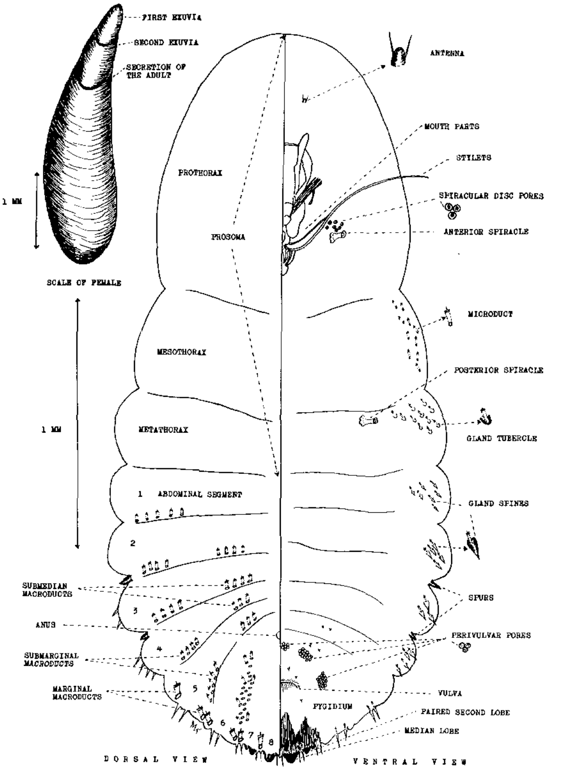

Fig. 7. A diagrammatic generalized drawing of a mature female armored scale showing the microscopic feature important for positive identification. Drawing by M. Kosztarab, VPI and SU.

ing of this group. Some *Xylococculus* and *Matsucoccus* scales develop into "cysts." The 2nd and/or 3rd instar becomes buried, living deep in the bark where its body becomes spherical to the extent that the term cyst applies. The cyst stage may be 2-3 mm at its widest point and bears little resemblance to an insect. The metamorphosis of the "cyst" results in an adult, crawling insect that inhabits the outer crevices of bark. *Xylococculus* scales may be found in alder, beech, birch and cypress.

Biology and Life Cycles

There is great confusion, misunderstanding, and, in many instances, a paucity of knowledge about the biology of scales, the common economic species notwithstanding. The common pine needle scale, *Phenacaspis pinifoliae,* a case in point, is known in practically every state and

Fig. 8. Female gloomy scales, *Melanaspis tenebricosa*, on the bark of a tree. The light round objects are the exposed scales. The arrow points to overturned tests or scale covers. Diameter 2 mm.

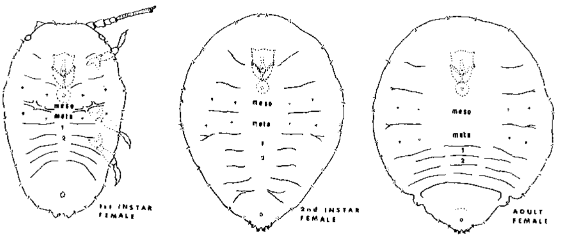

Fig. 9. Three stages of armored scales showing structures visible from the underside. There are no eyes, antennae or legs in the 2nd instar or adult stages. The mouthpart region is denoted by the stippled area in the upper center of the drawings. From Staetzel and Davidson, 1974.

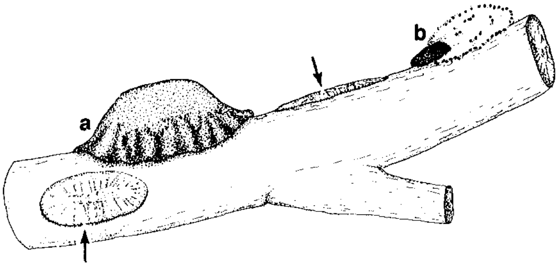

Fig. 10. General appearance of soft scales. a. adult female lecanium type scale, b. dead female *Pulvinaria* in front of her egg sac. Arrows point to 3rd instar (immature) females.

