

THE MORPHOLOGY, BIOLOGY AND CONTROL OF
CEROPLASTES CERIFERUS (FABRICIUS) AND
CEROPLASTES SINENSIS DEL GUERCIO IN VIRGINIA INCLUDING
A REDESCRIPTION OF CEROPLASTES FLORIDENSIS COMSTOCK
(HOMOPTERA: COCCOIDEA: COCCIDAE)

by

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LIST OF ABBREVIATIONS

(Collections, with names of curators in charge)

- DKPC - Dale K. Pollet's Collection, Blacksburg, Virginia
MKC - Michael Kosztarab's Collection, Blacksburg, Virginia
MLWC - Michael L. Williams' Collection, College Park, Maryland
USNM - United States National Museum of Natural History, Washington,
D. C., (L. M. Russell and D. R. Miller).
VPI - Virginia Polytechnic Institute and State University,
Blacksburg, Virginia (M. Kosztarab).

(Names of frequently mentioned collectors)

- | | |
|---------------------|-----------------------|
| DKP - D. K. Pollet | MLB - M. L. Bobb |
| FRF - F. R. Freund | MLW - M. L. Williams |
| GND - G. N. Duran | NTB - N. T. Beal |
| HCM - H. C. McSwain | RHC - R. H. Clark |
| JMP - J. M. Pierce | RNH - R. N. Hofmaster |
| Let.- Letter | Rec.- Received |

I. INTRODUCTION

Wax scales include those soft scale insects belonging to the genus *Ceroplastes* (Gray 1828). The genus contains 150 recorded species worldwide, occurring primarily in tropical and subtropical regions. The scales are covered by a heavy wax layer of variable thickness and consistency, which is predominantly white. The name *Ceroplastes* means tail former in reference to the sclerotized dermal area surrounding the anal plates. These insects occur primarily on citrus and ornamental plants. They feed on phloem and parenchyma by means of stylets inserted into stems and/or leaves.

Records from the Virginia Department of Agriculture (Regulatory Services Division), the State Survey Entomologist at VPI&SU, and the insect collection at VPI&SU indicate *Ceroplastes* has been present in Virginia since 1938. In the past ten years, *Ceroplastes ceriferus* (Fabricius), the Japanese wax scale, has become an extremely abundant insect infesting ornamentals in Virginia. Endemic in the southern region of the United States, it has spread and become established up the Atlantic Coast as far north as Maryland. Although there is only one generation a year, each female has the potential to increase two to four thousand times, so that in a short period of time, populations can become very extensive. Plants commonly become so severely infested that the entire woody surface is encrusted with scales. In Virginia, severe infestations have occurred extensively in the Coastal Plain and inland areas, particularly in Southeastern Virginia, the Eastern Shore,

Richmond west to Danville, and Charlottesville. Although many efficacious insecticides have been developed in recent years, they had not been evaluated for control of wax scales, and general scale insect control recommendations were not found to be adequately effective.

The abundance and continued spread of the wax scales has led to three current research projects. The Entomology Research Division, ARS, USDA initiated investigations on the life history and control of the Japanese wax scale at its Beltsville Laboratory in 1967 under the direction of Floyd F. Smith. In 1969 two research grants were sponsored by ERD-ARS through cooperative agreements. A taxonomic study of the adult females of the *Ceroplastes* of continental North America was conducted at the University of Maryland. Studies on the biology and control of *Ceroplastes* spp. of Virginia were undertaken here at VPI&SU. Apparently these projects are the first studies on the classification, bionomics, and control of *Ceroplastes* in the United States.

Severe infestations of wax scales cause weakening of host plants and gradual decline after repeated attack. However, infested plants are much less seriously affected in comparison to pests such as oystershell scale or soft brown scale which frequently cause rapid death of branches or large portions of trees. The presence of large populations of wax scales and abundant, sooty mold growth is unsightly and objectionable on ornamental plants. Sooty mold growth on honeydew excretions of the insect interferes with photosynthesis contributing to decline in vigor.

Wax scales as a group are not economically important nor are they considered major pests worldwide, while a few species are considered nuisance pests or as potential major pests. To nurserymen selling insect-free nursery stock, control is an important economic factor.

Initial investigations showed that *Ceroplastes ceriferus* (Fab.), *C. mexicanus* Ckll., *C. cirripediformis* Comstock, and *C. floridensis* Comstock had been reported from Virginia. Many additional listings were recorded as *Ceroplastes* spp. because of the lack of identifying characters and the specimens found fit more than one description. When these investigations were initiated, there was lack of agreement on the specific identification of what has now been confirmed as *C. ceriferus*.

Previous morphological studies of *Ceroplastes* have been confined almost entirely to descriptions of the adult female, most of which were incomplete, with only brief statements on the younger instars. Without comprehensive studies on all instars of a species, identification is extremely difficult.

This study was conducted to determine: a) the species of *Ceroplastes* occurring in Virginia, b) their host range and distribution, c) the biologies including life history and development, d) the natural enemies, and e) effective methods of control of the wax scales infesting ornamentals in Virginia. To gain the most comprehensive outlook of the biology of the scales, all the nymphal instars as well as the adults were studied and described in detail.

II. LITERATURE REVIEW

Taxonomy and Morphology

The genus *Ceroplastes* was erected by Gray in 1828. The subfamily Ceroplastinae was established by Borchenius (1957) for the genus *Ceroplastes*. After studying two species of males, Giliomee (1967) decided that *Ceroplastes* was closer to *Coccus* and, therefore, Ceroplastinae should be sunk as a synonym of Coccinae. Until a more comprehensive study of *Ceroplastes* is made and an acceptable decision is reached *Ceroplastes* are classified as follows:

Order:	Homoptera
Superfamily:	Coccoidea
Family:	Coccidae
Subfamily:	Ceroplastinae (Coccinae)
Genus:	<i>Ceroplastes</i>

A complete revision of the entire genus is needed. Cockerell (1910) originally divided *Ceroplastes* into 2 subgenera, *Ceroplastidia* and *Ceroplastina*. De Lotto (1965, 1969, 1970) started to rework the genus, dividing *Ceroplastes* into 3 additional genera. *Gascardia* Targioni-Tozzetti (1893), encompassing *Ceroplastidia*, was resurrected and *Cerostegia* De Lotto, 1969, and *Waxiella* De Lotto, 1971, were established. Hodgson (1969) concurred with De Lotto's resurrection of *Gascardia*.

Ceroplastes ceriferus was originally described as *Coccus ceriferus*

Fabricius, 1798, from India. Since the original description as *Coccus ceriferus* Fab. to the present *Ceroplastes ceriferus* (Fab.) the following changes have occurred: *Coccus chilensis* Gray (1828); *C. (Ceroplastes) chilensis* (Gray) White (1846); *Ceroplastes australiae* Walker (1852); *Columnea cerifera* (Fab.) Targioni - Tozzetti (1866); *Lacca alba* Signoret (1869); *Ceroplastes ceriferus* (Fab.) Signoret (1869); and *Gascardia cerifera* (Anderson) De Lotto (1965). Kawai and Tamaki (1967) gave a description of the wax development and the morphology of the nymphal instars and the adult of *C. ceriferus*.

Ceroplastes sinensis was originally described by Del Guercio, 1900, from *Citrus* sp. in Italy. Silvestri (1919), Spiller (1944), and Snowball (1970) have supplemented Del Guercio's early work by conducting additional studies on the biology and morphology of *C. sinensis*.

Ceroplastes floridensis was described by Comstock, 1881, from *Citrus* sp. in Florida. Amitai presented a brief description of the development of *C. floridensis* including a morphological comparison of the anal rings, anal plates, and spiracular setae of the different instars. Kuwana (1923) presented a brief morphology and description of what he considered to be *C. floridensis*. However, Takahaski (1953) observed that Kuwana's previous records were misidentifications of *C. japonicus* Green. Ferris (1950) redescribed and listed the morphological characters of *C. floridensis* from China. Ben-Dov (1970) redescribed *C. floridensis* comparing specimens from the United States, China, and Israel and noted several discrepancies in Ferris' descriptions.

A complete synonyme of each species is listed prior to the

descriptions of the adults. The adults have been roughly described in numerous articles with little emphasis on the younger instars.

Biology

Studies of the life history and development of wax scales have been documented by the wax secretions covering the scales, Smith *et al.* (1971), Blumburg (1935), Sankaran (1967), Kuwana (1923). This has been the basic method used to study wax scale biology as it indicates survival and development into subsequent instars and the adult stage.

McComb (1965) described the adult female as "sticky to the touch, one-quarter of an inch long, convex, circular with a dorsal nipple-like projection extending posteriorly. Under the wax covering the actual insect is pink in color." He found that all overwintering forms were mature adult females. Oviposition, 1000 eggs or more, began in early spring in Maryland with hatching occurring over a period of several weeks in late spring. The emerging crawlers are smaller than the head of a pin and pink in color. They move about the plant searching for a feeding site, it is at this time that they are easily blown by the wind to adjacent plantings. Once settled they remain sessile throughout their life cycle. Only one generation a year was recorded and only females were found.

Shriver *et al.* (1970) revised McComb's (1965) leaflet. They found that 1500-2000 eggs were laid in early spring and hatching continued over 2 to 3 weeks beginning in mid-June at College Park, Maryland. Outdoors there was found to be only 1 generation of *C. ceriferus* per

year and no males.

Smith *et al.* (1971) states that the overwintering mature female of *C. ceriferus*, is easily recognized by the thick, usually white, sticky, waxy covering that completely envelopes the pink or reddish-brown scale body. Females complete their growth period in early spring and may grow to 1/4 inch or more in size. Oviposition was noted to begin in May in the Richmond, Virginia, area and early June in Beltsville, Maryland, with 1 to 2000 or more dull reddish brown eggs laid by each female. Hatching occurs, 2 to 3 weeks later in early June in Richmond and mid to late June in Cheverly, Maryland. Four nymphal instars were also observed. Settled nymphs were first observed 1 to 2 days after hatching. Wax formations were found 1 to 2 days after feeding started. Nymphs are then in a sessile stage (Stage 2) or the 'cameo stage' which lasts for approximately 37 days and is so termed because of the white wax projections on the reddish-brown body. Stage 3, or the 'duncecap stage' is so termed because of the prominent conical accumulation of soft wax on the dorsum which expands basally into a continuous covering over the scale's body. The adult stage occurs beginning from September 1 to October 1. One generation per year was observed outdoors in the Maryland-Virginia area. In greenhouse colonies the start of a second generation was noted in 7 to 8 months. Reduced vigor and photosynthesis were accorded to scale feeding and sooty mold development respectively.

Kuwana (1923) gave a general account of the life history and wax development. He recorded a 90 day duration between egg hatch and

adult development of *C. ceriferus* in Japan. Eighteen species and 9 families of plants were listed as host in Japan.

Del Guercio (1900) in his original description of *C. sinensis* made a comprehensive study of the biology and morphology of all the male and female instars. He discussed wax development, hosts, natural enemies and the control of the Chinese wax scale in Italy. Silvestri (1919) also published the biology, morphology, and life history of *C. sinensis*. He observed that *C. sinensis* laid an average of 2000 eggs per female and indicated a host range of 13 genera and 11 species of plants in Italy. He described the first, second, and third larval instar and the adult of the females and the third larval, prepupal, pupal stages and adults of the male. The males were found to remain on the leaves throughout their life cycle while the females migrated to the stem to complete development. Spiller (1944) studied *C. sinensis* in New Zealand where it was considered a pest of citrus. He found that there was one generation per year. Oviposition occurred primarily in January and February but also as late as April. The crawlers hatching in February settled primarily on the leaves but migrated as maturity approached to the stems to complete development. Snowball (1970) also noted one generation per year in Australia with oviposition of an average of 2100 eggs per female mainly during November to March with minor hatchings as late as July. He recorded 4 nymphal instars in the female and 6 in the male. Differentiation of males and females in the younger instars was based on spiracular spines and the length of the anal plates. According to Snowball (1970), the hatching crawlers

usually settle on the leaves and later the females migrate to the stems, the males remaining on the leaves. Migration usually occurs in the adult or 3rd nymphal instar. No difference was discernible between the sexes in the first nymphal instar. In the second instar the male is distinguished by an elongation of the cephalic wax process not noted in the female. In the third instar the female body wax, usually pink, becomes bright red. Later in the adult stage the color fades to white. The fading continues until the wax cover becomes entirely white or brownish white. Snowball cites the distribution of *C. sinensis* as southern France, continental Italy, Shanghai, Hong Kong, northern Spain, New Zealand, Sicily, Algeria, Morocco, Jamaica, the Madeira Islands, the Solomon Islands, and New South Wales, Australia. Hosts include 59 species of plants in Australia.

Bodenheimer (1935) reported on the life cycle of *C. floridensis* in Palestine describing the adult female as follows, "heavily covered with a thick wax layer, broadly oval and strongly convex, opaque white in color, shaded with pink." The body of the scale is reddish brown. A monthly egg count revealed that *C. floridensis* in Israel has two generations per year and each female lays an average of 415 purplish-red or yellow eggs. The first generation occurs in April and May and the second in August and September.

According to Bodenheimer (1935) the first stage larva is ovoid, flat, reddish-brown and 0.35 mm long and 0.20 mm wide. It settles within 3 days of hatching and is sessile from then on. Settling is on the stems and veins of the leaves. Wax secretions produce a star

pattern dorsally on the scale. The second stage larva is oval, convex, and 1.4 mm long and 0.8 mm wide. The star wax pattern remains but is enlarged. The third larva is ovoid and convex but loses the star pattern and resembles a nipple 1.8 mm long and 1.5 mm wide. The body beneath the wax is reddish-brown in color. Bodenheimer recorded damage to the plants and the fruit because of the dense sooty mold growth on the wax scale honeydew excretions. He stated that populations of *C. floridensis* were reduced about 32 percent yearly: 19 percent owing to climatic conditions, 8 percent to fungi and 5 percent due to parasites and predators. Ben-Dov (1970b) and Bodenheimer provide a comprehensive host list for *C. floridensis* in Israel.

Ben-Dov (1970c) reared wax and other scales in the laboratory on rooted citrus leaves and squash. These techniques were developed as an aid in the biological control studies on scales.

Bedford (1968) conducted an intensive study of the biology of *C. sinoiae* Hall with special reference to ecdysis and the morphology of the wax covering or test. He noted that early wax secretions and shed skins are used as supporting and strengthening structures in the test of the adult female.

Studies which cover details on biology, ecology, and morphology of other wax scales include: Blumberg's (1935) study on *C. rubens*; Sankaran's (1959) study on *C. pseudoceriferus*; and Cilliers's (1967) work on *C. mimosae*, *C. brevicauda* and *C. destructor*.

Males

Males have been reported for only a few species of wax scales.

Green (1909) wrote, "the male in any stage is extremely scarce and has been observed only by Newstead who described the male puparium and imago of *C. ceriferus*." In many cases, Balachowsky (1933), Blumberg (1935) and Bedford (1968), no males were found. Kawai and Tamaki (1967), in a study of the morphology of *C. ceriferus* with special reference to the wax secretions made no record of males or of wax formation characteristic of males.

Snowball (personal communication, 1970), Del Guercio (1900), Silvestri (1919), and Williams and Gimpel (personal communication, 1971) state that the populations of male *Ceroplastes* are so low that it is doubtful if the male performs any function in the reproductive cycle.

Del Guercio (1900) gave a description of all stages of male development of *C. sinensis* except the third instar which Snowball (1970) subsequently completed. Kuwana (1923) briefly described and illustrated the stages of development of males of *C. ceriferus*, *C. japonicus*, and *C. rubens* in Japan. Smith (1971) briefly mentions observing males but did not include a description or illustration.

Sankaran (1959) has found that *C. pseudoceriferus* Green, was the exception as males were collected in large numbers. He stated that early wax development of the male may easily be overlooked as it compares closely with that of the female.

Parasites, Predators and Attendants

Parasites and predators have proved to be generally effective in controlling scale populations. Dozier (1935) reported that *Coccidoctonus*

ceroplaste Dozier was the controlling factor of *Ceroplastes floridensis* in Haiti and Merrill (1953) stated that parasites were the controlling factor of *C. floridensis* in citrus groves in Florida.

Research by Thompson (1944), Ben-Dov (1970b), Rosen (1967), Ballou (1912), Anneck (1967), Gurney (1936) and Snowball (1970) indicates that *Anicetus ceroplastis* Ishii, *Coccophagus lycimnia* (Walk.) *Scutellesta cyanea* Motsch, *Tetrastichus ceroplastae* (Girault), and *Diversinervus elegans* Silvestri are the most common parasites of *C. ceriferus*, *floridensis*, and *sinensis*. Twenty-four other species of parasites from various parts of the world were also listed for these three species by these authors.

Cilliers (1967) listed 14 genera of parasites from *Ceroplastes mimosae*, *brevicauda*, and *destructor*. She also recorded three predatory lepidopterans; *Coccothera spissana* Zell., *Eublemma scitule* Ramb. and *E. costimacula* Saalm, feeding on the wax scales. Duckworth (1969) described a new species, *Synanthedon coccidivora*, feeding on *Ceroplastes* in Venezuela.

Bedford (1968) observed the ant, *Pheidole megacephala* (F), attending *Gascardia sinoiae* Hall, and Das (1959) recorded the ant and coccid associations on tea in India. Way (1963) reviewed the studies of ant and homopteran relationships. He showed that populations of homopterans have adapted to this tending activity of the ants in honeydew production and in structure and life cycle modifications. The benefits received by both the ants and the homopterans and the specific relationships between species were also noted. The possibility of the

ant-homopteran relationship as a means of natural control was tentatively discussed.

Control

Previous studies indicated that chemical control measures should be directed against the first (crawler) or second instar nymphs. Berger (1917) and Kawai and Tamaki (1967) stated that younger instars were easier to control compared to the later instars which were completely covered by a wax layer.

Smith *et al.* (1971) in greenhouse tests found that dipping in azinphosmethyl, Bay 93820, propoxur, carbofuran, diazinon, dimethoate, and ethion in oil effectively controlled the first and second instar nymphs of *Ceroplastes ceriferus*. Dip treatments of Bay 93820 and carbofuran also killed third instar nymphs. Bark treatments revealed that Dasanit[®] and phorate killed second instar nymphs. Phorate and carbofuran granular soil treatments killed second and third instar nymphs, respectively.

The Department of Agriculture, New South Wales (Anonymous, 1965), reported that mid-December and early January sprays of white oil, lime sulphur, and certain organophosphorus insecticides and carbaryl with half strength white oil produce effective results against the crawlers of *C. ceriferus*, *C. destructor*, and *C. rubens*. Sprays properly applied soon after hatching gave satisfactory control with one application. The organophosphates tested included malathion, azinphosmethyl, carbophenothion, dimethoate, and ethion. Carbaryl was

the most effective material tested against wax scales. Where additional pests were found in combination with wax scales, organophosphates were used. Washing soda or soda ash sprays applied early, by mid-February or late, in March or April, were used against later instars. These soda or ash sprays were previously recommended against the early instars of *C. ceriferus*, *C. destructor* and *C. rubens* by Froggatt (1902), Newman *et al.* (1929), Manefield and Passlow (1954) and Manefield (1956). Although effective, these sprays have undesirable side effects on the host plants if sprays are too strong or applied at the wrong time. Berger (1917) recommended applications of oil emulsions or mixtures of soap and water at emergence and 2 or 3 additional sprays at two week intervals.