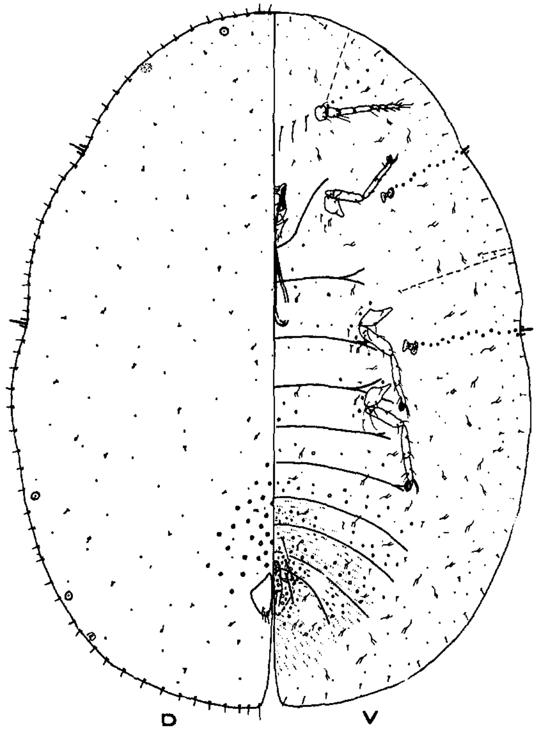

Fig. 11. A diagrammatic generalized drawing of a mature female soft scale (Coccidae). The major morphological features, visible only by means of a microscope, are shown. D-Dorsal half; V-Ventral half. Drawing by M.L. Williams.

Canadian province.

In the most northern part of its range there is one generation per year with the life cycle illustrated in Fig. 15. We in upstate New York thought there was one generation per year in our region until about 10 years ago. We now know that there are two generations (Fig. 16) in parts of Ontario and throughout most of the eastern half of the United States. If you in the northern states have been unsuccessful with control of pine needle scale, perhaps your problem is spray timing for two generations instead of one.

In Northern California, investigators have encountered an anomaly in what we believe to be the normal overwintering stage. Instead of overwintering as eggs, they overwinter as gravid females. They begin to lay eggs in the spring after the season for dormant oil treatment is past. This, of course, accounts for poor control because

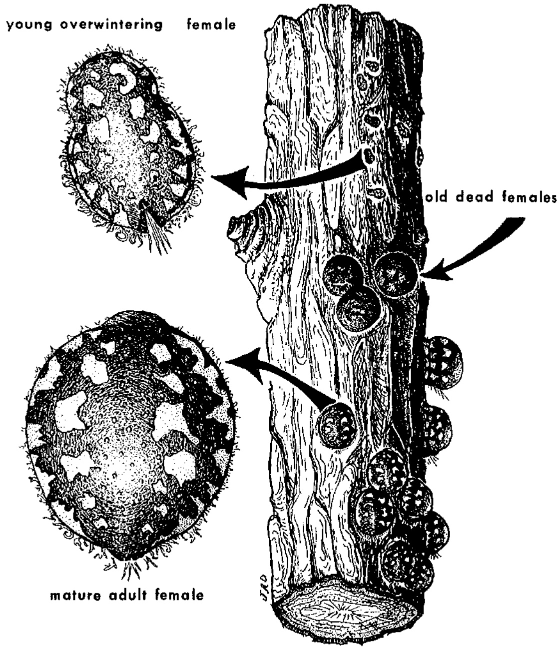

Fig. 12. Calico scale, *Eulecanium cerasorum*, showing general features of the female. Drawing by J.A. Davidson, University of Maryland.