Lochner (1956) in test with *Gascardia sinoiae* (Hall) [= *C. hilichrysi* Hall var. *sinoiae* Hall (De Lotto 1965, 1971)] obtained effective control of second instar nymphs with demeton and malathion foliage sprays and with soil and banding treatments of demeton. Amos (1969) recommended the use of malathion and Trithion[®] for crawler control and noted that carbaryl appeared promising as a control for crawlers. The Virginia Department of Agriculture (1970) also recommended the use of malathion for crawler control. Bodenheimer (1935) and Ezzat and Rawhy (1966) recommended volck oil and volck oil plus malathion, respectively, for the control of the crawlers of *C. floridensis*. Ezzat and Rawhy stated that dimethoate showed promise in scale control. Nishino and Ohgushi (1969) found that Imidan[®] was effective 25 to 30 days after emergence and Fussol[®] about 50 days after crawler

emergence of *C. japonicus* (Green).

McComb (1965) and Shriver *et al.* (1970) recommended the application of malathion and diazinon at crawler emergence for best control results.

III. METHODS AND MATERIALS

A study of the biology, life history, and control of an insect requires that the geographic distribution, the hosts, the species, and the severity of infestations in the study area be determined. This information aids in locating field sites which may be used to study seasonal growth and development and which may provide infestations for control testing. These field sites will also provide some idea of the ability of the scale insect to adapt to various locations representing different climatic and ecological variations. They will also serve as a source for infesting greenhouse plants for subsequent and more comprehensive observations. The greenhouse colonies would allow for manipulation of the insects' environment allowing more in-depth studies to be undertaken than are possible in the field. Greenhouse colonies enable one to make close observations of the developmental stages, habits, and growth of the insect.

Existing records of host, distribution, and species of wax scales reported in Virginia were obtained from the State Survey Entomologist (VPI&SU), the Virginia Department of Agriculture and Commerce (Plant Pest Control Section); and the Entomology collections and records (USNM & VPI&SU). This data was supplemented through a statewide survey with the assistance of collections and records presented by extension agents, nursery inspectors, and growers. The collections and records were individually processed and each collection received was assigned a number, labeled, and preserved in 70 percent ethyl alcohol.

Identification of the species was made after mounting 1 or 2 adults from each sample and noting the morphological and taxonomic characters. These identifications were then verified by the Mr. Gimpel who is working on the taxonomy of *Ceroplastes* at the University of Maryland. Host determinations were made by the collectors and those questionable were checked personally in the field. Samples were taken for verification by the plant taxonomists at VPI&SU when necessary.

To make a complete study of the biology and life history it is important to be able to distinguish the different nymphal instars as they develop. Without an understanding of all the nymphal instars, it is difficult to completely study the biology of the scale. Wax secretions and microscopic morphological characters can be used to correlate the biology and life history of wax scales.

To collect specimens at the correct times so that the wax secretions and morphological characters could be studied, 5 biological study sites were secured and sampled weekly to provide samples for studying wax development and for slide mounting of specimens for microscopic examination. These two means of identification allowed complete detailed descriptions of the different instars of each species showing the characters which separate the instars of the species studied. The morphological characters were used to make keys for the identification of each species of wax scale at each stage of development. Greenhouse colonies provided sufficient specimens to supplement the field collected data, for illustration and photography, and they aided in determining the body color changes of the nymphal instars as they developed.

This descriptive work greatly supplemented the life history studies on *Ceroplastes*. Daily observation and records on live specimens and the field data revealed the duration of the nymphal instars. Ten marked specimens of each species in the greenhouse colonies were observed daily using a 15X hand lens and a binocular scope. These studies provided the opportunity to observe the preparation for oviposition, hatching, emergence, molting and honeydew excretions of the scales.

Additional observations and records were made on the survival potential of the wax scales, their parasites, predators, and attendants, and the sooty molds associated with *Ceroplastes*. All studies were a combination of field and greenhouse observations.

Collecting and Surveying

Information on the distribution, the extent of infestation, and host range of the wax scales in Virginia, was gathered through the aid of personnel in the Virginia Department of Agriculture and Commerce, Division of Regulatory Services, nursery inspectors, extension agents, growers, and personal field trips.

A data sheet was prepared and distributed (Appendix page 209). The appropriate information was filled in and returned with a sample from each reported infestation. The samples were labeled and preserved in 70 percent ethyl alcohol in 7 dram vials with rubber stoppers. A small portion of each sample was mounted on microscope slides to determine species.

All specimens collected in this study were from Virginia, except a sample of *C. sinensis* from Australia and one sample of *C. floridensis*

from Louisiana. Additional mounted material was obtained from the VPI&SU and USNM collections and from the private collections of Drs. Michael Kosztarab and Michael L. Williams.

Sampling

To complete a comprehensive study on the biology of the two established species of *Ceroplastes*, a sampling technique was devised. *Ceroplastes ceriferus* infestations in Richmond, Kilmarnock, Portsmouth, and Danville, Virginia, were selected for study and sampling sites. *Ceroplastes sinensis* infestation in Franklin, Virginia, was used as a study and sampling site. *Ceroplastes floridensis* material was transported from Richmond to the greenhouse at Virginia Polytechnic Institute and State University for limited biological studies.

Starting in early April 1970 and 1971, infested plants were checked twice a week to determine initial oviposition time. Two weeks after oviposition began the infestations were checked at 2 to 3 day intervals to determine initial egg hatching time. The first sample was taken at hatching, then samples were taken weekly until the scale insects reached maturity. Samples consisted of three or four infested cuttings, two to three inches in length, from the plants. These cuttings were preserved in 70 percent ethyl alcohol in 7 dram vials with rubber stoppers and labeled with the date taken, location, and name of collector enclosed. Monthly collections of these samples were made. Half of each sample was mounted on slides to determine the morphology of the instars, the remainder were used to study the wax development.

Color Coding

The color coding used in this paper is taken from the Munsell's Book of Color (Anonymous, 1965).

Infestations

Two methods were used to infest greenhouse plants for test purposes. The first method was adopted from Blumberg (1935), using a conical paper funnel affixed to the plant. Infested cuttings with egg laden females were placed in a small box and all light sources were sealed off. A small vial was inserted through one end of the box. Upon hatching the crawlers were attracted to the light source and collected in the vial. The crawlers were poured into the paper funnel from the collecting vial. The cone was left in position for a 24 hour period, after which time it was removed (Blumberg, 1935; Cilliers, 1967; Bedford, 1968).

The second method which proved much easier consisted of tying the cuttings infested with the egg laden females directly to the plants. These cuttings were left on the plants and removed after hatching and settling of the crawlers.

Mounting Techniques

The study of the Coccoidea requires an examination of microscopic characters of taxonomic and biological value. This necessitates processing of the specimens, clearing by removal of body contents, staining and finally positioning on microscope slides.

Species of the genus *Ceroplastes* have a heavy wax covering on the

derm which requires removal before mounting. Live material or alcohol preserved specimens make better slide preparations than do those stored dry. Specimens from hatching to adult females, prior to egg development and laying, make the best mounts for taxonomic examination.

The mounting techniques used in the mounting of wax scales are listed below. Procedures I and II were initially used without satisfactory results. Procedure III is a modification of Procedure II and was found to be the most successful for mounting.

Procedure I. General Mounting Method

1. Shake specimens (live or liquid preserved) in Carnory II to remove wax.
2. Place specimens in a 25 ml. Pyrex casserole dish about half-filled with 10% KOH and heat rapidly at about 500 to 600°F, until KOH starts to bubble. Make a small incision either on the lateral side or between the antennae, and tease out (by slightly pressing) all body contents of the insect with a small spatula.
3. Once specimens become transparent, wash in distilled water for 5 minutes. Old and fungus-infested specimens may require additional time in KOH.
4. Transfer specimens to 95% ethyl alcohol for 10 to 15 minutes.
5. Stain in acid fuchsin for 1 or 2 hours or Chlorazol Black E for 1/2 to 1 hour. Both time intervals are dependent on the degree of sclerotization of the specimen. Specimens should be checked periodically while in stain to prevent overstaining.
6. Transfer specimens back to 95% ethyl alcohol for 5 to 10 minutes or until excess stain is removed. Any material, tracheae, etc., which remains inside the body may be removed with the aid of fine pointed curved forceps. This could be done prior to staining but it is

recommended to be done after staining to avoid accidental tearing of the derm, since staining makes both the derm and the internal contents distinct.

7. Transfer specimens to clove oil for at least 10 minutes.
8. Mount specimens in Canada balsam under a 12 or 15 mm round cover glass. Before placing the cover glass, add a drop of xylene to the surface of the balsam. This makes positioning of the cover glass much easier.
9. Mark slides with diamond point pencil for permanent identification.
10. Place slides on tray and dry in slide drying oven for two weeks at 40°C before labeling.

Procedure II. Wilkey's Method

1. Place specimens in 25 ml Pyrex casserole dish approximately half-filled with Essig's Aphid Fluid (formula below) and heat (125-130°F) until clear (30 minutes to 1 hour). It will help to speed up the clearing of larger specimens by first making a lateral incision in the abdomen.*
2. Remove from hot plate and tease out body contents. If not thoroughly clear tease out loosened body contents and transfer to fresh clearing solution and reheat.
3. If stain is desired, add 3 or 4 drops or more of prepared staining solution (formula below) depending on degree of staining necessary (this may be done when specimens are first placed into the clearing solution if desired). Heat again until the specimens have absorbed the stain (15 to 30 minutes depending on the insect involved).
4. Transfer specimens directly to tetrahydrofuran (C_4H_8O), and tease out remaining body contents and excess stain. Allow specimens to remain in the tetrahydrofuran for 1 to 5 minutes only. Specimens tend to shrivel when placed in the balsam if kept in the solution for too long a period. In the case of very fragile

*Specimens with heavy wax deposits are vigorously shaken in a solution of Chloroform and Acetic-acid (CAA).

specimens, add some of the tetrahydrofuran gradually to the clearing solution before transferring to straight tetrahydrofuran; this prevents shriveling.

5. Mount directly in balsam.

Procedure III. Wilkey's Modified Method

1. Place specimens (live or liquid preserved) in a small vial with Carnoy II, shake vigorously, let stand overnight or pour into a Pyrex casserole dish, cover and heat at 100-150°F until wax is removed.
2. Make an incision between the antennae, or an angular incision on the abdomen. Very small specimens may be punctured with a minuten pin. Transfer specimens to a 25 ml Pyrex casserole dish half-filled with Essig's Aphid Fluid, cover and heat at 300-350°F for 5 to 10 minutes, then add 3 to 5 drops or more of prepared staining solution and continue heating specimens about 30 to 45 minutes.
3. Transfer specimens to 95% ethyl alcohol, pull and tease out body contents using a spatula and fine pointed curved forceps. Specimens which are cleaned should be pressed slightly to remove Essig's Aphid Fluid from the body cavity. Old and fungus infested specimens may require additional treatment in fresh clearing fluid.
4. Transfer cleared specimens to clove oil for 10 minutes before mounting in Canada balsam on microscope slides under a 12-15 mm round cover glass.
5. Mark slides with diamond point pencil. Place slides on tray and dry in slide drying oven at 40°C for 2 weeks before labeling.

In Procedure III the length of time required for the mounting procedure and the amount of handling and transferring of specimens is greatly reduced from Procedure II. It is also a more convenient process that may be halted for a time at any stage. There is no critical period with regard to staining as this technique rarely overstains,

by comparison with the method used in Procedure I. Although all methods have proved to be effective in mounting scales and other small arthropods, Procedure III was used because I found it easier, quicker, and more convenient besides producing excellent results.

The formulas used to prepare Essig's Aphid Fluid and Stain used in Procedures II and III, are as follows:

Essig's Aphid Fluid

Lactic acid (reagent grade 855)	20 parts
Phenol (saturated in distilled water)	2 parts
Glacial acetic acid	4 parts
Distilled water	1 part

Stain

Essig's Aphid Fluid	15 ml.
Acid fuchsin (2% aqueous solution)	20 drops
Lignin pink (2% aqueous solution)	20 drops
Erythrosin (2% aqueous solution)	20 drops

Measurements, Illustrations and Material Studied

Measurements are given in microns unless otherwise stated. All measurements were made using an ocular micrometer and a Zeiss P. A. phase contrast microscope, with magnification ranging from 160X to 2000X. The measurements in the text show the average followed by the range in parentheses. Averages under 10 microns are rounded off to the nearest tenth of a micron. Measurements were made of 10 specimens for each instar and species.

Drawings of each instar and the adults were outlined using a Leitz Prado 500 microslide projector. The details and enlargements were drawn by using a Zeiss phase contrast microscope. Each figure

has a central drawing for the whole specimen with the left half representing the dorsal surface and the right half the ventral surface. All drawings are not made to the same scale and the enlargements are not in proportion with each other, as an effort was made to use the available space most economically. The dermal structures within the outline are enlarged to show their approximate distribution and attention is drawn to the fact that this larger scale may show some inconsistencies in the relative sizes of these structures. Therefore the reader is urged to consult the measurements within the text when such questions arise.

The terminology used in the morphology text of the paper was adapted from Steinweden (1929) and Kawai and Tamaki (1967). Two new terms used in the text include monolocular ring pore and bi-locular barred pore. The monolocular ring pore is a circular pore with a thickened sclerotized rim and a small central opening (Plate 4, fig. g) and is found on the adults of all species concerned. The bi-locular barred pore is ovoid to oblong with 2 lateral openings separated by an ovoid bar slightly constricted at the middle (Plate 4, fig. i).

To conserve space in the description under materials studied, the number of slides and specimens studied per instar are listed as; (ex.) 1(5), 1, referring to the number of slides and (5) to the number of specimens. Unless otherwise specified, all counties, towns, or cities mentioned are Virginia localities.

Fecundity

Counts on the number of eggs laid by 20 females of each species were made during 1970 and 1971. Stems containing ovipositing females were cut into sections and the females were individually isolated in 7 dram vials plugged with cotton. After the hatching of crawlers was observed, the vials were filled with 70% alcohol and sealed with rubber stoppers. All eggs were then counted using a bruchner funnel, grid filter paper, and a binocular microscope. The eggs were shaken in the alcohol vial to release them from under the females, poured on the filter paper in the funnel and the alcohol was vacuumed off leaving the eggs adhering to the damp filter paper. The filter paper was then removed from the funnel, placed on the cover of a petrie dish and then under the microscope where the eggs were individually counted.

Fifty eggs of each species were measured using a binocular microscope calibration slide and binocular microscope. The eggs of each species were also color coded using Munsell's Book of Color (Anonymous, 1965).

Males

All second and third nymphal instar material mounted was carefully checked for characteristic male features. Samples collected in the field and greenhouse colonies were thoroughly examined for any variation in wax development which might identify males.

Parasites, Predators and Attendants

State-wide field collections of twigs infested with wax scales

were placed in plastic bags and checked daily for parasite emergence. The parasites were removed with an aspirator, stored in 70 percent ethyl alcohol, and labeled.

Predatory Lepidoptera and other large larvae brought in from the field were put in individual plastic cages with screened bottoms, labeled, and reared in an 80°F temperature cabinet. Most emerging Lepidopterans were placed in a large cage with an infested plant to see if mating and oviposition would occur in captivity. The remainder were killed, pinned and labeled as were the adults of other predators.

Small predatory larvae were preserved in 70 percent ethyl alcohol and labeled. These larvae fed on early instars which died soon after the infested stem was cut. A number of larvae were lost in attempts to rear these young larvae to adults.

A series of ants found attending the wax scales were also collected, labeled, and preserved in 70 percent ethyl alcohol.

All specimens collected and reared and some immatures were sent to the U. S. National Museum for identification.

A small population of *Tetrastichus ceroplastae* (Girault) was obtained for testing on greenhouse colonies.

Survival Potential

Twenty adult females of *C. ceriferus* and *C. sinensis* (10 of each prior to oviposition and 10 of each with eggs) were removed from their host plant. Two females of *C. ceriferus* without eggs were placed on the soil surface in each of five 10-inch pots with uninfested hosts

(*Ilex* spp.). Each female was placed individually at the extreme margin of the pot 4 to 5 inches from the host. This same procedure was conducted with *C. ceriferus* females with eggs and *C. sinensis* females with and without eggs. These tests were conducted to illustrate the ability of *Ceroplastes* to reinfest host if removed from the host at the wrong time and not disposed of properly.

Overwintering

Tests were conducted in the winters of 1970 and 1971 to check the survival potential of *C. ceriferus* outdoors west of the Blue Ridge Mountains. Twenty-four uninfested (*Ilex cornuta* var. *Burfordii* and *Euonymus japonica*) plants were infested with crawlers in June and maintained under greenhouse conditions until they matured in early September. At this time the plants were removed from the greenhouse and set outdoors to allow both the plants and the scales to become accustomed to outdoor temperatures gradually prior to winter. The plants were numbered consecutively and placed in rows of six plants. Sawdust was used as an embedding material to prevent the roots from freezing.

Prior to removal from the greenhouse, all scales on each infested plant were counted so that a more accurate count of survivors could be made.

Six plants were removed from the plot on December 1, January 1, February 1, and March 1, by using a random numbers table to check scale survival to that point in the test. Those plants removed December 1 represented the survival of the scales from September to

December 1; those removed January 1, represented the scales surviving through December 31; those removed February 1, represented those scales surviving through January 31; and those removed March 1, represented the scales surviving through February 28. The plants were brought indoors and gradually introduced to the greenhouse temperatures. Thirty days after removal from the outdoors, the females were removed from the plants and a count of the live females was made.

Sooty Molds

Field-collected samples, leaves and twigs with fungus growth were collected periodically from each test plot in 1970-71 and 1971-72 for isolation and identification of the fungi on Difco potato-dextrose agar containing 200 ppm chloramphenicol to reduce or eliminate bacterial contamination. Agar culture facilitated identification.

To prevent contamination when plating the fungi, a probe was flamed and cooled before removal of inocula from the leaf samples and placement on the media. The probe was heat sterilized before and after each inoculation. Plates were incubated at 24°C until cultures grew out, then placed at 5-10°C to prevent overgrowth of inoculation sites until observations could be made.

Control

Insecticide Control Tests on *Ceroplastes ceriferus*

Selected insecticides for control of *Ceroplastes* in Virginia were tested in field plots during 1970 and 1971. The plots were located in areas heavily infested with scales and the treatments were planned so

that a series of applications could be made. The principal objectives were to determine the number of applications required to adequately control the scales and the most effective timing of the applications in relations to seasonal development of the insects. The evaluation of the insecticides was based on the number of scales surviving the treatments applied.

The materials used had been screened in preliminary greenhouse testing of selected insecticides by Floyd Smith (1971), Entomology Research Division, USDA. These insecticides, plus additional materials which were thought to provide adequate control of the wax scales, were field tested. Those insecticides used along with such pertinent information as the additives, dosage applied and their equivalent per 100 gallons are listed in Table 1. All dry materials were weighed in the laboratory and transported to the field in plastic bags. The liquid materials were measured prior to mixing in the field.

The Admiralty Motor Hotel, located in Norfolk, Virginia, provided an adequate site for Control Test 1 on *C. ceriferus* (Fab.) in 1970. The motel, presented an ideal situation with individual plantings of *Ilex cornuta* var. *Burfordii* with medium to heavy infestation of *C. ceriferus*, located near the outer door of each room. The plants were separated from each other and partially protected from adverse weather conditions by cinder block partitions extending out about 4 feet from the outer wall on each side of the rooms. Granular applications could not be used because of the plastic ground covers used to control weeds around the plantings. These plantings had been previously treated with

Table 1. Insecticides tested in the control study of *Ceroplastes ceriferus*.

Common name	Trade name	Formulation ^{1/}	Appl. rate per 100 gal. ^{2/}	Amount form. per gal. ^{3/}	% A.I. ^{4/}
carbaryl	Sevin	80.0% WP	2 lb	11.34 gm	0.24
		80.0% WP	1 lb	5.67 gm	0.12
		41.8% F	2 qt	38.00 ml	0.24
		41.8% F	1 qt	19.00 ml	0.12
carbofuran	Furadan	43.8% F	1/2 pt	2.34 ml	0.06
		43.8% F	1/4 pt	1.17 ml	0.03
	Imidan	50.0% WP	2 lb	18.16 gm	0.24
		50.0% WP	1 lb	9.08 gm	0.12
malathion	Cythion	57.0% EC	1 qt	19.00 ml	0.14
malathion ^{5/} & Nufilm ^{5/}		57.0% EC	1 qt & 1 pt	19.00 ml 9.50 ml	0.14
diazinon	Spectracide	48.0% EC	1 qt	19.00 ml	0.12
diazinon & Nufilm-17		48.0% EC	1 qt & 1 pt	19.00 ml 9.50 ml	0.12
ethion-oil	Nialate	9.0% M	4 qt	76.00 ml	0.08
		9.0% M	6 qt	114.00 ml	0.12
carbophenothion	Trithion	79.1% EC	1 pt	9.50 ml	0.12
carbophenothion & Nufilm-17		79.1% EC	1 pt & 1 pt	9.50 ml 9.50 ml	0.12
monitor	Tamaron	56.0% EC	1/2 pt	2.34 ml	0.09
oxydemetonmethyl	Meta-Systox-R	25.4% EC	1 pt	9.50 ml	0.03
	Supracide	24.4% EC	1 qt	19.00 ml	0.06
	Orthene	75.0% WP	1-1/4 lb	6.00 gm	0.15
dimethoate	Cygon	23.4% EC	1 qt	19.00 ml	0.06

Table 1. Insecticides tested in the control study of *Ceroplastes ceriferus* (Continued).

Common name	Trade name	Formulation ^{1/}	Appl. rate per 100 gal. ^{2/}	Amount form. per gal. ^{3/}	% A.I. ^{4/}
			Amt. Form./9 sq ft ^{6/}		A.I./sq ft ^{7/}
phorate	Thimet	10.0% G	28.4 gm		0.32 gm
disulfoton	Disyston	10.0% G	28.4 gm		0.32 gm
carbofuran	Furadan	10.0% G	28.4 gm		0.32 gm
aldicarb	Temik	10.0% G	28.4 gm		0.32 gm

^{1/} Formulations: WP-wettable powder; F-flowable; EC-emulsifiable concentrate; M-miscible; G-granules.

^{2/} Application rate per 100 gallons.

^{3/} Amount formulation per gallon.

^{4/} Percent active ingredient.

^{5/} Nufilm-17 - wetting agent.

^{6/} Amount formulation per 9 square feet.

^{7/} Active ingredient per square foot.

Volck oil and Isotox, with little success.

The test site was divided into three areas receiving I, II, or III applications; each area was divided into plots of three consecutive plants. Plots receiving I application were treated on July 6; plots receiving II applications were treated on June 21 and July 6; and plots receiving III applications were treated on June 7, June 21, and July 6. Plots which were treated with insecticide plus additives were treated at four-week intervals. Those plots in area III received two applications, one on June 7 and another on July 6 while plants in areas I and II received one application on June 21 and July 6, respectively. The control plots were sprayed with water. Initial spraying began with the hatching of crawlers.

In 1970 a Domina Knap-Sack Pressure Sprayer with a built in piston pump was used to apply the test materials. The formulations were prepared in pint jars and then emptied into the sprayer and water added. This type of procedure allowed for the treatment of an individual plot only. Each plant was sprayed to runoff.

The Park Towne Apartments, Norfolk, provided the site for Control Test II (1971) on the Japanese wax scale. The plantings here included *Ilex cornuta* var. *Burfordii*, *Ilex crenata*, *Euonymus japonicus*, *Pyraecantha* sp. and *Cydonia japonica*. These plants were exposed to prevailing climatic conditions and were set in both group and individual plantings. Volck oil and Isotox had also been applied to these plantings in previous years with little observable results.

Treatments at the Park Towne Apartments were arranged differently.

The infested plants were marked on a map of the complex and were identified numerically and consecutively. Then using a random numbers table and a list of the insecticides the treatments were assigned. The first three numbers corresponded to the three applications of the first insecticide. The first number for each treatment represented area I, and received one application on June 7; the second number, area II, received two applications on June 7 and June 21; area III, represented by the third numbers, received three applications on June 7, June 21, and July 6. Treatments with insecticide and additives were treated twice on June 7 and July 6. Four granular systemics were also applied to three plants each in late April at this site. The bedding material around the plants was removed, the granules applied at the base of the plants, raked into the soil, the bedding replaced and the plants watered to aid movement of the insecticide into the soil. The sprayer used to apply the insecticides in 1971 was a John Bean, Royalette 5 pump powered by a Briggs and Stratton motor fixed on a wheel mount. The pump was carried and operated from the tailgate of a station wagon. Two 10-gallon milk cans were used as water tanks. The materials were mixed in quart jars and then added to the water tanks. This sprayer allowed mixing of enough material to spray all the plots of a particular insecticide at one time and allowed for a greater penetration of the foliage from a distance of 6 to 10 feet. The plots were again sprayed to runoff.

To determine the effectiveness of the insecticide application, each plot was sampled four times. Each sample consisted of 10 random

six-inch infested cuttings from each plot. Samples were placed in individual plastic bags and labeled. The live female scales on each cutting were counted and recorded.

The first samples were taken shortly after crawler emergence. This sample was used to determine the reproducing adult population on the plants prior to treatment. Two successive samples taken in August and December were made to check the effectiveness of the treatments on the developing population. The fourth sample was taken in April (1971) and March (1972) to compare the surviving with the initial populations and to try to estimate the mortality due to winter.

The data recorded were analyzed statistically using Analysis of Variance and Duncans New Multiple Range Test. The average counts are presented in table form so comparisons between the treatments and the controls could be made.

Greenhouse Test with Carbaryl on *Ceroplastes ceriferus*

A greenhouse test was conducted in 1971 to determine carbaryl's effectiveness in preventing and eliminating wax scale infestations. One-hundred and ten plants (55 *Ilex glabra* and 55 *Euonymus japonicus*) were obtained from scale-infested nursery stock in September 1970. All scales were removed and the plants were transplanted, fertilized, and arranged in eleven groups of ten plants each (5 *Ilex* and 5 *Euonymus*).

The experiment was designed so that groups I to V were treated at 10-day intervals prior to infestation, and groups VI to X were treated at 10-day intervals after infestation. The time of initial application was selected and based on previous hatch records so that

8 to 10 days would elapse between both the treatment of group V, infestation of all plants, and the treatment of group VI. Group XI was used as a control.

Carbaryl was applied at the rate of 1 pound actual per 100 gallons of water (5.67 gm 80% WP/gal). At each application each group of plants was removed from the bench, treated, allowed to dry and replaced on the bench. A three gallon knap sack sprayer was used for application.

Infestations were made by tying a three inch cutting infested with egg-laden females to the main stems of each plant. The infested cuttings were obtained from untreated field plots. Eight days after emergence was initially noted the cuttings were removed. At this time group VI was sprayed and the succeeding groups at 10 day intervals thereafter.

Presumably all plants were subject to the same environmental conditions and they were cared for in the same manner (watering, fertilizing, etc.). The initial application was made April 23, 1971, and the final application was July 28, 1971. The test was terminated on December 20, 1971, after those scales infesting the control had developed to the adult stages. Each scale was then individually removed and checked for survival. Survival was determined by the observance of the normal pink body color and issuance of the pink or red body fluids upon rupture of the derm.

Insecticide Control Test on *Ceroplastes sinensis*

A test similar to those conducted on *C. ceriferus* was conducted on *C. sinensis*. A single application of carbofuran was applied as a

soil drench to determine the extent of the systemic action against the first and second instars which settled on the leaves of the host. One and a half gallons of water with 2.34 ml carbofuran (4F) per gallon were applied at the base of each of 2 of the 3 infested plants in April 1970. These plants were sampled and counted by the procedure previously mentioned. The data were recorded and presented in table form to permit actual count comparisons between the treatments and the control.

IV. RESULTS AND DISCUSSION

A. OCCURRENCE IN VIRGINIA

Distribution

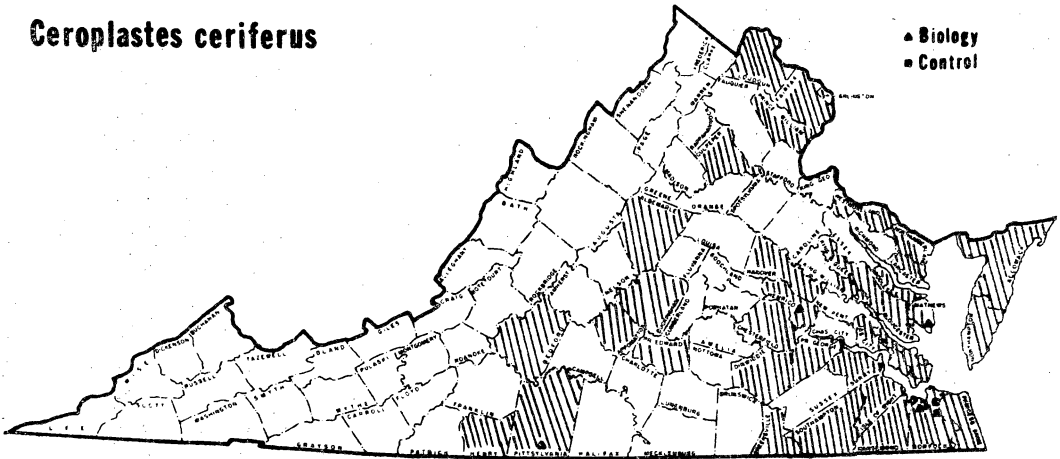
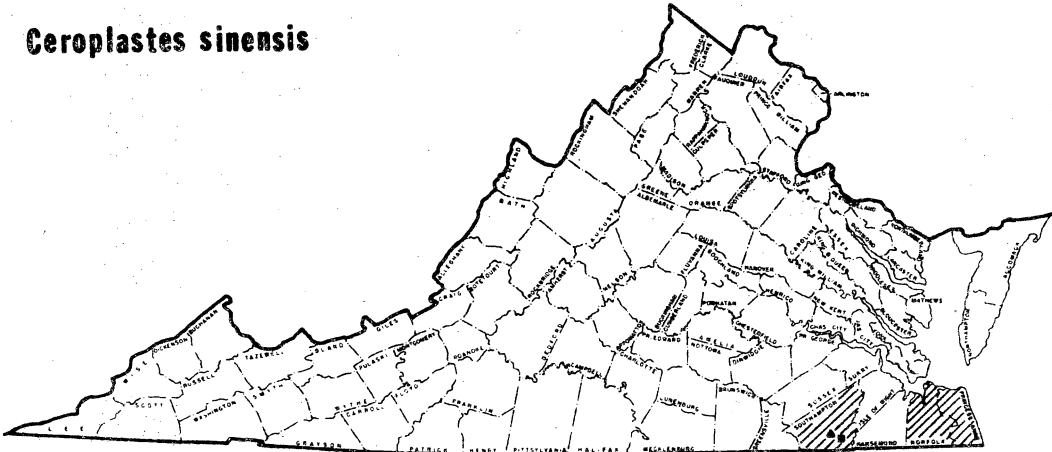
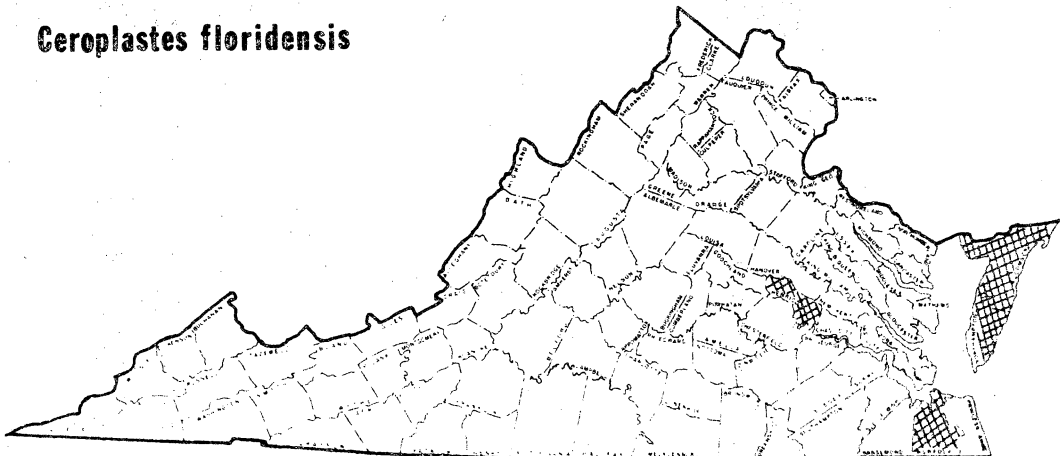
In recent years *Ceroplastes ceriferus*, the Japanese wax scale, has spread over 2/3 of Virginia. This scale insect pest of ornamentals and shade trees has been recorded from 40 counties east of the Blue Ridge Mountains (Map, page 39). The coastal plain inland to Richmond is the most severely infested area. Those remaining areas appear to have smaller isolated areas of infestation. The oldest record of occurrence in Virginia is from Norfolk in 1942. It is thought to have migrated northward along the coast and to have been brought in on nursery stock from the south. Its polyphagous habit and high reproductive capacity have apparently contributed to its spread at a very rapid pace through the commonwealth.

Ceroplastes sinensis, the Chinese wax scale, by comparison has a very limited distribution of only 3 counties in southeastern Virginia (Map). The earliest record of this species in Virginia is recorded in 1938 from Norfolk. Although records and reports were thoroughly checked no definite indication can be made as to the origin of the infestations. It is assumed that they also were initially introduced on nursery stock. These two species represent the only established populations of *Ceroplastes* in Virginia.

Ceroplastes floridensis, the Florida wax scale, has been recorded in 4 eastern counties of Virginia on nursery stock (*Ilex* sp.) brought

Ceroplastes ceriferus

• Biology
• Control

**Ceroplastes sinensis****Ceroplastes floridensis**

Distribution of Ceroplastes in Virginia.

in from the south. These records are few and spaced over a period of 29 years (Map). The first known record of the Florida wax scale occurred in Richmond in 1941. This species although very prolific is apparently unable to overwinter in Virginia.

Dispersal

The greatest factor aiding in the spread of scale insects is wind, Quayle (1911), Stabberg (1938), Jenkins *et al.* (1953), Hely (1960), Hulley (1962), Cilliers (1967).

Wax scale populations which were treated and controlled on ornamental plantings in Newport News during 1970 were found to be reinfested in 1971. The crawlers were evidently wind-blown from infested hollies 25-30 yards away as no adult females which could have produced the eggs were present on the plantings.

Two other possible means of infestation are also recognizable. Movement of the crawlers on the feet and feathers of birds and by the unknowing everyday person who breaks an infested twig from a shrub or tree and carelessly drops it on or near another host as he walks down the street.

Hosts

The host range of *Ceroplastes ceriferus* in Virginia encompasses 122 species of plants in 46 families. Extensive infestations are commonly found on: Burford holly, English holly, Chinese hollies (including dwarf varieties), Japanese holly varieties, flowering quince, pyracantha, barberry, boxwood, hemlock, hawthorne, magnolia, English

ivy, podocarpus, and occasionally on other hosts. Other ornamentals may be infested to various lesser degrees often depending on the proximity of populations on more preferred hosts.

In some locations, wax scales have developed to maturity on certain shade trees near infestations on ornamental shrubs. Nurseries have wax scale problems and therefore caution should be taken to prevent the spread of this scale through the purchase of uninfested plants. Just one or two scales overlooked on a plant can produce four to eight thousand scales the following spring.

Ceroplastes infestations were also recorded from several weeds; three annuals including lamb's quarters, horse-weed fleabane and sow thistle; four perennials, golden rod, aster, dogfennel, and cats-ear; and the biennial, evening primrose. These weeds were located near heavily infested ornamentals and were infested by crawlers falling from the infested plants.

Host List of *Ceroplastes ceriferus* (Fab.)

ACERACEAE

Acer palmatum (Thunb.)
Acer palmatum var. *atropurpureum* Van Houtte
Acer saccharinum L.
Acer saccharum Marsh.
Acer sp.

AGAVACEAE

Yucca aloifolia L.

ANACARDIACEAE

Rhus sp.

AQUIFOLACEAE

- Ilex aquifolium* L.
I. aquifolium var. *angustifolia*
I. cassine L.
I. cornuta Lindl.
I. cornuta var. *Burfordii* DeFrance
I. crenata Thunb.
I. crenata var. *compacta*
I. crenata var. *convexa* Makino
I. crenata var. *helleri* Bailey
I. crenata var. *hetzi*
I. crenata var. *microphylla* Maxim.
I. crenata var. *repandens*
I. crenata var. *rotundifolia* Hort.
I. crenata var. *willow leaf*
I. glabra Gray
I. integra Thunb.
I. koehneana Loes
I. latifolia Thunb.
I. opaca Ait.
I. opaca var. *east palatka*
I. pernyi Franch
I. rotunda Thunb.
I. vomitoria Ait.
I. vomitoria var. *nana*
I. vomitoria var. *fosteri*

ARALIACEAE

- Hedra helix* L.
Hedra sp.

BERBERIDACEAE

- Berberis julianae* Schneid.
Berberis thunbergi DC.
Berberis thunbergi var. *atropurpurea* Chenault
Berberis triacanthophora Fedde.

Mahonia bealei (Fort) Carr

BIGNONIACEAE

- Paulownia tomentosa* Steud.

BUXACEAE

- Buxus sempervirens* L.

BUXACEAE

Buxus sempervirens var. *suffruticosa* L.
Buxus sp.

CALYCANTHACEAE

Chionanthus sp.

CAPRIFOLIACEAE

Lonicera sp.

Viburnum sp.

CELASTRACEAE

Celastrus scandens L.