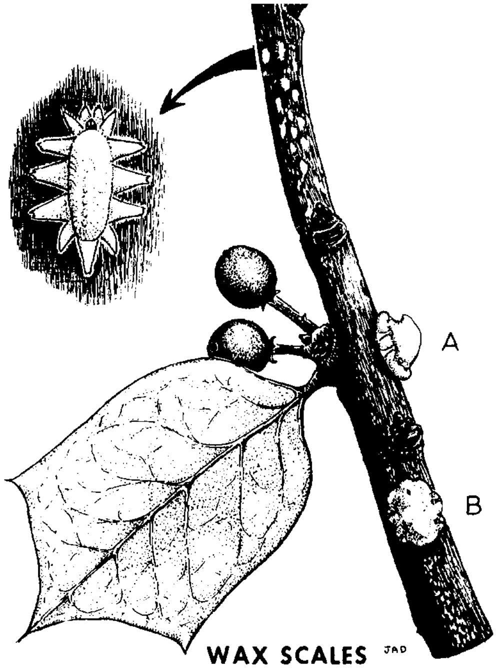

Fig. 13. A drawing of the Indian wax scale *Ceroplastes ceriferus*. A and B are adult females. The star-like insert is an immature scale. By J.A. Davidson, University of Maryland.

spray schedules are out of synchronization. This phenomenon was found to occur on *Pinus jeffreyi*. It is not known whether the deviation is due to the host or to biological change that has occurred in a small isolated population.

A similar situation was found by Stoetzel and Davidson (12) to occur with the obscure scale *Melanaspis obscurus* in Maryland. This insect has 15 or more host trees. On white oak, *Quercus alba*, the insect overwinters as a settled crawler; on pin oak, *Quercus palustris*, it overwinters as a second stage immature, complicating the generalized spray recommendations.

There are two species of "pine needle scales." The test of the two species looks identical but the females that produced these shells have distinct differences when examined with of a microscope. The species *Phenacaspis heterophyllae* is considered to be primarily a southern species but it has been found as far north as New York, further complicating control for pine needle scales in the overlapping regions, because of a difference in life cycle.

The scale insect mouth parts are poorly understood. The stylets are made up of 2 pairs of flexible but sclerotized mandibles and maxillae. These are long and hairlike. When inserted through the labrum, they interlock into a single feeding tool that has a salivary tube and a food canal. Wallner (14) was able to photograph a recently moulted 2nd instar elongate hemlock scale to show the mouth parts coiled up inside the oral cavity (Fig. 17). He was also able to measure the length of their stylets and made some assumptions that most female armored scales have mouth parts that are 4 to 8 times the length of their bodies.

Scale insects have the muscles to insert their mouth parts deep into host tissue but it is presumed that most species do not have the capacity to remove them. Those species that feed on two kinds of tissue (leaf, bark) and move from one site to another either leave their old mouth parts buried in plant tissue when they moult or have the capacity to withdraw them back into the body.

Questions have been raised about the lack of

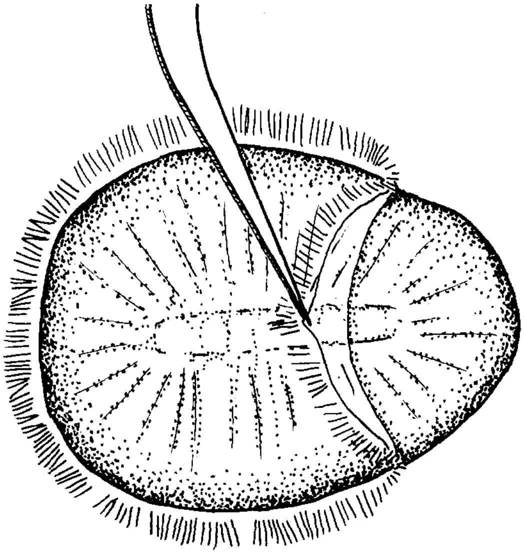

Fig. 14. A pit scale showing the thin wax membrane with feathery sides. A dorsal view.