Euonymus alatus Sieb.
Euonymus alatus var. *compactus* Bailey
Euonymus americanus L.
Euonymus japonicus L.
Euonymus kiautschovicus Loes.
Euonymus microphyllus Sieb.
Euonymus patens Rehd.
Euonymus radicans Rehd.
Euonymus sieboldianus Hort.
Euonymus vegetus Rehd.

CHENOPODIACEAE

Chenopodium album L.

CISTACEAE

Halimicistus sahucii (Coste and Saulie) Janchen

COMPOSITAE

Artemesia abrotanum L.
Aster vimineus Lam.
Chrysanthmum spp.
Erigeron canadensis L.
Eupatorium capillifolium (Lam.)

Hypochoeris radicata (L.) Wallr

Salidago altissima L.

Santolina virens Mill.

Sonchus asper (L.) Hill

CORYLACEAE

Betula pendula Roth

CORNACEAE

Aucuba sp.

Cornus florida L.

CUPRESSACEAE

Thuja occidentalis var. *Douglasii pyramidalis* Spaeth.

EBENACEAE

Diospyros virginiana L.

ERICACEAE

Vaccinium sp.

GRAMINEAE

Cynodon dactylon Pers.

HYPERICACEAE

Hypericum patulum Thunb.

LAURACEAE

Lindera sp.

Persea borbonia (L.) Spreng.

LEGUMINOSAE

Cytisus scoparins (L.) Link

LYTHRACEAE

Lagerstroemia indica L.

MAGNOLIACEAE

Liriodendron tulipifera L.

Magnolia grandiflora L.

Magnolia soulangeana Soul.

MORACEAE

Morus sp.

MYRICACEAE

Myrica cerifera L.

MYRTAGEAE

Myrtus communis L.

NANDINACEAE

Nandina domestica Thunb.

OLEACEAE

Fosythia sp.

ONAGRACEAE

Oenothera biennis L.

PHILADELPHACEAE

Deutzia sp.

PINACEAE

Cedrus deodara Loud.

Pinus strobus L.

Tsuga canadensis (L.) Carr

PITTOSPORACEAE

Pittosporum sp.

PLATANACEAE

Platanus occidentalis (Tourn.) L.

PODOCARPACEAE

Podocarpus macrophylla D.
Podocarpus sp.

RANUNCULACEAE

Clematis sp.

ROSACEAE

Chaenomeles lagenaria (Loisel) Koidz.

Cotoneaster sp.

Crataegus sp.

Cydonia oblonga Mill.
Cydonia sp.

Malus pumila Mill.

Prunus laurocerasus var. *schipkaensis* Spaeth.
P. virginiana L.

Pyracantha coccinea Roem.
P. coccinea var. *lalandi*
P. crenata var. *serrata* (Hance) Rehd.
Pyracantha sp.

Rosa sp.

Spirea intermedia
S. japonica L.
S. japonica var. *snowmount*
Spirea sp.

RUBIACEAE

Gardenia jasminoides Ellis.

SALICACEAE

Populus nigra var. *italica* Muenchh.
P. tremuloides Michx.

Salix humilis Marsh.

SIMBAROUBACEAE

Ailanthus sp.

TAMARICACEAE

Tamarix gallica L.

THEACEAE

Camellia japonica L.

C. sasangua Thunb.

Cleyera japonica Thunb.

ULMACEAE

Ulmus sp.

Host List
of *Ceroplastes sinensis* DelGuercio

AQUIFOLIACEAE

Ilex aquifolium L.

I. cornuta var. *Burfordii*, DeFrance

I. crenata var. *microphylla*, Maxim.

I. crenata var. *rotundifolia*, Hort.

Ilex sp.

RUTACEAE

Citrus sp. L.

Host List
of *Ceroplastes floridensis* Comstock

AQUIFOLIACEAE

Ilex cornuta var. *Burfordii*, DeFrance

Ilex sp.

RUBIACEAE

Gardenia sp.

RUTACEAE

Citrus sp.

Effect of Scales on Plant

The wax scale population on some plant species reach tremendous proportions. In some instances the entire woody surface of the plant may appear to have a white wax covering. To date no plants have been observed to have been killed but growth is greatly reduced by wax scale infestation. This was also noted by Cilliers (1967) and Bedford (1968). Plants heavily infested tend to grow irregularly and look spindly. Sooty molds which develop on the honeydew excretions of the scales form dense mat-like growths on the leaves and stems. This mold growth probably reduces the amount of light received by the plant and this in conjunction with scale feeding causes the irregular, spindly, and reduced growth.

The two factors, scale feeding and sooty mold growth may possibly weaken the infested plant so as to allow the entrance of a plant pathogen.

Field observation has shown that dense compact shrubs usually have heavier infestation compared to shrubs which are open allowing penetration of wind, rain, and sunshine. This also helps to reduce the sooty mold growth as much of the honeydew is blown away as it is excreted or washed off by rains.

B. MORPHOLOGY AND DESCRIPTION

The identification of each nymphal instar is a must in the study of any insect. Without a thorough knowledge of the development it is almost impossible to make a positive identification. Wax scale species have a definite pattern in development and morphological characteristics which aid in their determination. One or both of these methods have been used by previous workers to study various scales and other insects.

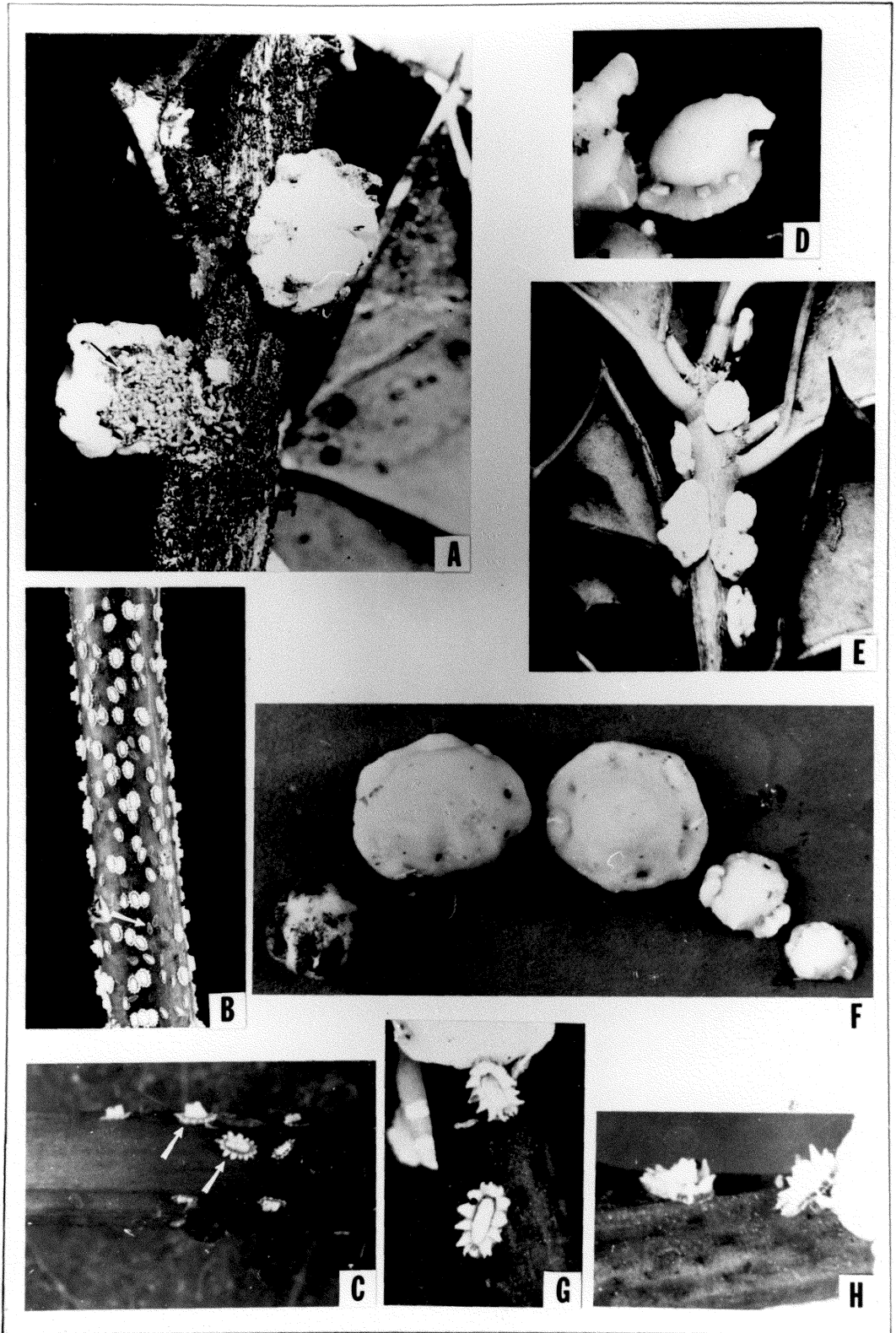
In this study the development of the wax secretions on the wax scales has been found to be distinctive enough that each instar of each species can be readily identified with the aid of only a hand lens. The wax patterns and illustrations described herein clearly demonstrate the development of the nymphal instars and the adults of the wax scales in Virginia. The color of the body is also given for each instar when it is described. Plates 1, 2, and 3 show illustrations of the wax formations which are described and Photoplates 1, 2, and 3 show pictures of the actual specimens. Each plate and photoplate is described by the legend on the opposite page.

A supplementary text which also clearly defines the development of the nymphal instars are the illustrations and descriptions of the microscopic morphological characters (plates 4-15). The change in these characters can be directly related to changes in the dorsal wax formation on each instar. Each of the characters found is clearly illustrated and described in the text along with its measurements in microns. Each plate has a central drawing for the whole specimen, the left half representing the dorsal surface and the right half the

PHOTOPLATE 1

Ceroplastes ceriferus (Fabricius) Photos A-H

- Photo A: Adult female with eggs. (7X)
Photo B: Crawlers (arrow) and first instar nymphs. (5X)
Photo C: Second instar nymphs "cameo state."
(Indicated by arrows 9X)
Photo D: Third instar nymph, "dunce cap stage." (12X)
Photo E: Adults on *Ilex cornuta*. (6X)
Photo F: Adults showing range in size due to population
densities. Black coloration on adult to
extreme left is sooty mold. (6X)
Photo G: Male cover dorsal view. (17X)
Photo H: Male cover side view. (17X)

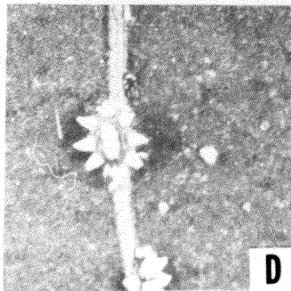
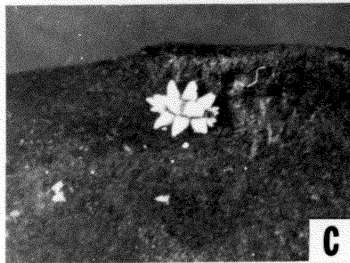
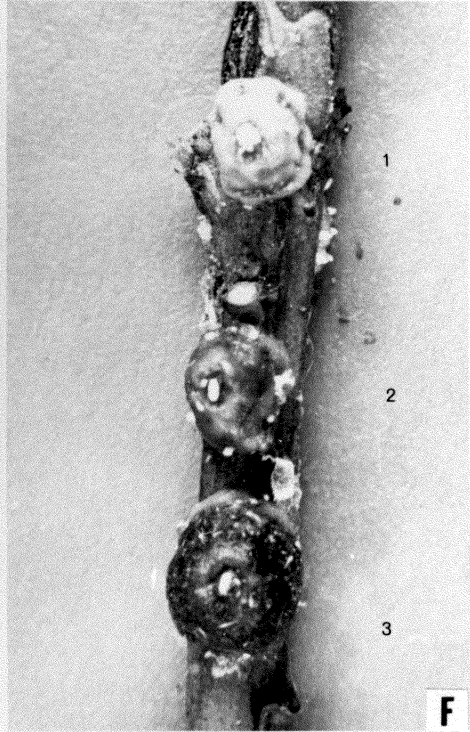
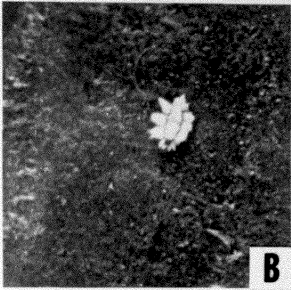
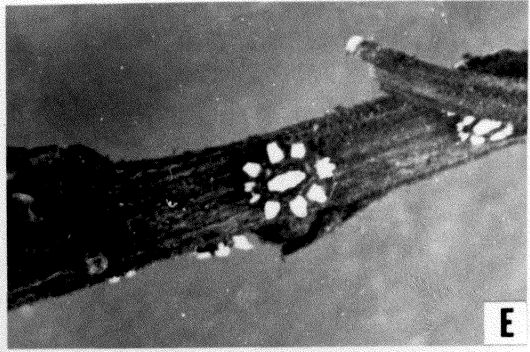
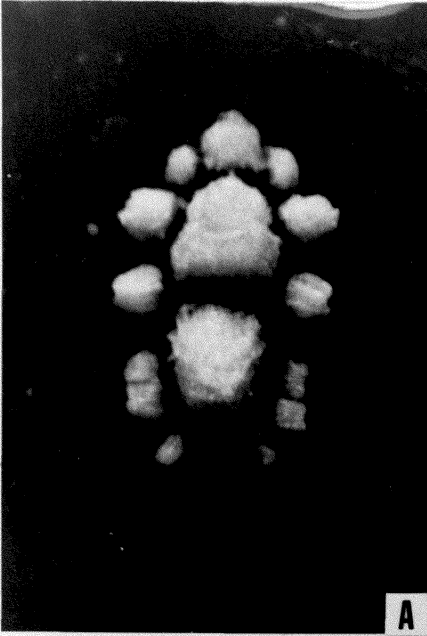


Photoplate 1

PHOTOPLATE 2

Ceroplastes sinensis Del Guercio, Photos A-F

- Photo A: Early first instar nymph. (85X)
- Photo B: Late first instar nymph. (12X)
- Photo C: Second instar nymph. (13X)
- Photo D: Early third instar nymph. (9X)
- Photo E: Late third instar nymph. (8X)
- Photo F: Adults: 1-young female, 2-egg-laying female, 3-old dead female.
- Photo G: *Anicetus toumeyellae* Milliron, parasite of adult *C. sinensis*. (8X)

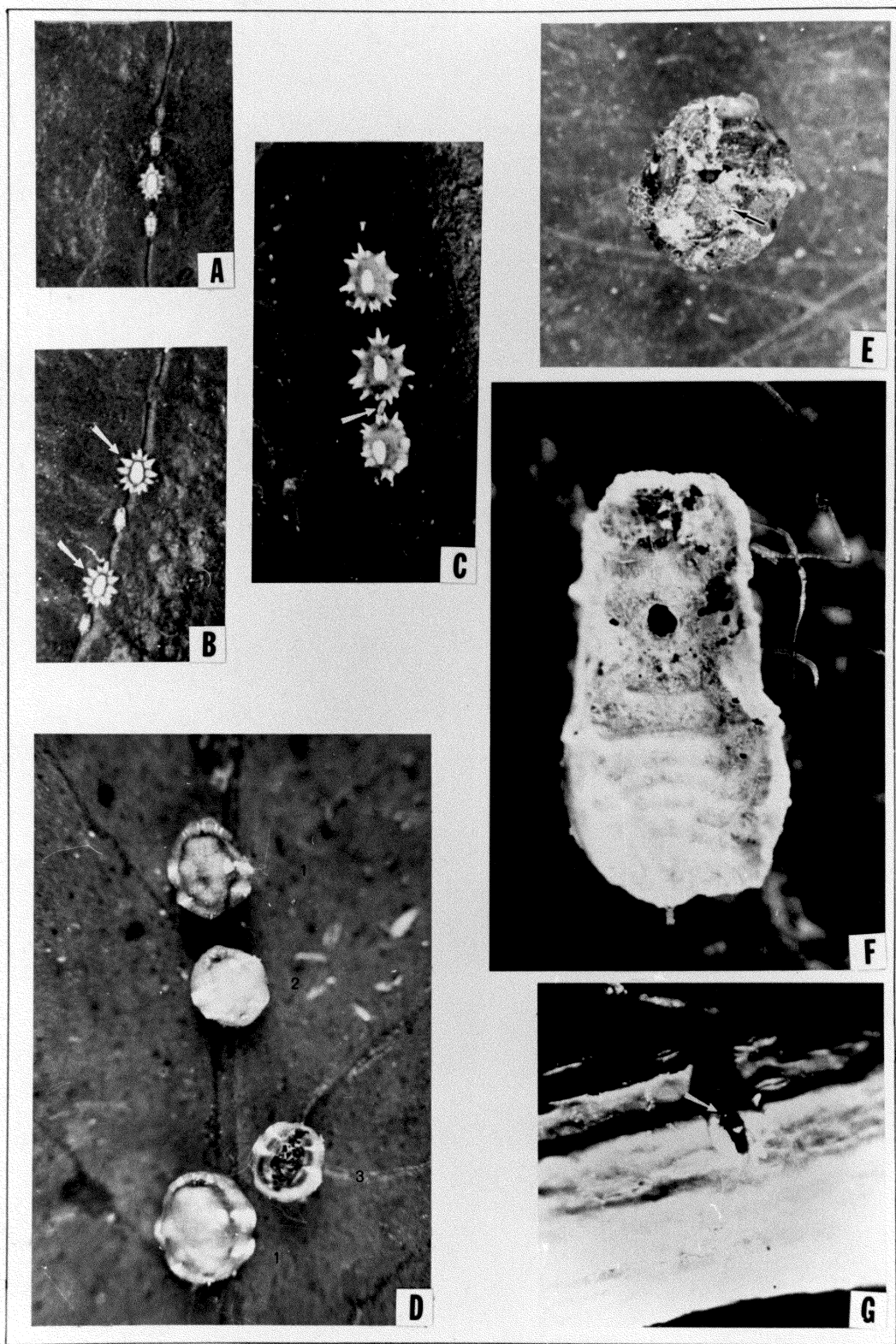


Photoplate 2

PHOTOPLATE 3

Ceroplastes floridensis Comstock, Photos A-D

- Photo A: Stages in development of first instar nymph. (9X)
Photo B: Second instar nymphs. (Indicated by arrow) (10X)
Photo C: Third instar nymphs-arrow indicating shed skin of second instar. (12X)
Photo D: Adults: 1-old dead adult female, 2-young females, 3-females with hatching crawlers. (15)
Photo E: Ventrum of adult female *C. sinensis* showing wax plate which encloses the eggs under female. (10X)
Photo F: Ventral wax plate removed from *C. ceriferus*, holes in plate indicate location of mouth parts and legs. Photo D-3 shows a partial wax plate on female *C. floridensis*. (15X)
Photo G: *Coccophagus fratermus* Howard, emerging from third instar nymph of *C. floridensis*.



Photoplate 3

ventral surface. It should be noted that the dermal structures within the outline are enlarged to show their approximate distribution, and attention is drawn to the fact that this larger scale may show some inconsistencies in the relative size of the structure as the drawings are not made to the same scale or proportioned with each other. Measurements within the text should be consulted when such questions arise. The egg stage of each species was measured to check for variations which might aid in identification. The measurements in Table 2 show the egg size to be very similar and of no taxonomic value.

The morphological terminology used was adapted from Steinweiden (1929) and Kawai and Tamaki (1967). Two new terms used in the text include monolocular ring pore and bilocular barred pore. The monolocular ring pore is circular with a thickened sclerotized rim and a small central opening (Plate 4, fig. g). The bilocular barred pore is ovoid to oblong with 2 lateral openings separated by an ovoid bar slightly constricted at the middle (Plate 4, fig. i).

To conserve space in the descriptions, the material studied section has been abbreviated. Instead of writing out 6 slide 12 specimens, it is written 6(12). Also all towns, cities, and counties named unless otherwise stated are Virginia localities.

It is noted that previous authors have measured each instar with its wax development at its initial secretion of wax and at that point just prior to or at the following moults. Reading of these variations in measurement and observation of the gross variation in development within different population densities, the author has measured only

Table 2. Egg Measurements for *Ceroplastes ceriferus* of Virginia.

Ceroplastes:

Location	<i>ceriferus</i>		<i>sinensis</i>		<i>floridensis</i>	
	Average lng/wth	Range	Average lng/wth	Range	Average lng/wth	Range
Richmond	295x114	280x100-320x130			265x132	240x140-280x140
Portsmouth	304x124	280x120-340x130				
Danville	288x136	240x100-340x140				
Kilmarnock	307x115	290x100-340x130				
Norfolk	305x124	280x130-340x130				
Newport News	305x124	285x130-340x130				
Franklin			313x142	270x140-340x160		

the variation in size which occurred between the egg laying adults of each species. Measurements of the various instars are given in the taxonomy section.

First Instar Nymphs

The term "crawler" applies to that stage in the life history of any scale insect where the young nymph is moving about searching for a place to settle. Crawler (Plate 1, fig. A, D, G) is used to denote the period between eclosion and the time the nymph settles and begins feeding. First instar nymph denotes the crawler plus the period between settling, wax development, and the first molt (Plate 1, fig. C, F, I).

Wax Development

Each species has some physical characteristics which distinguishes it from the other species in this study. The development of wax on the body begins two to three days after settling. Initial secretions begin on the dorsal medial area of the thorax and abdomen. The first marginal secretions are the medial cephalic and the caudal wax rays. Wax rays refer to those individual or combined wax secretions which develop on the margins of the scales. Subsequently, the remaining marginal secretions appear. Two and sometimes four white hairlike projections (anal ring setae) may be evident protruding from between the anal plates (Plate 1-B, C, E, F, H, I).

First Instar Nymphs

The first instar nymph of *C. ceriferus* upon settling is reddish pink in color (5R: 4/10, 4/12). The ocelli are black in contrast to

EXPLANATION OF PLATE 1.*Ceroplastes ceriferus*

- A. Crawler
- B. Initial wax secretions
- C. Late first instar

Ceroplastes sinensis

- D. Crawler
- E. Initial wax secretions
- F. Late first instar

Ceroplastes floridensis

- G. Crawler
- H. Initial wax secretions
- I. Late first instar

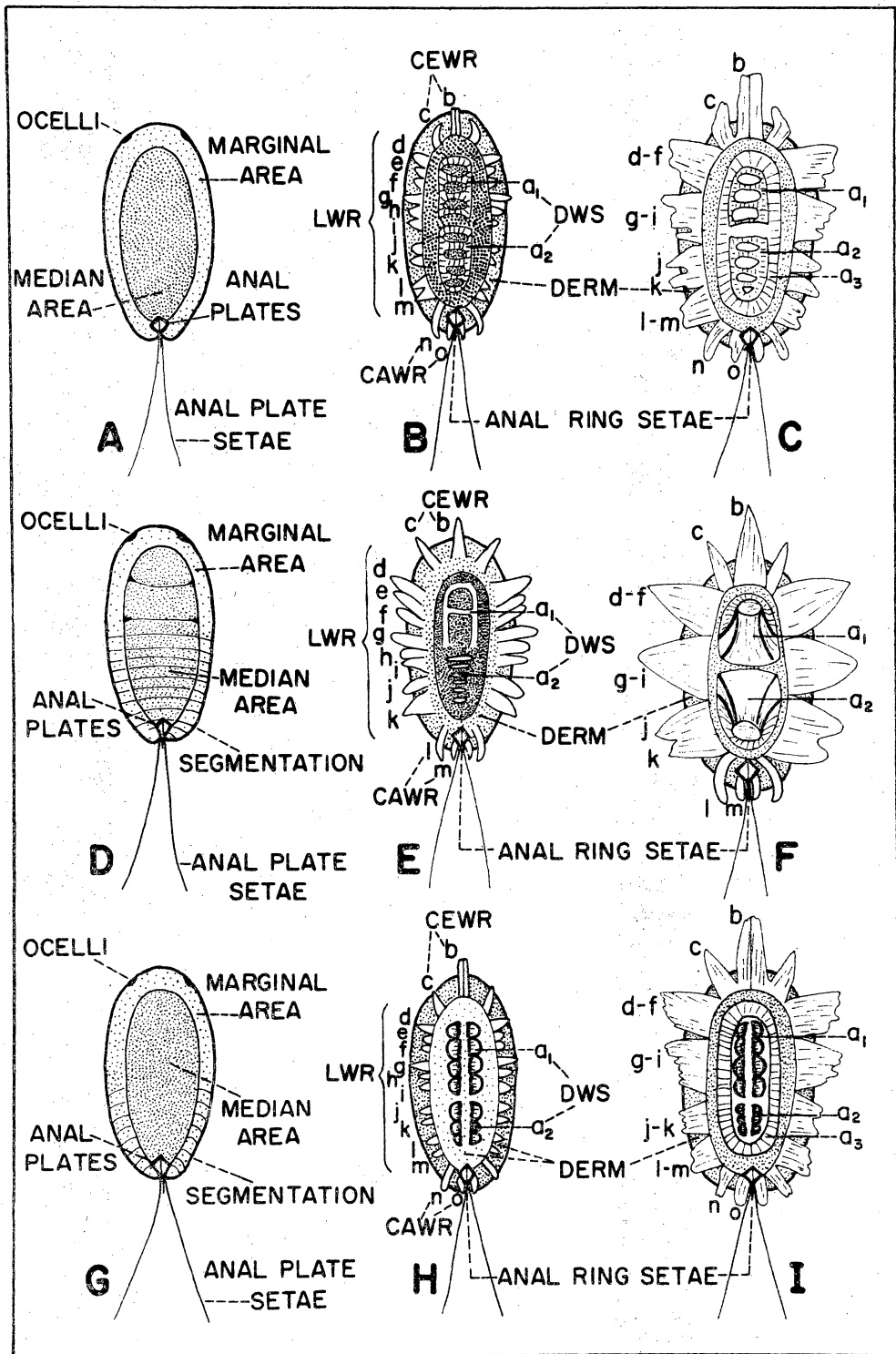


Plate I. - First instar nymph wax development.
 DWS - dorsal wax secretion; CEWR - cephalic wax rays; LWR - lateral wax rays; CAWR - caudal wax rays

the body color and the two long anal plate setae are distinct. (Plate 1-A.) The body is ovoid, with a raised median area and no visible body segmentation. The anal plates are distinct and lie flat against the body. Legs and antennae are folded beneath the body.

Two to three days after settling and feeding wax development begins (Plate 1, fig. B). Three rectangular wax outlines develop on the thorax and four on the abdomen of each specimen (Plate 1-B, DWS). Occasionally there are three on each area. Two distinct, medial cephalic, marginal wax rays and two small caudal wax rays, develop near the caudolateral margins of the anal plates, are the first marginal wax secretions. (Plate 1-B, CEWP-b, CAWR.)

Shortly after, eleven additional wax rays develop, 1 lateral cephalic and 10 laterally on each margin between the anal plates and the cephalic wax rays (Plate 1-B, c-m). This development of 28 wax rays in the early first instar develops into 15 distinct wax rays by the late first instar (Plate I-C). The rays are arranged as described: cephalically, 1 straight blunt medial cephalic ray, 2 lateral curved cephalic rays pointed at the vertex; 8 lateral rays (1 large, broad ray over each spiracular area (4), and two wide rays on each margin of the abdomen), and 4 caudal rays (2 curved blunt, 2 broad, rounded) on each specimen. Dorsally additional wax has been secreted and the rectangular wax outlines are raised on a solid formation. It is slightly ovoid and is inclined forward, (Photoplate 1-B).

Ceroplastes sinensis first instar nymphs are darker red in color (7.5R: 4/8-10R: 4.8). The ocelli are black but not as contrasting

as in *C. ceriferus*. The anal plates and anal plate setae are the same. The body is also ovoid, with a raised medial area and distinct segmentation on the abdomen and thorax. The legs and antennae are in the same position as in *C. ceriferus*, (Plate 1-D).

Wax secretions begin in the same locations but in different formations. Dorsally on the thorax 2 rectangular wax outlines develop the second open posteriorly. On the abdomen 5 or 6 transverse bands of wax are developed. (Plate 1-E-a₁ a₂.) Cephalic marginal wax development is similar except for 1 median cephalic ray and two larger wax rays on each margin of the abdomen instead of four small ones so that 23 rays are developed instead of 28.

In the late first instar the rays are reduced to 13 and are arranged as described: cephalically, 1 large conical medial ray, 2 smaller conical lateral rays; 6 lateral rays (1 broad, bifurcate ray on each abdominal margin); 4 caudal rays (2 curved pointed, 2 bladelike pointed), on each specimen (Plate 1-F). Dorsally the wax secretions have separated. On the thorax the wax secretions have formed a conical wax process directed anteriorly and those on the abdomen have formed a similar process directed posteriorly (Plate 1-F a₁-a₂).

C. floridensis first instar nymphs vary in color, some lighter and some darker specimens, (5R: 4/10-10R: 6/8). The ocelli are black and contrasted with the body colors. The general description is the same as the other first nymphal instars with segmentation observable only marginally (Plate 1-G).

Wax secretions begin in the same areas but are again different in

formation. Dorsally the wax develops in four distinct quadrants, 2 on both the abdomen and the thorax. They are distinct and separate forming a cross on the dorsal surface (Plate 1-H, DWS). Caudal and cephalic wax development are similar to *C. ceriferus*, except the lateral cephalic rays are conical (Plate 1-H-c). In the late first instar the rays are reduced to 15 and are arranged as described: cephalically, 1 straight blunt medial ray, 2 conical lateral rays, occasionally bifurcate; 8 lateral rays (1 broad irregular shaped ray over each spiracular area (4), 2 straight irregular rays on each abdominal margin) and 4 caudal rays (2 curved blunt, 2 bladelike) on each specimen (Plate 1-I). Dorsally a solid, ovoid wax formation develops with the initial wax formation above (Plate 1-I a₂).

In the first instars very little dermal area is observable except a narrow band between the dorsal and the marginal wax formation and the narrow areas between the marginal rays. In all species the anal plates are clearly observable.

Second Instar Nymphs

The early second instars are exactly the same as the late first instars with the exception of the long anal plate setae. Observable differences are not noted until 3 to 5 days after moulting. In all species a distinct line is formed between the wax secreted by the first instar and the new secretions of the second instar (Plate 2-WB). The anal plates are distinctly visible. The antenna and legs are as in the first instar, folded under the ovoid body and the ocelli are

indistinct in most cases due to wax formation but when observable are black in color.

Ceroplastes ceriferus body color is a reddish pink (5R: 5/8-5/10). The wax rays secreted by the second instar appear heavier or thicker and are wider than that secreted by the first instar (Plate 2-A). The same number of rays are present but the lateral rays are now conical. The lateral cephalic rays are still curved and the median ray remained blunt. The caudal rays are unchanged except in size. More dermal area is also exposed between the dorsal and marginal secretions. This second instar, because of the wax formation and visible contrasting derm, is termed the "cameo" instar.

Ceroplastes sinensis, second nymphal instar, is very similar to the first instar with the exception that the lateral and medial cephalic rays have fused along half their length so that the cephalic rays appear as a small crown (Plate 2-D). The remainder of the wax formations are larger; each ray and the median formation having a distinct border indicating the development of the second instar. In comparison to *C. ceriferus* and *C. floridensis* very little of the dermal area is visible. Ventrally the body color is dark red (5R: 3/4). The wax as in *C. ceriferus*, appears heavier and thicker and the lateral rays are wider.

Ceroplastes floridensis is almost identical to *C. ceriferus* (Plate 2-F). The wax rays are conical except the median cephalic and the 4 caudal rays. Dorsally the wax formation has become more oblong and appears in most specimens to be slightly wider at the posterior

EXPLANATION OF PLATE 2.*Ceroplastes ceriferus*

- A. Second instar
- B. Third instar dorsal view
- C. Third instar lateral view

Ceroplastes sinensis

- D. Second instar
- E. Third instar

Ceroplastes floridensis

- F. Second instar
- G. Third instar

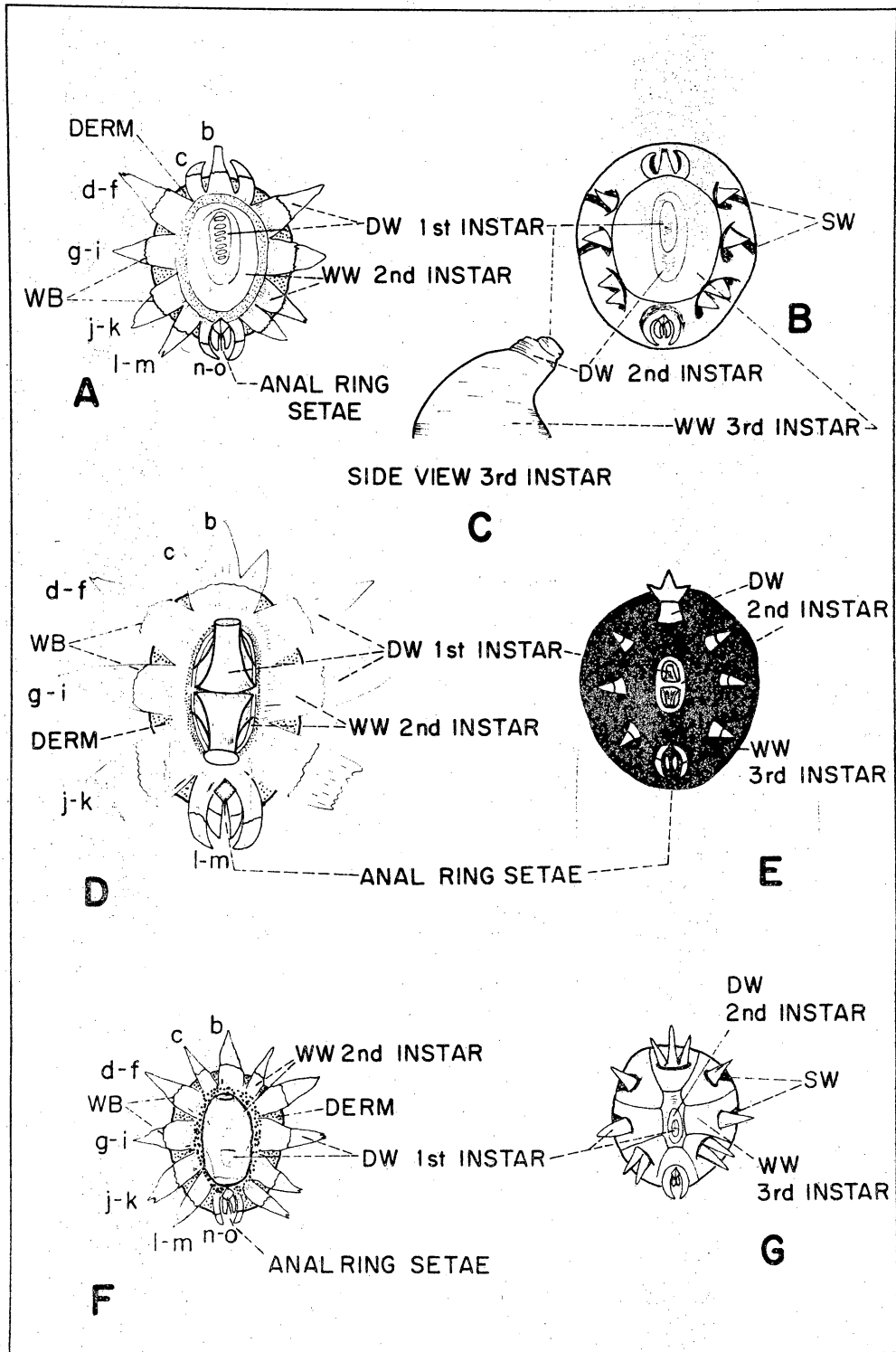


Plate 2.- Second and third instar nymph wax development.
 DW - dry wax ; WW - wet wax ; SW - spiracular wax ;
 WB - wax border

end, tapering anteriorly. The cross formation of wax is usually visible dorsally above the wax secreted by the second instar. The dermal area observable is much larger here than in any of the other species at this stage.

Third Instar Nymphs

The early third instars resemble the late second instars until 3 to 5 days after moulting. At this time because of the development of numerous dorsal pores the secretion of wax is extensive and the entire dorsal surface becomes covered with wax giving the instar a circular appearance (Plate 2-B-E-G). In *C. floridensis* and *C. sinensis* the scales become slightly convex. In both species, the wax covering appears in plates with lines of demarcation observable on *C. sinensis* only under the microscope due to wax coloration (Plate 2-G). *Ceroplastes ceriferus* produces a conical wax prominence dorsally, slanted forward, with an expanded marginal rim. This formation provides the term "dunce cap" stage for the third instar. The anal plates as well as each wax ray on each species appear to be protruding from a shallow depression in the wax covering. The appearance of two white powdery bands of wax on each lateral margin of the thorax also becomes evident below each conical ray covering the spiracular areas (Plate 2-SW). The rays appear very small, as wax secretions increase the wax rays are gradually encased in the main body of wax.

Ceroplastes ceriferus retains all the wax rays as previously described (Plate 2-B). In some cases, depending on the amount of wax secreted, the rays of the second instar may be completely covered and

only sections of the wax rays secreted by the first instar are visible. The dorsal conical formation is slanted forward and bears the wax secretions of the first and part of the second instar dorsal formations (Plate 2-C). The wax initially is somewhat opaque in color but becomes white with age. The ventral body color is pinkish red (7.5R: 5/10).

Ceroplastes sinensis retains all the wax rays marginally and dorsally as previously described (Plate 2-E). The dorsal formation appears sculptured marginally and conforms with the plating design on the body. The wax coloration on the third instar is a yellowish-red (5YR: 3/4). The derm is dark red (2.5R: 3/4). This coloration makes the wax appear to be continuous and not plated.

Ceroplastes floridensis early third instar nymph closely resembles the second instar. It also has evidence of plating in the wax and a sculptured margin on the dorsal wax formation. Marginal ray formation remains unchanged from the second instar. The wax coloration of the third instar is reddish purple (10RP: 7/4) and the dermal color is pinkish red (5R: 6/8) (Plate 2-G).