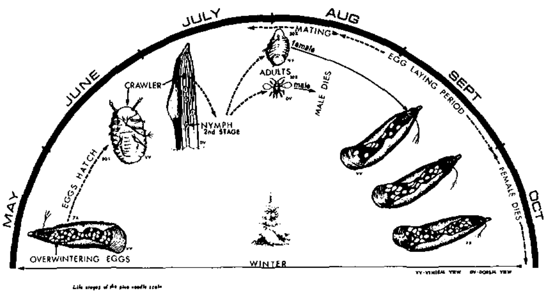

Fig. 15. Life stages of the pine needle scale *Phenacaspis pinifoliae* as observed in Alberta and Saskatchewan, Canada. Courtesy Canadian Forest Service. Environment Canada.

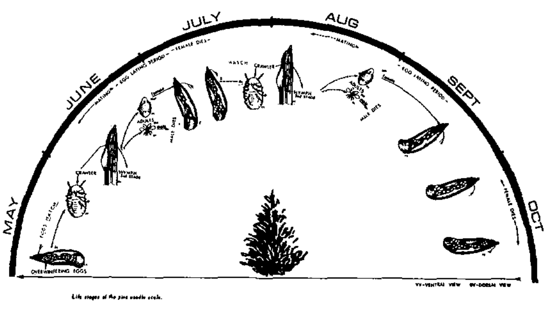

Fig. 16. Life cycle of pine needle scale as found from southern Michigan west to New York and southern New England and south to Virginia. Modified from Canadian Forest Service.

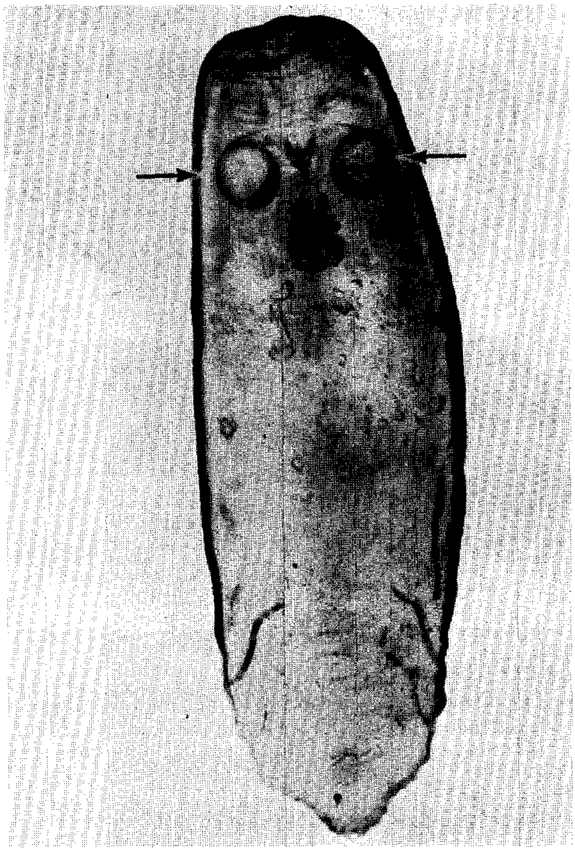

Fig. 17. A 2nd instar armored scale at time of moult showing the mouth part stylets coiled up in the oral cavity. When the stylets are fully extended, they may be 6-8 times the length of the insect's body. Body length 2 mm. W.E. Wallner.

apparent cellular damage at the point where the stylets penetrate the plant. Where within the plant does the extraction of fluids take place? It has been presumed that scales producing honeydew feed in the phloem sieve tubes, like aphids. The sap at this point contains mostly carbohydrate and minute amounts of amino acids and other proteins. Since protein is a food requirement for animals, insects tapping the sieve tubes would have to filter a lot of sap through their digestive system to obtain an adequate amount of protein. Scales not producing honeydew are presumed to feed primarily within the living cell. How this is done without killing numerous cells and without producing gross injury symptoms at the site of stylet penetration, remains unknown.