Adult Females

The wax formation developed during the earlier stages are used as structures of support and formation of the wax in the adults. In all specimens the young adults are identical to their late third instars. The specimens on maturing become convex and are circular to ovate. The white, dry waxy powder from the spiracular furrows are present as in the third instars.

Ceroplastes ceriferus is a large species varying in size from 4.5 to 7 mm long and 4.5 to 9 mm wide. The wax secretions of the adult completely encompasses the cephalic and marginal wax rays. The caudal rays are usually evident but sometimes even the anal plates are not visible. The wax formation is massive and usually has a small rounded margin expanded laterally over the spiracular area (Plate 3-C). Dorsally the wax is smooth and glossy white, terminating in a small peak which overhangs the cephalic region (Plate 3-C, DOWC). scale is alive, the wax is very wet and sticky.

The ventral dermal color is reddish-orange (7.5R:5/12). It was observed that scales which produce large quantities of wax and were on the underside of stems or on the sides of stems will drip wax like a burning candle. This is not true of all *C. ceriferus* but of those which it is believed have an abundant food source. The wax of an old female is usually a grayish yellow and usually dries after the female dies. After oviposition begins the dorsal dermal surface begins to sclerotize and upon the completion of oviposition the ventral surface sclerotizes.

Ceroplastes sinensis develops ovoid or circular and measures 2.5 to 6 mm long and 2.5 to 4 mm wide (Plate 3-D). The wax of this species is not sticky and has a dried appearance. The wax formation is smooth and consistent on the surface of the female. In young adults wax plates are evident but after oviposition are not observable due to the extreme swelling of the female. Marginally the wax is yellowish-gray (5Y: 8/2-8/4) and dorsally it is gray (5Y: 7/1) with a grayish-green coloration (5Y: 5/2) around the base of each wax ray, both dorsally

EXPLANATION OF PLATE 3

- | | |
|--------------------------------|----------------------------|
| <i>Ceroplastes ceriferus</i> | A. Male cover dorsal view |
| | B. Male cover lateral view |
| | C. Adult female |
| <i>Ceroplastes sinensis</i> | D. Adult female |
| <i>Ceroplastes floridensis</i> | E. Adult female |

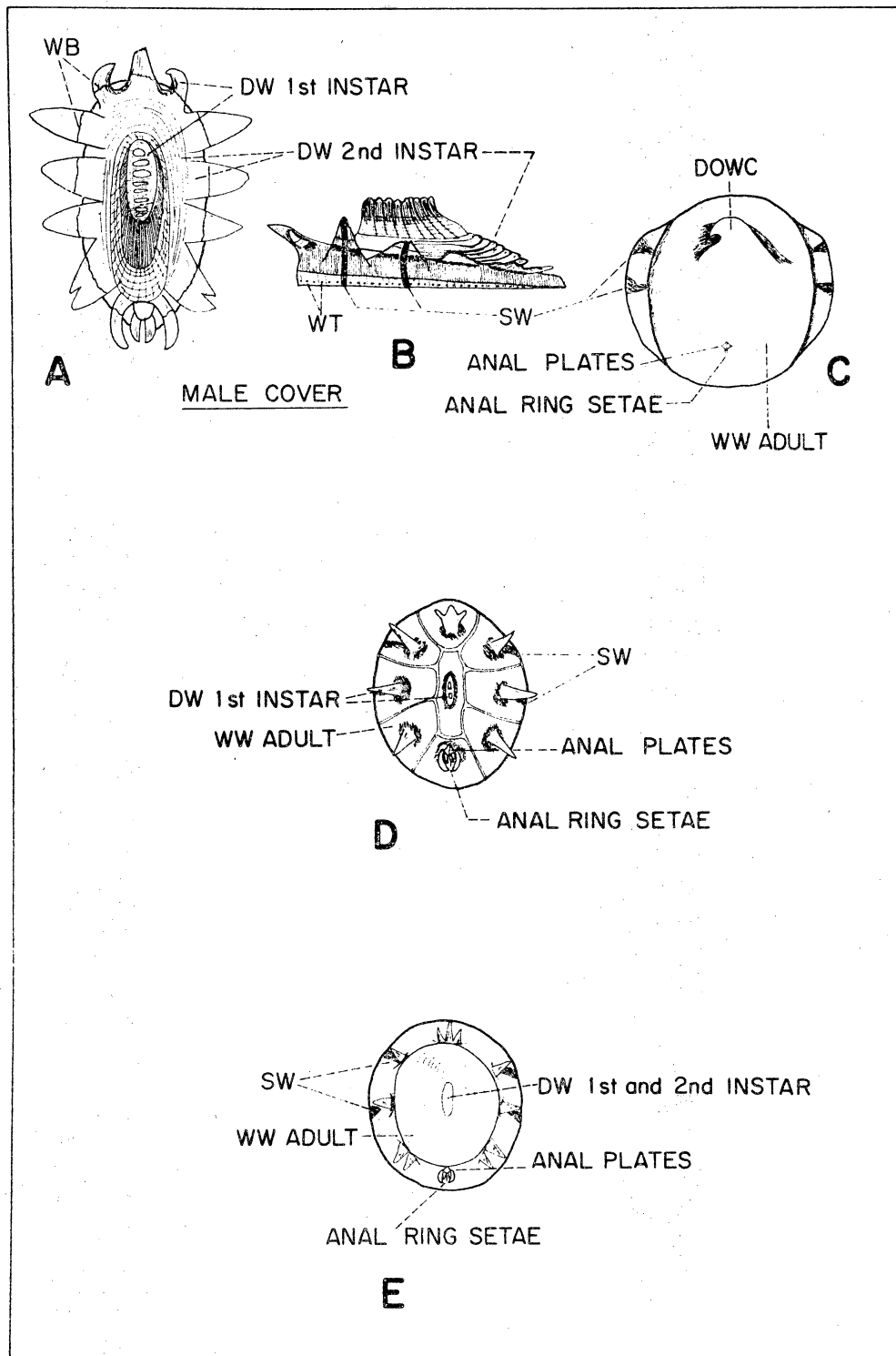


Plate 3. - Adult wax development. WT - wax tufts; DOWC - dorsal wax cap; SW - spiracular wax; DW - dry wax; WW - wet wax; WB - wax border

and marginally. The ventral dermal color is a dark pinkish-red (2.5R: 5/8). After oviposition the dorsal wax is a very dark yellowish-red (5YR: 3/1) and like *C. ceriferus* the derms are heavily sclerotized. All wax rays are white, marginally and dorsally. *Ceroplastes floridensis* is subcircular to circular and the wax is white and sticky (Plate 3-E). The median area of the scale is convexed and a narrow to moderately wide wax margin exists completely around the scale. Adult females measure 1.5 to 2.75 mm long and 1.25 to 2.25 mm wide. All wax rays found in the third instar are visible in the adult. Dorsally the wax on the adult is smooth in conformation to the body of the scale. Occasionally, there is a small ovoid patch of wax from a previous instar medially. Ventrally the dermal color is a deep red (5R: 3/6). After oviposition, the wax cover of the old sclerotized female becomes a translucent yellow-orange (5 YR: 7/8).

Adult Males

No male *Ceroplastes* were found in field populations in the United States in this or any previous study. Male *Ceroplastes ceriferus* were found in small populations in greenhouse colonies by Gimpel in Maryland and by the author in Virginia. Illustrations of the wax cover are shown in (Plate 3-A-B). No attempts were made in this paper to illustrate the male development. Smith *et al.* (1971) stated, "Occasional males found with females in the cameo stage in 1967 and 1969 were white and slightly more elongate than the females." As no specimens, photographs, or illustrations were recorded, it is impossible for the author to verify this note. It was assumed that as in previous studies where males were found, differentiation was not possible in

the first and early second instars. In the late second instar the wax covering was elevated apically and sloped gradually to the posterior margin. This, in conjunction with the wax ray formations pointing upward, gave the male the appearance of a small boat. The wax cover measured approximately 1.33 mm long, 0.75 mm wide and 0.50 mm high. The marginal wax rays were pointed upwards compared to lateral in the female but are in the same configuration as described for the female. The elevated cephalic and lateral sides of the wax cover were divided into a lower translucent section with a series of wax tufts and an upper opac section. This wax formation was assumed to be produced by the tubular ducts which extend through the body wall and were easily observed in the second instars collected.

The spiracular wax is readily observable rising vertically on the lateral margins extending to the tips of the wax rays above the spiracular areas (Plate 3-B, SW). The development of the male wax through the second instar is evidenced by the formation of the wax border in the marginal rays. Dorsally the dry wax of the first instar rests atop the ovate wax layers which were shifted anteriorly producing a perpendicular wax wall anteriorly and a series of step-like wax layers posteriorly. The anal plates usually visible during development were no longer observed at the propupal stage and a small translucent wax cover was observed where the anal plates normally were found. Ventrally, there is a translucent wax layer which supports the male instars during development. This layer is similar to that secreted by the female prior to oviposition.

All attempts to rear the male have failed. Development reaches the adult stage but the males die prior to emergence from the wax covering. In all correspondence and literature cited with the exception of Sankaran (1959) male populations represent a small fraction of the progeny and were assumed to be non-functional reproductively.

Key to the Different Instars of *Ceroplastes* of Virginia.

1. Elongate apical setae extending from each anal plate;
 - 3 short, rounded, bullet-shaped spiracular setae terminating each anterior and posterior spiracular furrow.....First Instar
 - No elongate apical setae extending from anal plates;
 - 3 or more spiracular setae terminating each anterior and posterior spiracular furrow, these not short, rounded, or bullet shaped.....2
2. Two stout conical setae on each anal lobe; 2 pairs of stout conical setae on fringe of anal fold;
 - 3 elongate conical spiracular setae in each group.....Second Instar
 - Three to 5 stout conical setae on each anal lobe;
 - 3 pairs of stout conical setae on fringe of anal fold; more than 3 stout spiracular setae in each group.....3
3. Eight to 16 spiracular setae; anal lobes with

3 stout conical setae; no multilocular pores
 near vulva; tubular ducts absent; derm around
 anal plates membranous; anal ring with 3
 pairs of setae.....Third Instar

More than 16 spiracular setae; anal lobes usually
 with 4 to 6 stout conical setae, rarely with
 3; multilocular pores concentrated near vulva;
 tubular ducts present; derm around anal plates
 sclerotized; anal ring with 4 pairs of setae.....Adults

Key to First Instar Nymphs

1. Anal plates reticulated; 28 thickened marginal
 setae.....*sinensis*, p. 111
- Anal plates not reticulated; 26 hairlike marginal
 setae.....2
2. Median pair of cephalic marginal setae longer,
 10.9 long, than other marginal setae,
 7.30 long.....*floridensis*, p. 132
- Median pair of cephalic marginal setae equal
 to other marginal setae.....*ceriferus*, p. 88

Key to Second Instar Nymphs

1. Twenty-eight marginal hairlike setae; ventral
 segmentation distinct; anal plates with
 3 or 4 sclerotized bars.....*sinensis*, p. 116

- Twenty-six marginal hairlike setae; ventral
segmentation indistinct; anal plates without
sclerotized bars.....2
2. Dorsal surface with 3 longitudinal rows of discordal
pores (Plate 6, fig. e).....*ceriferus*, p. 93
- Dorsal surface without longitudinal rows of
discordal pores.....*floridensis*, p. 137

Key to Third Instar Nymphs

1. Marginal setae numerous, 60 to 68.....*floridensis*, p. 141
- Marginal setae few, 26 to 28.....2
2. Twenty-six marginal setae; triangular tri-
locular pores (Plate 7, fig. h)
scattered on dorsum; median cephalic
membraneous area with 1 pair of blunt
setae (fig. c); marginal row of fila-
mentous ducts on dorsum (fig. i).....*ceriferus*, p. 98
- Twenty-eight marginal setae; oval trilocular
pores (Plate 8, fig. j) scattered on
dorsum; median cephalic membraneous
area without setae; no filamentous ducts
on dorsum, marginal longitudinal row of
filamentous ducts (fig. s) on venter.....*sinensis*, p. 126

Key to Adult Females

1. Marginal setae numerous, 140 (135-145); tubular ducts with an everted, expanded inner filament (Plate 12, fig. s) arranged in a noncontinuous submarginal band.....*floridensis*, p. 125
- Marginal setae few, 28 (26-30); tubular ducts not as above (Plate 4, fig. t; Plate 8, fig. t).....2
2. Filamentous ducts in a marginal row on dorsal and ventral surfaces; anal plates elevated above derm on a conical sclerotized dermal shield; 11 clear membraneous submedian areas on dorsum, none medially; ventral submarginal setae uniform in size (Plate 4, fig. u).....*ceriferus*, p. 78
- Filamentous ducts in a marginal row on venter only; anal plates recessed on derm; not elevated on sclerotized dermal shield; 7 clear membraneous submedian areas on dorsum, 1 medially; ventral submarginal setae in 2 sizes (Plate 8, figs. u and v)....*sinensis*, p. 114

Ceroplastes ceriferus (Fabricius), 1798

Adult female

Japanese Wax Scale

Plate 4; Photoplate 1-A,E,F.

Coccus ceriferus Fabricius, 1798:546; 1809:311; *C. chilensis* Gray, 1828:7; *C. (Ceroplastes) chilensis* (Gray), White, 1846:333; *Ceroplastes australiae* Walker, 1852:1087; *Columnea cerifera* (Fab.), Targioni-Tozzetti, 1866:144; *Lacca alba* Signoret, 1869:848; *Ceroplastes ceriferus* (Fab.), Signoret, 1869:848; 1872:40; Blanchard, 1883:26; Hubbard, 1885-57; Atkinson, 1889:189; Cotes, 1889:91; Maskell, 1892:216; Newstead, 1894:21; 1910:66, 195; Cockerell, 1895:7; 1899:90; Fawcett, 1895:7; Craw, 1896:44; Green 1899:190; 1900:8, 1921:259; 1935:180; Froggatt, 1897:2; 1902:919; Howard, 1897:39; Kuwana, 1902:62; 1923:43; Fernald, 1903:149; Carnes 1907:182; Green and Mann, 1907:340; Berger, 1917:72; Ramakrishna, 1919:29; 1930:73; Morrison, 1920:188; Merrill and Chaffin, 1923:85,254; Steinweden 1929:231; Zeck, 1932:611; Gardner, 1934:30; Cheo, 1935:95; Herrick, 1935:174; Garney, 1936:453; Martorell, 1945:395; Merrill, 1953:85; Brimblecombe, 1956:1; 1962:224; Borchsenius, 1957:457; Das and Ganguli, 1961:247; Anonymous, 1965:2; Morrison and Morrison, 1966:206; Annecke, 1967:120; Ali, 1968:120; Tamaki, 1970:6; De Lotto, 1971:133; Pollet *et al.*, 1971:100; Smith *et al.*, 1971:889; Weidhaas, 1971:3. *C. chilensis* (Gray), Signoret, 1972:44; Cockerell, 1899:191; Green, 1899:191. *C. australiae* Walker, Signoret, 1872:45; Green, 1899:191. *C. cerifer* (Anderson), Lindinger, 1907:4. *C. pseudoceriferus* Green, Kawai and Tamaki, 1967:133. *Gascardia cerifera*

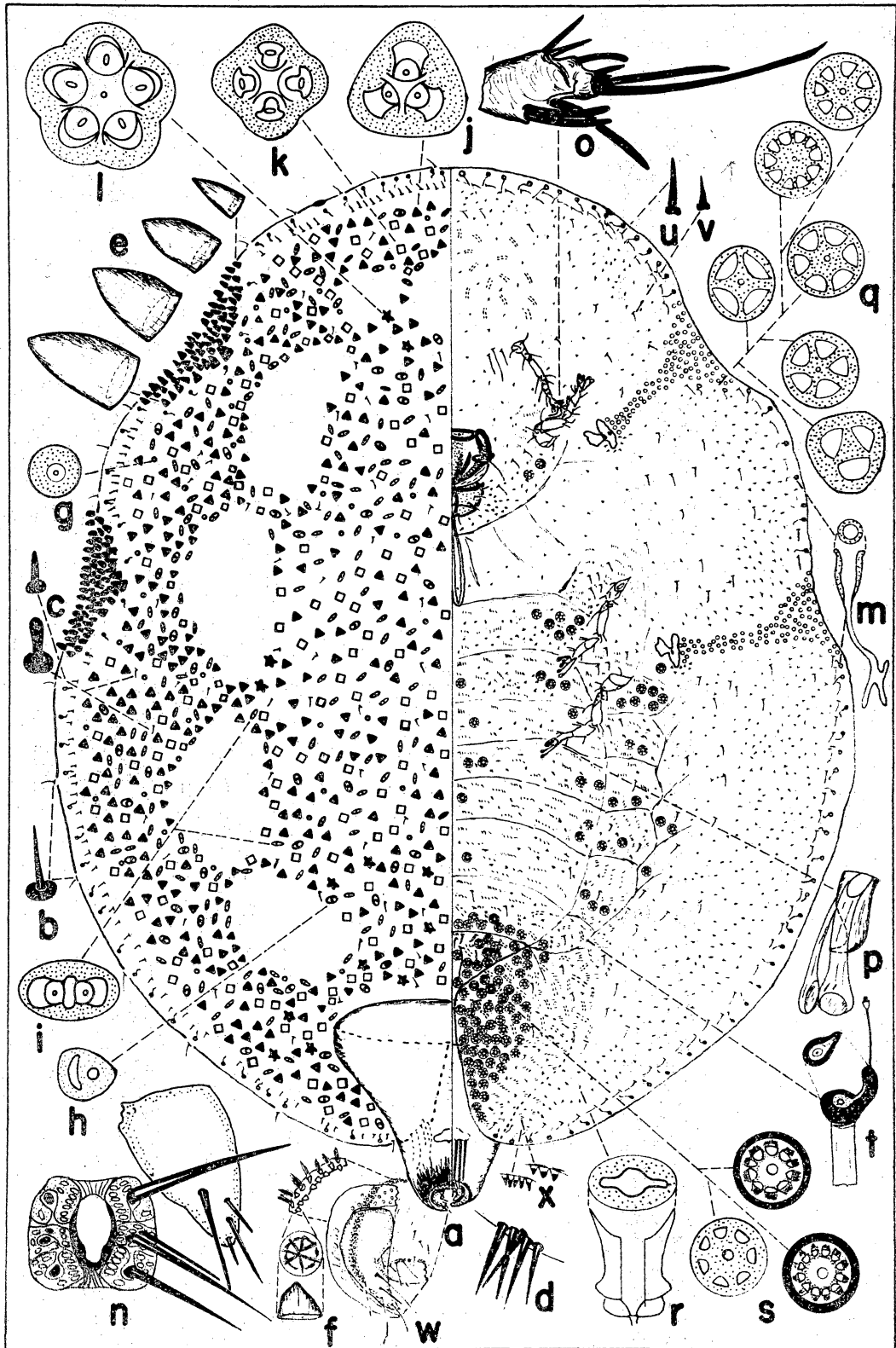


Plate 4.- *Ceroplastes ceriferus* (Fabricius), adult female

(Anderson), De Lotto, 1965:198.