There are many examples of misunderstood scale biology that have resulted in poor scale control. Where sweetgum, *Liquidambar styraciflua*, grows, so grows the sweetgum scale, *Diaspidiotus liquidambaris.* As an armored scale, it is expected to have one generation each year, or if a second generation occurs, to be found on the same plant part, but this is not the case. The adult female of the first generation feeds on the leaf, causing small, gall-like pits and depressions on the leaves. When her eggs hatch, the 2nd generation crawlers move to the shoots to feed and overwinter.

Control and Pest Management Systems

Control is the prime reason for an arborist to spend time learning about insects. They are fascinating creatures and have ways that are "stranger than fiction." However, to the applied horticulturist, the bottom line remains, what can be done to control them?

This paper has thus far emphasized problems in scale control owing to species diversity and complicated life cycles. There are also points of confusion in the mechanics and selection of pest control techniques.

For the past 2 decades, chemicals for control of scale insects have been applied during the dormant season, and in the growing seasons during periods of crawler movement. These "timing" recommendations remain fairly dependable, although some of the chemicals have changed. Caustic chemicals are no longer recommended during the dormant season, having given way to better, superior-type horticultural oils. Confusion continues to exist about the use of superior oil during the growing season. Spray oil will kill settled crawlers and other immature stages when applied in the summer and without danger of phytotoxicity when used at the proper dosage. There are few, if any native woody plants in the northern half of the United States and in Canada that are intolerant to superior oil when used at a dosage level of 2 gallons of oil per 100 gallons of water; a point of caution, however. Any plant under moisture stress may not tolerate oil and may develop damaged leaves.

Internal poisoning of the sap stream with systemic insecticides has often been disappointing. Scales feeding on foliage can be controlled by foliage sprays but translocation to twigs, branches and trunk either by sprays or granular application to soil has been inconsistent. The use of Bidrin, via the Mauget injection system, has also been erratic.

New control considerations include the use of sex pheromones for armored scales. As with most other sex pheromones, the communications substance is produced by the female, and the male, having wings, flies to the female to mate.

Biochemists have now been able to synthesize some of the scale insect sex pheromones. By placing the synthetic pheromone in traps, males can be attracted and caught. Pheromone traps are primarily useful in detection and in timing sprays to kill both male and female. They may have potential for control when used alone, but most certainly when used together with insecticides. Pheromone traps for San Jose red scale and yellow scales are available commercially from Zoecon Corporation in Palo Alto, California. New pheromones are being developed with regularity.

There is growing evidence that tree defoliators, such as caterpillars and leaf beetles, cause less damage to healthy, well fertilized trees. Sap feeder populations, in particular aphids and scales, generally are enhanced by nitrogen fertilization. Work by McClure (6) gives added evidence that nitrogen and particularly ammonium nitrate applied to hemlock and 13 other host species of the elongate hemlock scale, *Fiorinia externa* improves the survival rate of females, and further, resulted in doubling the number of eggs produced. These are significant data for arborists. It appears that certain forms of nitrogen fertilizer may make scale control more difficult. Such data put the field man in the proverbial position "damned if you do and damned if you don't."

Conclusions

Scale insects are a paragon of confusion but scientists in entomology continue to resolve some of the points of confusion. The arboriculturist in his role of an applied horticulturist finds himself inundated by new information coming from plant physiology, entomology, plant pathology, soil

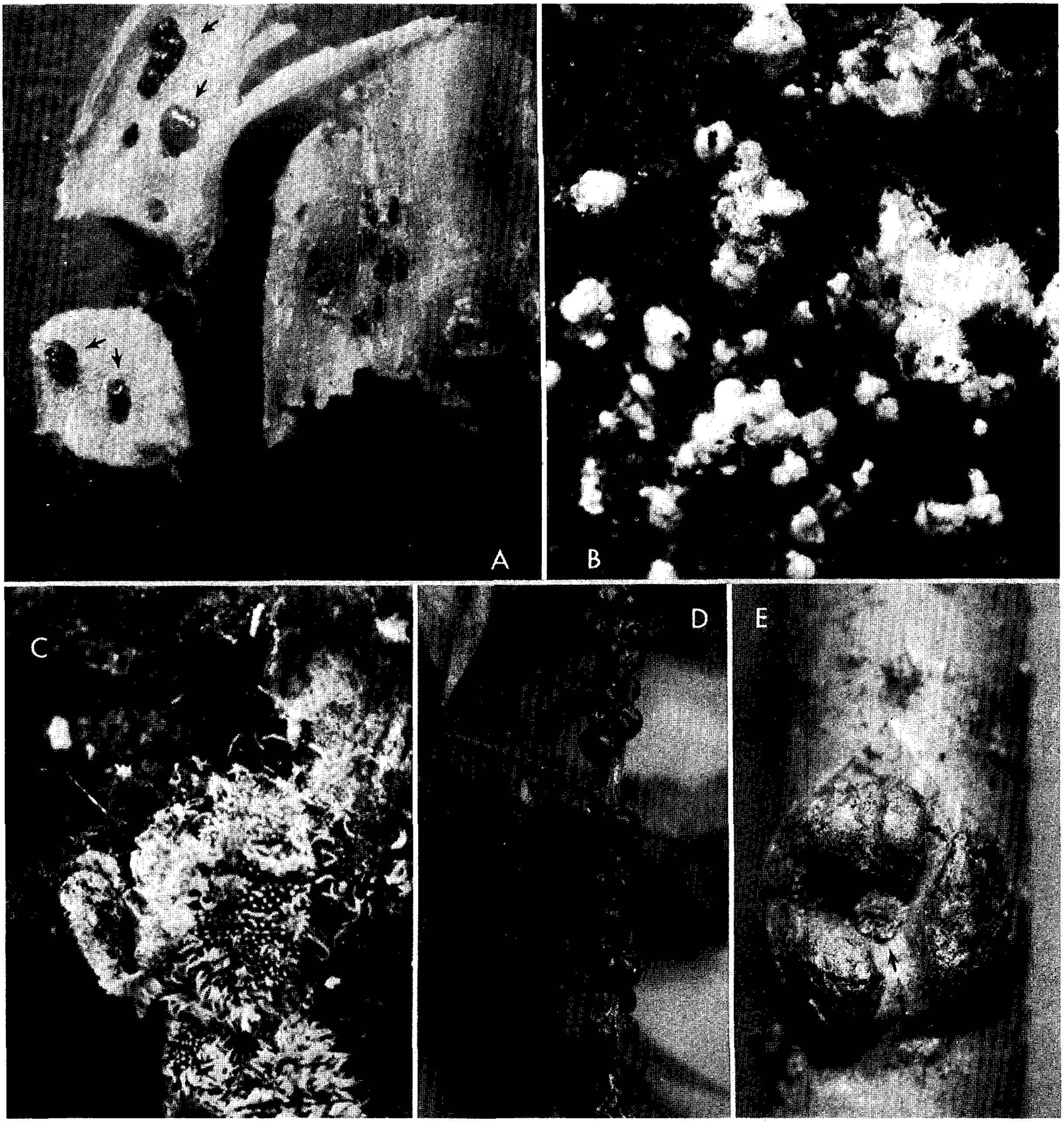

Plate 1. Some scale insect coverings and body forms. A. The scale insect *Matsucoccus gallicolus*, with a suggested common name gall pine scale, has been exposed by removing the bark from the xylem core. The cyst stage can be seen on the inner face of the bark; note the spherical bodies at arrow points. The black, long oval spots on the external bark at the right are cast skins of the insects pointed out by the arrows. B. The white fiberous covers of the beech scale, *Cryptococcus fagisuga*. C. The mealybug-like appearance of immature azalea bark scales. D. The oak lecanium scale *Parthenolecanium quercifex* on water oak. E. A pit scale *Asterolecanium puteaum* in a bark depression as found on a holly twig. *Credits: Photos A, B, and E by H.H. Lyon.*

science and a host of other disciplines. One answer to this problem is to become more specialized, another, to rely more on specialty consultants to aid in technical decision making. Pest management specialists for arborists will be in our future. But until they arrive, you will have to rely on the more traditional resources.