DESCRIPTION: Body (fig. a), ovoid, rounded anteriorly, notched at spiracular margin; length 2987 (1944-3921); width, 2306 (1322-3063); widest behind posterior spiracles; anal lobes rounded and tapered; lacelike pore pattern showing dorsally; anal plates elevated on sclerotized dermal projection, length, 697 (454-1157); segmentation distinct ventrally.

DORSAL SURFACE

Setae: 28 to 30 hairlike marginal setae (fig. b); 18.54 (14.6-25.4) long; a longitudinal dorsal submarginal row of blunt setae (fig. c), 5.48 (3.90-6.83) long, with an expanded rounded tip and occasionally with a slightly pointed apex; a variable number scattered over dorsal surface, more numerous on some specimens than others; 5 or 6 (fig. d) (usually 5) stout conical setae on each anal lobe.

Spiracular setae (fig. e): 55(52-58) anterior and 65(60-70) posterior stout conical setae, arranged in 6 longitudinal rows, terminating spiracular pore bands, present at margins of dermal fold; the number of spiracular setae is extremely variable and this study may not encompass the full range of variability. Measurements on the spiracular setae; 13.9 (12.7-15.6), 19.6 (16.6-20.5), 22.8 (21.5-23.4), 28.8 (27.3-30.3) long, respectively.

Pores: Arranged in a dense lacelike pattern dorsally with 3 cephalic and 8 lateral membraneous areas without pores or setae except for the median cephalic area which has 1 blunt seta on each lateral margin.

Conical disc pores (fig. f): 20 to 30 on lip of dermal sclerotization cephalad of anal plates, 4.32 (3.13-3.92) high, 3.57 (2.93-4.88) in diameter.

Monolocular ring pores (fig. g): Few scattered throughout pore pattern, circular, 3.60 (2.92-4.88) in diameter.

Bilocular pores (fig. h): Scattered throughout pore pattern, ovoid 4.88 (4.88) in diameter.

Bilocular-barred pores (fig. i): Numerous, throughout pore pattern ovoid, 6.83 (6.62-7.41) in diameter.

Trilocular pores (fig. j): Primary pore on dorsal surface, triangular, 7.00 (6.83-7.41) in diameter; many aberrant forms found on derm.

Quadrilocular pores (fig. k): Few scattered over derm, square, 7.00 (6.83-7.54) in diameter; in some cases it is evident that the quadrilocular pore is an aberrant trilocular, in others it has a definite quadrilocular form.

Quinguelocular pores (fig. l): Very few, predominantly around anal area, occasionally scattered on derm; star-shaped, 8.76 (7.81-9.88) in diameter; 6 and 7-locular pores have been found but are aberrant forms of 5-loculars.

Filamentous ducts (fig. m): Marginal longitudinal row, circular, 1.42 (0.98-1.71) in diameter.

Anal plates (fig. n): Triangular, tapering apically, 167 (165-170) long, 68.7 (53.7-81.5) wide, 4 stout conical apical setae on each plate.

Anal ring (fig. n): Rectangular, rounded on outer margins: 75.3 (61.8-96.3) long, 81.7 (61.8-101) wide; 6 groups of translucent pores,

variable in number; 8 anal ring setae; 2 anterior, 215 (178-242) long; 4 median, larger, 204 (168-223) long; smaller, 107 (61.8-131) long; 2 posterior, 190 (168-211) long; inner margin U-shaped; ring heavily sclerotized.

VETRAL SURFACE:

Eyes: present and ovoid.

Antennae: 6 segmented, 187 (151-217) long; scape 22.2 (14.8-29.6) long, 32.4 (27.2-37.5) wide; segments II to VI, 26.7 (22.2-29.6), 75.6 (59.3-86.5), 18.7 (14.8-24.7), 18.8 (17.3-19.8), 24.9 (22.2-27.2) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae and a sensory pore on anterior margin; III, 2 long and 1 short hairlike seta; IV, 1 heavy fleshy blunt seta; V, 1 heavy fleshy blunt seta; VI, 4 heavy fleshy blunt setae, 2 to 4 short bristle-like, 2 long, 1 very long hairlike seta, number of setae on this segment varies from 9-11 (fig. o).

Clypeolabral shield: Length 179 (173-185), width 160 (156-173); 1 pair long hairlike seta on middle of shield.

Legs: Claw digitules unequal; 25.0 (22.2-29.6) long, 1 broad, 1 slender, both expanded at tips (fig. p); tarsal digitules 32.0 (29.6-39.5) long, slender, knobbed at tips; 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	58.3 (49.4-66.7)	56.1 (49.4-69.2)	55.6 (49.4-66.7)
Trochanter	34.3 (29.6-39.5)	35.8 (32.1-39.5)	42.4 (39.5-46.9)
Femur	74.8 (71.6-76.6)	72.6 (66.7-76.6)	75.6 (66.7-81.5)
Tarsus	39.5 (34.7-44.5)	48.9 (44.5-51.9)	50.4 (46.9-54.3)
Claw	13.0 (12.4-14.8)	14.3 (12.4-17.3)	15.1 (12.4-17.3)
Entire leg	278 (250-304)	288 (262-316)	301 (272-333)

Spiracles: Anterior pair, 66.4 (59.3-79.0) long; atrium, 66.4 (54.3-74.1) wide; a band of 124 (110-138) pores, 3-4-5-6-7- and 10-locular (fig. q), 5 or 6 loculars predominantly; 6 to 8 pores wide at margin; anterior furrow angled forward; posterior pair, 74.6 (54.3-86.5) long; atrium, 72.1 (46.9-83.9) wide; a band of pores 136 (125-165) pores, 3 to 8 and 10-locular occasionally, 5-loculars predominantly; 6 to 8 pores wide at margin; pore number variable and count may not cover range of variability.

Cruciform pores (fig. r): Primarily concentrated in a wide ventral submarginal band, pores scattered over rest of ventral surface, ovoid, 3.15 (2.68-3.42) in diameter.

Multilocular pores (fig. s): Heavily concentrated around vulva; 10 to 12-locular; few scattered over medial and submedial ventral area, no consistent number or arrangement of pores, predominantly 7 to 10 locular, occasionally 5 or 6-locular, all similar to spiracular pores, though larger.

Filamentous ducts (fig. m): Marginal longitudinal noncontinuous row, circular, 1.42 (0.98-1.71) in diameter.

Tubular ducts (fig. t): Length, 19.8 (15.6-22.5), width, 2.63 (2.19-2.93); apical margin heavily sclerotized and bearing a cupped fingerlike process terminating with a thin filament enlarged apically; 20 to 30 grouped between antennae, 30 to 50 grouped in vulval area.

Setae: One pair long, 2 pairs medium hairlike setae between antennae; ventral submarginal row of long conical setae 8.29 (7.80-8.78) long,

(fig. u); bristlelike setae scattered over submedial surface with 2 to 5 setae at base of each coxa; 6.30 (5.86-6.83) long (fig. v); 1 pair hairlike 41.8 (30.3-45.9) long and 3 or 4 conical bristlelike prevulvar setae; 3 pairs stout conical fringe setae; 2 or 3 bristlelike hypopygial setae; 1 stout conical ventral subapical seta (fig. w).

Microspines (fig. x): Heavily concentrated around area of vulva; anterior to base of mesothoracic coxae; a small patch at base of each prothoracic coxa.

Material Studied: To conserve space, the number of slides and specimens studied per instar are referenced as 1(5), 1 referring to the number of slides and (5) to the number of specimens. Also, unless otherwise specified all counties, cities, or towns mentioned are Virginia localities. This format continues throughout the material studied sections on all morphological descriptions. *Buxus* sp.: 1(3), Portsmouth, 1954, A. M. Woodside; 1(4), Buckrow Beach, June, 1957, MLB; 1(2), Windsor, June 24, 1964, H. Jones; 1(1), Petersburg, Oct. 23, 1965, E. Powers. *Camellia* sp.: 1(1), Norfolk, Sept. 25, 1942, H. G. Walker; 2(10), Norfolk, Oct. 6, 1949, RNH; 1(4), Newport News, Rec. Sept. 1958, K. L. Allen; 1(2), King and Queen Co., March 18, 1964, C. J. Siding. *Chaenomeles japonica*: 1(3), Norfolk, Sept. 15, 1952, H. C. Barker; 1(4), Williamsburg, Sept. 17, 1954, E. Raynes. *Crataegus* sp.: 1(3), Williamsburg, 1st. December 24, 1953, E. Raynes. *Euonymus kiautschovica*: 5(9), Danville, Feb. 27, 1970, GND. *Euonymus* sp.: 2(2), VPI Greenhouse,

Blacksburg, Jan. 16, 1968, MLW; 1(1) Hawksville, Ga., Nov. 14, 1968, M. F. Alligood; 8(9), Blacksburg (Greenhouse), March 3, 1969, MLW.

Gardinia sp.: 1(2), Richmond, Oct. 6, 1963, FRF. *Halmiocistus sahucii*: 5(5), Wachapreague, March 24, 1970, JMP. *Hackberry*: 1(1), Echols Co., Ga., Oct. 6, 1968, R. Beshear. *Ilex cornuta*: 1(4), Windsor, June 24, 1964, H. Jones; 10(24), Surry co., April 29, 1969, E. L. Rawls. *I. cornuta* var. *Burfordii*: 1(4), Richmond, Dec. 3, 1962, FRF; 6(6), Richmond, Dec. 10, 1968, TEP; 2(3), Kilmarnock, Va., Oct. 28, 1969, HCM; 8(13), Leesburg, Jan. 6, 1970, W. J. Brown; 4(4), Mobjack, March 5, 1970, J. May; 15(15), Newport News, March 19, 1970, JCJ: 12(12), Hampton, March 19, 1970, JCJ: 5(5), Eastville, March 25, 1970, C. T. Edwards; 1(1), Richmond, April 9, 1970, FRF; 8(16), Kilmarnock, Sept. 1, 1970, HCM: 7(14), Kilmarnock, Sept. 8, 1970, HCM; 10(23), Kilmarnock, Sept. 16, 1970, HCM; 12(25), Kilmarnock, Sept. 23, 1970, HCM: 8(12), Kilmarnock, Sept. 30, 1970, HCM; 1(1), Richmond, Aug. 13, 1970, FRF; 3(10), Richmond, Aug. 20, 1970, FRF; 9(27), Richmond, Aug. 27, 1970, FRF; 10(29), Richmond, Sept. 3, 1970, FRF; 14(30), Richmond, Sept. 10, 1970, FRF; 12(30), Richmond, Sept. 17, 1970, FRF; 8(16), Richmond, Sept. 25, 1971, FRF; 4(9), Danville, Aug. 13, 1971, GND; 5(11), Danville, Aug. 21, 1971, GND; 1(2), Richmond, Aug. 19, 1970, FRF; 4(9), Richmond, Aug. 26, 1971, FRF; 1(4), Richmond, Sept. 2, 1971, FRF; 2(16), Richmond, Sept. 9, 1971, FRF; 3(31), Richmond, Sept. 15, 1971, FRF; 3(35), Richmond, Sept. 24, 1971, FRF; 3(23), Richmond, Sept. 30, 1970, FRF.

I. crenata: 10(10), Newport News, April 12, 1968, NTB. *I. c.* var. *helleri*: 2(2), Kilmarnock, Oct. 28, 1969, HCM. *I. c.* var. *microphylla*:

2(2), Collossee, March 20, 1970, JCJ. *I. c.* var. *rotundifolia*: 3(3), Danville, Aug. 7, 1970, GND; 5(10), Danville, Aug. 14, 1970, GND; 6(11), Danville, Aug. 21, 1970, GND; 7(9), Danville, Aug. 24, 1970, GND; 3(3), Danville, Sept. 4, 1970, GND; 5(5), Danville, Sept. 11, 1970, GND; 8(8), Danville, Sept. 25, 1970, GND. *I. vomitoria*: 8(9), Portsmouth, March 19, 1970, JMP. *Ilex* sp.: 2(2), Norfolk, April 14, 1945, Walker; 2(3), Farmville, Sept. 11, 1959, B. D. Burks; 1(2), Richmond, Nov. 20, 1963, B. K. Kyle; 1(3), Va. Beach, Sept. 30, 1966, C. Hayes; 4(4), Newport News, April 12, 1968, NTB; 5(5), Newport News, April 27, 1968, NTB; 7(7), Franklin, April 30, 1968, W. A. Allen.

Lonicera sp.: 6(6), Richmond, Feb. 25, 1970, D. P. Innes. *Monotoca elliptica*: 1(1), Sydney, Australia, May 8, 1968, D. P. Sands.

Podocarpus nagai: 3(3), Windermere, Fla., May 16, 1969, F. D. Ware.

Pyracantha coccinea: 6(6), E. 4th St., N.W., Washington, D. C., July 6, 1969, MK; 3(25), Portsmouth, Aug. 6, 1971, RHC; 1(6), Portsmouth, Aug. 13, 1971, RHC; 3(31), Portsmouth, Aug. 20, 1971, RHC; 5(40), Portsmouth, Aug. 28, 1971, RHC. *P. c.* var. *lalandi*: 4(4), Newport News, March 19, 1970, JCJ. *Spirea japonica* var. *snowmount*: 9(9), Wachapreague, March 24, 1970, JMP. *Tsuga canadensis*: 8(8), Colonial Heights, Feb. 1967, T. M. Winfree. "Sumac-like bush": 6(6) Seashore State Park, Aug. 18, 1969, MLW.

Notes: Mexican wax scale has been erroneously used as the common name of *C. ceriferus*. Another species *C. mexicanus* bears the common name Mexican wax scale. This species is not found in Virginia. This confusion was due to calling the third instar the Mexican hat stage.

It is now termed the dunce cap stage.

De Lotto (1971) illustrates some of the problems in the genus *Ceroplastes* with the following quotes on *Ceroplastes ceriferus*, "For the past hundred years the species has been credited to a man who never named it. The supposed source of his description, though cited again and again, has never been seen by anybody and there is no agreement on the date of its publication. The plant on which the insect was actually collected has never been recorded; while that usually recorded as the type host has never been described."

This species appears closely related to *C. pseudoceriferus* and may be separated on the basis of the numerous marginal setae between the anterior spiracles, of which *C. ceriferus* has only 9 or 10.

Ceroplastes ceriferus was also confused with *C. destructor*. These are separated by the projection of the anal processes. It is directed straight behind the body in *C. destructor* and at a distinct angle above the body of *C. ceriferus*. The dorsal wax cap is another means of separating *C. ceriferus*, which has it, from *C. destructor*, which does not.

First Instar Nymph

Plate 5; Photoplate 1-B

DESCRIPTION: Body (fig. a) ovoid, smoothly rounded anteriorly; length, 521 (393-726); width, 295 (215-432); widest between spiracles, tapering posteriorly, anal lobes rounded and curved inward; derm membraneous and wrinkled with segmentation showing both dorsally and ventrally.

DORSAL SURFACE:

Setae: 26 marginal hairlike setae (fig. b), 3.70 (2.93-4.14) long, 1 stout conical seta (fig. c) on each anal lobe, 5.70 (4.63-6.58) long.

Spiracular setae (fig. d): 3 thick rounded setae terminating the row of spiracular pores of both anterior and posterior furrows, positioned at margin of dermal fold; 2 outer setae, 1.63 (1.22-1.95) long, stout, bullet shaped and smoothly rounded; middle seta, 3.18 (2.93-3.65) long, stout, tapering apically and rounded.

Simple disc pores (fig. e): 2 longitudinal rows of circular pores, 1.10 (0.98-1.22) in diameter; submedial rows with 8 pores; dorsal submarginal row with 12 pores.

Trilocular pores (fig. f): One pair triangular submarginal pores cephalid of eyes 1.94 (1.47-2.19) in diameter.

Anal plates (fig. g): Triangular and smoothly rounded 29.6 (27.2-32.1) long, 18.2 (14.8-20.4) wide; tapering both cephalolaterally and caudolaterally, apex bluntly rounded; 4 stout conical apical setae on each plate, main apical seta elongate, 283 (217-324) long, whiplike and

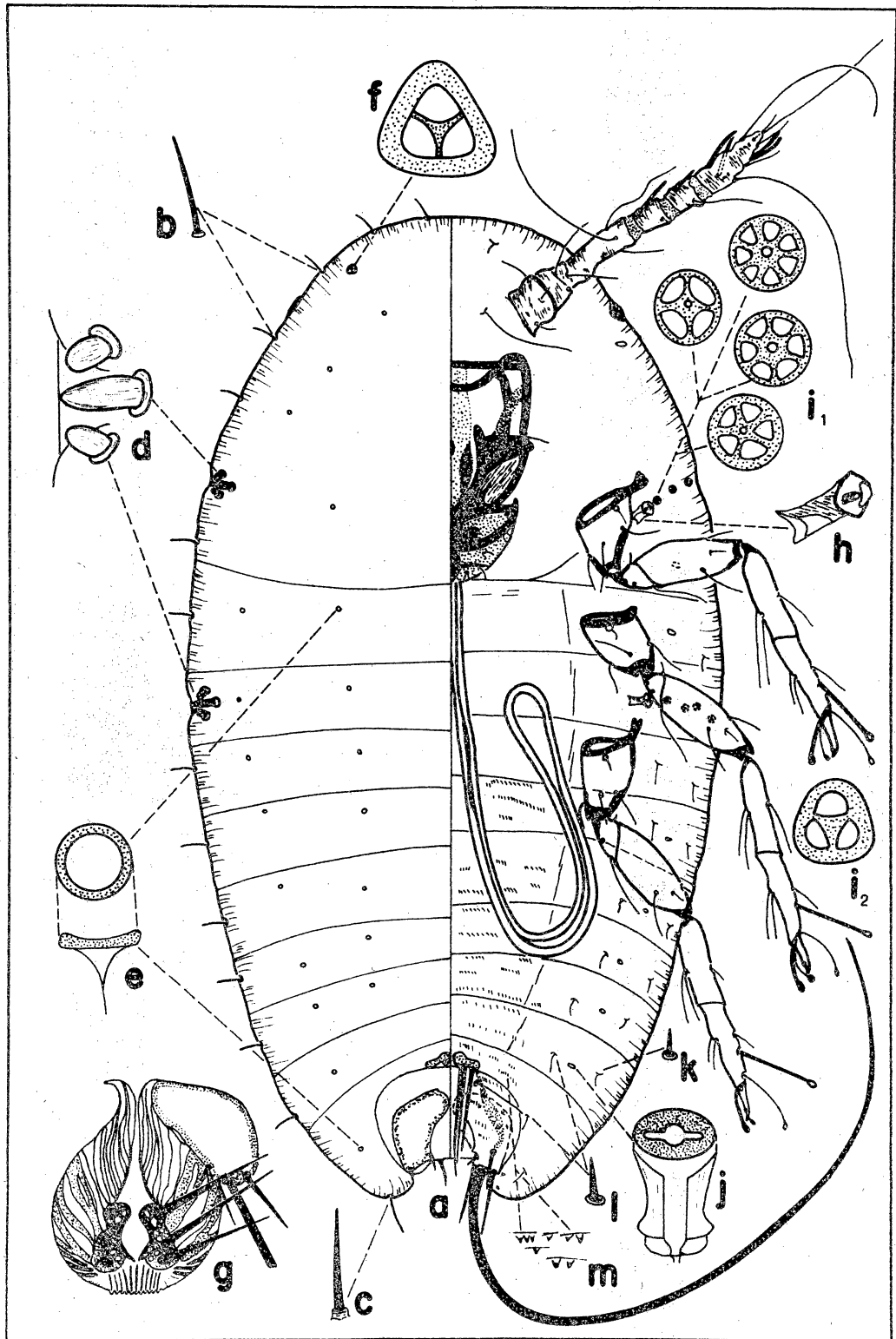


Plate 5.- *Ceroplastes ceriferus* (Fabricius), first instar nymph

tapering.