Literature Cited

1. Dekle, G.W. 1976. Florida armored scale insects. Fl. Dept. of Agr. and Cons. Serv. Vol. 3 Arthropods of Florida. Rev. 345 p.
2. Doane, C.C. 1959. The red pine scale. Circ. 207 Conn. Agr. Exp. Sta. 7 p.
3. Howell, J.O. and M.L. Williams. 1976. An annotated key to the families of scale insects (Homoptera: Coccoidea) of America, North of Mexico, based on characteristics of the adult female.
4. Johnson, W.T. and H.H. Lyon. 1976. Insects that feed on trees and shrubs. Cornell Univ. Press. 464 p.
5. List, G.M. 1920. The European elm scale. Circular 29 Colorado Agr. College, Fort Collins, CO. 12 p.
6. McClure, M.S. 1980. *Foliar nitrogen: a basis for host suitability for elongate hemlock scale, Fiorinia externa (Homoptera: Diaspididae)* Ecology 6(1): 72-79.
7. Miller, D.R. and M. Kosztarab. 1979. *Recent advances in the study of scale insects.* Ann. Rev. Entomol. 24: 1-27.
8. Nakahara, S. 1981. *The proper placements of the nearctic soft scale species assigned to the genus Lecanium Burmeister (Homoptera: Coccidae).* Proc. Entomol. Soc. Wash. 83(2): 283-286.
9. Peterson, L.O.T. and R.F. DeBoo. 1969. Pine needle scale in the prairie provinces. Canada Dept. of Fisheries & Forests. Note MS-L-5 9 p.
10. Roelofs, W.L., M.J. Gieselmann, A.M. Carde, H. Tashiro, D.S. Moreno, C.A. Hendrich, and R.J. Anderson. 1977. *Sex pheromone of the California red scale, Aonidiella aurantii.* Nature 267: 698-699.
11. Shigo, A.L. 1976. *The beech bark disease.* J. Arboric. 2(2): 21-25.
12. Stoetzel, M.B. and J.A. Davidson. 1971. *Biology of the obscure scale, Melanaspis obscura in Maryland (Homoptera: Diaspididae).* Ann. Entomol. Soc. Am. 64: 45-50.
13. Stoetzel, M.B. and J.A. Davidson. 1974. *Sexual dimorphism in all stages of the Aspidiotini (Homoptera: Diaspididae).* Ann. Entomol. Soc. of Am. 67(1): 138-140.
14. Wallner, W.E. 1978. *Scale insects: what the arboriculturist needs to know about them.* Jour. Arboric. 4(5): 97-103.
15. Williams, M.L. and M. Kosztarab. 1972. Coccidae of Virginia. Res. Div. Bul. 74. VPI and SU 215 p.

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ABSTRACT

LAMBE, R.C. 1981. **Entomosporium leaf spot.** Am. Nurseryman 153(9): 14, 36, 40.

Entomosporium leaf spot is caused by the fungus *Entomosporium maculatum,* which has the perfect stage *Fabraea maculata* (also known as *Diplocarpon maculatum*). The disease infects several of the choice ornamentals grown in nurseries. Particularly susceptible are *Photinia serrulata, P. glabra,* the hybrid *P.* X *fraseri,* Indian hawthorn, and loquat. The disease also affects juneberry, flowering quince, fire thorn, and mountain ash. Every effort should be made to avoid introducing diseased plants into nurseries and landscapes, to eliminate diseased leaves and plants once they are discovered, and to follow and promote cultural practices that discourage the intrusion and development of Entomosporium leaf spot.