Anal ring (fig. g): Elliptical 23.2 (21.0-24.7) long, 15.7 (12.4-16.7) wide and notched on cephalolateral margins; 6 groups of translucent pores, variable in number; 6 setae, 2 anterior, 42.5 (38.3-44.5) long; 2 median, 41.4 (38.3-43.2) long; 2 posterior, 33.2 (29.6-34.6) long; inner margin strongly angled, open apically closed basally, and heavily sclerotized; when everted, ring rests on a lightly sclerotized bulbous tube.

VENTRAL SURFACE:

Eyes: Present and slight convex.

Antennae: Six-segmented, 113 (92.0-137) long, scape, 11.5 (9.26-14.8) long, 20.0 (12.4-27.2) wide; segments II to VI, 12.7 (12.4-13.6) 31.9 (27.2-34.6) 13.1 (12.4-14.8) 11.2 (7.41-17.3) 32.3 (23.5-42.0) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae and a sensory pore on anterior margin; III, 2 very long and 1 short hairlike setae; IV, 1 fleshy blunt seta; V, 1 fleshy blunt seta and one moderately long hairlike seta; VI, 4 stout fleshy setae, 3 short, 2 long, and 1 very long hairlike seta.

Clypeolabral shield: Length, 83.9 (80.3-86.5), width, 69.7 (61.8-79.0); 1 pair of very long hairlike setae on middle of shield.

Labium: Bowl-shaped; apparently 2-segmented, 4 setae on each segment.

Legs: Tarsal digitules present 32.7 (25.9-45.8) long and unequal, one thickened, 1 slender, both knobbed at tip; claw digitules present 14.86 (11.7-17.9) long and unequal; claw with denticle; 4 sensory pores on trochanter of each leg.

Part of Leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	26.2 (22.2-29.6)	28.4 (24.7-32.1)	29.0 (24.7-32.1)
Trochanter	19.0 (14.8-24.7)	19.3 (14.8-22.2)	18.8 (17.3-19.8)
Femur	40.3 (34.6-46.9)	41.7 (37.1-44.5)	41.7 (39.5-46.9)
Tibia	44.1 (42.0-46.9)	47.2 (44.5-49.4)	46.8 (43.2-56.8)
Tarsus	38.8 (37.1-42.0)	39.0 (34.6-42.0)	34.6 (24.7-39.5)
Claw	12.3 (10.5-13.0)	12.9 (9.88-15.4)	12.5 (11.1-13.0)
Entire leg	181 (161 - 203)	189 (175 - 205)	183 (161 - 208)

Spiracles (fig. h): Anterior pair, 10.4 (9.88-11.7) long; atrium, 5.81 (4.94-6.99) wide; with a row of 3 pores, 3-4-5-locular, predominantly 5-locular (fig. i); anterior furrow angled forward; posterior pair 10.4 (7.41-12.4) long; atrium, 6.55 (4.94-8.64) wide; a row of 4 pores 3-4-5-6-7-locular (3 and 5-loculars predominantly); pore combinations variable.

Cruciform pores (fig. j): Submarginal row of 8 ovoid pores; diameter, 2.20 (1.70-2.44).

Setae: 2 rows of 2 hairlike setae between antennae; 2 longitudinal rows of bristlelike setae, 1 ventral submarginal row with 8 setae, 1.70 (1.22-2.19) long (fig. k), 7 on abdomen and 1 between spiracles, 1 submedian row with 7 setae, 3.18 (2.44-3.90) long (fig. l); all, except those on first and last abdominal segment associated with cruciform pores; 1 pair of hairlike prevulvar setae 23.9 (17.6-28.3) long; 1 pair stout conical subapical setae; 1 pair stout conical setae on fringe of vulva.

Microspines (fig. m): Concentrated around vulva; anterior to hind coxae.

Material Studied: *Camellia* sp.: 1(4), Richmond, Oct. 6, 1949, RNH.

Ilex cornuta var. *Burfordii*: 5(22), Kilmarnock, June 18, 1970, HCM; 6(28), Kilmarnock, June 29, 1970, HCM; 3(7), Kilmarnock, July 3, 1970, HCM; 5(16), Kilmarnock, July 10, 1970, HCM; 7(12), Kilmarnock, July 17, 1970, HCM; 8(32), Richmond, June 11, 1970, FRF; 6(14), Richmond, June 18, 1970, FRF; 8(25), Richmond, June 26, 1970, FRF; 8(33), Richmond, July 2, 1970, FRF; 5(10), Richmond, July 9, 1970, FRF; 6(6), Richmond, July 16, 1970, FRF; 6(65), Danville, June 10, 1971, GND; 3(31), Danville, June 18, 1971, GND; 6(101), Danville, June 23, 1971, GND; 3(20), Danville, July 2, 1971, GND; 3(16), Danville, July 9, 1971, GND; 3(43), Richmond, June 24, 1971, FRF; 5(78), Richmond, July 1, 1971, FRF; 7(167), Richmond, July 8, 1971, FRF; 5(10), Richmond, July 22, 1971, FRF. *Ilex crenata* var. *rotundifolia*: 8(41), Danville, June 4, 1970, GND; 6(21), Danville, June 12, 1970, GND; 8(39), Danville, June 19, 1970; 10(32), Danville, June 26, 1970, GND. *Podocarpus nagi*: 1(2), Windermere, Fla., May 16, 1969, FLW. *Pyracantha coccinea*: 4(88), Portsmouth, June 3, 1971, RHC; 2(32), Portsmouth, June 10, 1971, RHC; 3(6), Portsmouth, June 24, 1971, RHC; 1(2), Portsmouth, July 1, 1971, RHC; 1(1), Portsmouth, July 8, 1971, RHC.

Note: The first instars of *C. ceriferus* is very closely related to the first instar of *C. floridensis*. Characters are very similar and they are separated by the median cephalic setae, which is longer in *C. floridensis*.

Second Instar, Nymph

Plate 6; Photoplate 1-C

DESCRIPTION: Body (fig. a) ovoid; length, 864 (827-889); width, 623 (588-667); rounded anteriorly, slightly tapered posteriorly; widest behind posterior spiracles; anal lobes tapered and bluntly rounded; body segmentation not showing dorsally or ventrally, but based on marginal and ventral setal arrangements, 8 segments can be distinguished.

DORSAL SURFACE:

Setae: 26 hairlike marginal setae (fig. b), 9.01 (7.81-10.40) long; 2 stout conical setae on each anal lobe (fig. c), 12.1 (8.45-15.6) long.

Spiracular setae (fig. d): 3 elongate conical setae terminating the row of spiracular pores of both anterior and posterior furrows, positioned at margin of dermal fold, 2 smaller outer setae, 15.3 (14.6-18.5) long, larger median seta, 18.0 (16.6-19.5) long.

Discoidal pores (fig. e): Circular, 3 longitudinal rows, 2.40 (1.95-2.93) in diameter; 1 medial from caudal area anteriorly to thorax, 2 submedial from caudal to cephalic region.

Simple disc pores (fig. f): All circular, 3 longitudinal rows, 1.70 (1.47-1.95) in diameter, 2 submedial and 1 dorsal submarginal; outer submedial and submarginal rows connected by 6 transverse rows of 1 or 2 pores.

Anal plates (fig. g): Triangular, smoothly rounded and elongate apically; 57.3 (42.0-64.2) long, 31.4 (27.2-39.5) wide; 4 stout conical apical setae on each plate.

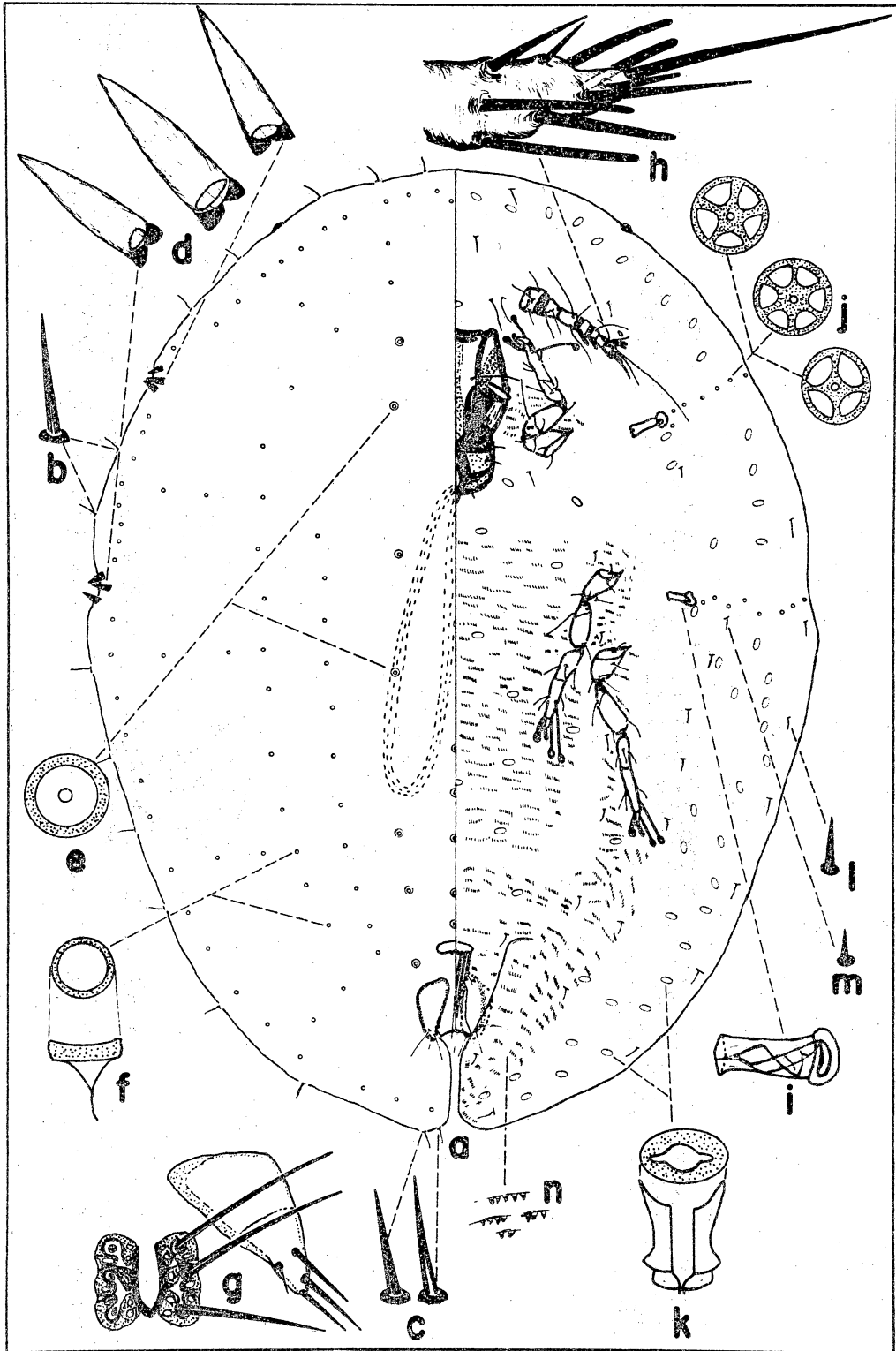


Plate 6. - *Ceroplastes ceriferus* (Fabricius), second instar nymph

Anal ring (fig. g): Rectangular, 28.1 (27.2-29.0) long, 33.4 (29.6-37.1) wide; with 2 shallow notches on lateral margins; 6 groups of translucent pores, variable in number; 6 setae; 2 anterior, 72.2 (56.8-84.0) long; 2 median, 67.2 (51.9-79.0) long; 2 posterior, 52.9 (42.0-64.2) long; inner margin U-shaped; ring heavily sclerotized; when everted anal ring rests on a lightly sclerotized eversible tube.

VENTRAL SURFACE:

Eyes: Present and ovoid.

Antennae: 6 segmented, 97.1 (80.3-113) long, scape, 14.3 (9.88-16.1) long; 16.8 (14.8-19.8) wide; Segments II to VI 12.8 (11.1-14.8), 29.4 (27.2-32.1), 10.4 (7.41-12.4) 9.41 (7.41-12.4), 20.8 (17.3-24.7) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae and a sensory pore on anterior margin; III, 2 long and 1 short hairlike setae; IV, 1 heavy fleshy blunt seta; V, 1 heavy fleshy blunt and 1 long hairlike seta; VI, 4 heavy fleshy blunt setae, 3 short, 2 long, 1 very long hairlike setae (fig. h).

Clypeoplalbral shield: Length, 108 (86.5-124), width, 93.9 (91.4-98.8); 1 pair of long hairlike seta on middle of shield.

Labium: Bowl-shaped; apparently 2-segmented, 4 setae on each segment.

Spiracles (fig. i): Anterior pair, 25.8 (22.2-29.6) long; atrium, 13.0 (11.7-14.8) wide; a row of 5 to 9 predominantly 5-locular pores (occasionally 4-6-and 7-locular) (fig. j); anterior spiracle and furrow extending forward; posterior pair, 25.1 (17.3-29.6) long; atrium, 13.9 (12.4-16.7) wide; a row of 6 to 9 predominantly 5-locular pores, (occasionally 4 or 6 locular); pore combinations variable in both

furrows.

Legs: Tarsal digitules present 22.9 (17.3-27.2) long, slender, knobbed at tips; claw digitules present 14.5 (11.7-17.3) long and unequal, 1 broad and expanded at tip and 1 slender, knobbed at tip; 4 sensory pores on trochanter of each leg.

Part of leg	Length prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	25.1 (19.8-25.4)	25.7 (19.8-29.6)	26.0 (22.2-32.1)
Trochanter	19.5 (16.7-24.7)	18.5 (14.8-22.2)	18.3 (14.8-19.8)
Femur	35.2 (27.2-39.5)	34.6 (27.2-39.5)	36.5 (27.2-42.0)
Tibia	38.8 (34.6-42.0)	41.9 (37.1-44.5)	42.7 (39.5-44.5)
Tarsus	33.9 (27.2-39.5)	32.9 (29.6-37.1)	32.1 (27.2-34.6)
Claw	11.1 (8.69-12.4)	11.0 (9.88-13.0)	11.0 (9.88-12.4)
Entire leg	144 (134-184)	165 (138-186)	167 (141-185)

Criciform pores (fig. k): Concentrated in a submarginal band; diameter 5.58 (3.71-6.83); a few sparsely scattered over rest of venter; number of pores and the arrangement varies between specimens.

Setae: Two pairs of long hairlike setae between antennae; 3 longitudinal rows of conical bristlelike setae; 1 ventral submarginal row with 9 setae (fig. l), 4.81 (3.90-6.47) long; 2 submedial rows (fig. m), 3.34 (2.92-3.90) long, an inner row with 8 setae, an outer row with 11 setae; 1 pair hairlike prevulvar seta 28.9 (23.4-34.2), 2 pairs of stout conical setae on fringe of vulva; 1 pair of stout conical subapical setae.

Microspines (fig. n): With heavy concentrations near vulva, anterior to mouthparts and a small patch anterior to prothoracic coxa.

Material Studied: *Ilex cornuta* var. *Burfordii*: 1(1), Kilmarnock,

July 3, 1970, HCM; 4(8), Kilmarnock, July 10, 1970, HCM; 8(13), Kilmarnock, July 17, 1970, 6(13), Kilmarnock, Aug. 4, 1970, HCM; 6(13), Kilmarnock, Aug. 11, 1970, HCM; 3(4), Kilmarnock, Aug. 18, 1970, HCM; 2(2), Kilmarnock, Aug. 23, 1970, HCM; 1(2), Richmond, July 2, 1970, FRF: 10(33), Richmond, July 16, 1970, FRF; 8(33), Richmond, July 23, 1970, FRF; 8(29), Richmond, July 30, 1970, FRF; 2(2) Richmond, Aug. 20, 1970, FRF; 2(3), Danville, June 23, 1971, GND; 3(29), Danville, July 2, 1971, GND; 3(25), Danville, July 2, 1971, GND; 2(6), Danville, July 16, 1971, GND; 2(7), Danville, July 24, 1971, GND; 4(24), Danville, Aug. 3, 1971, GND; 4(7), Danville, Aug. 13, 1971, GND; 2(3), Danville, Aug. 21, 1971, GND; 2(2), Richmond, July 1, 1971, FRF; 6(42), Richmond, July 8, 1971, FRF; 5(86), Richmond, July 22, 1971, FRF; 6(33), Richmond, July 29, 1971, FRF; 4(14), Richmond, Aug. 5, 1971, FRF; 2(3), Richmond, Aug. 19, 1971, FRF.

Ilex crenata var. *rotundifolia*: 2(2), Danville, June 19, 1970, GND; 9(17), Danville, June 26, 1970, GND; 9(27), Danville, July 3, 1970, GND; 5(11), Danville, July 10, 1970, GND. *Pyracantha coccinea*: 3(18), Portsmouth, June 24, 1971, RHC; 1(9), Portsmouth, July 1, 1971, RHC; 1(1), Portsmouth, July 8, 1971, RHC.

Third Instar, Nymph

Plate 7; Photoplate I-D

DESCRIPTION: Body (fig. a) ovoid, rounded anteriorly and posteriorly; length, 894 (808-1089), width, 671 (571-823); anal lobes angular; widest between spiracles; lackelike pore pattern showing dorsally; segmentation distinct ventrally.

DORSAL SURFACE:

Setae: 26 marginal hairlike setae (fig. b), 10.8 (9.88-11.7) long; a lateral longitudinal and a submedial cephalothoracic row of blunt setae (fig. c), 4.23 (3.90-4.88) long, with an expanded rounded tip and occasionally with a slightly pointed apex, 3 stout conical setae on each anal lobe (fig. d), 21.9 (13.7-29.3) long.

Spiracular setae (fig. e): 9 to 13 stout conical spiracular setae terminating spiracular pore band of both anterior and posterior furrows; positioned at margin of dermal fold in 3 rows dorsally; 11.8 (10.7-13.7), 18.5 (17.6-19.5), 21.5 (20.5-23.4) long, respectively.

Pores: Arranged in a lacelike pattern dorsally with 3 cephalic and 10 lateral membraneous areas devoid of pores and setae except for the median cephalic area which has 1 pair blunt setae on the lateral margins.

Bilocular pores (fig. f): Numerous and evenly distributed on dorsal surface; diameter, 4.64 (3.90-5.14).

Bilocular-barred pores (fig. g): Numerous, oval, predominant pore on dorsal surface; diameter, 5.86 (5.44-6.83).

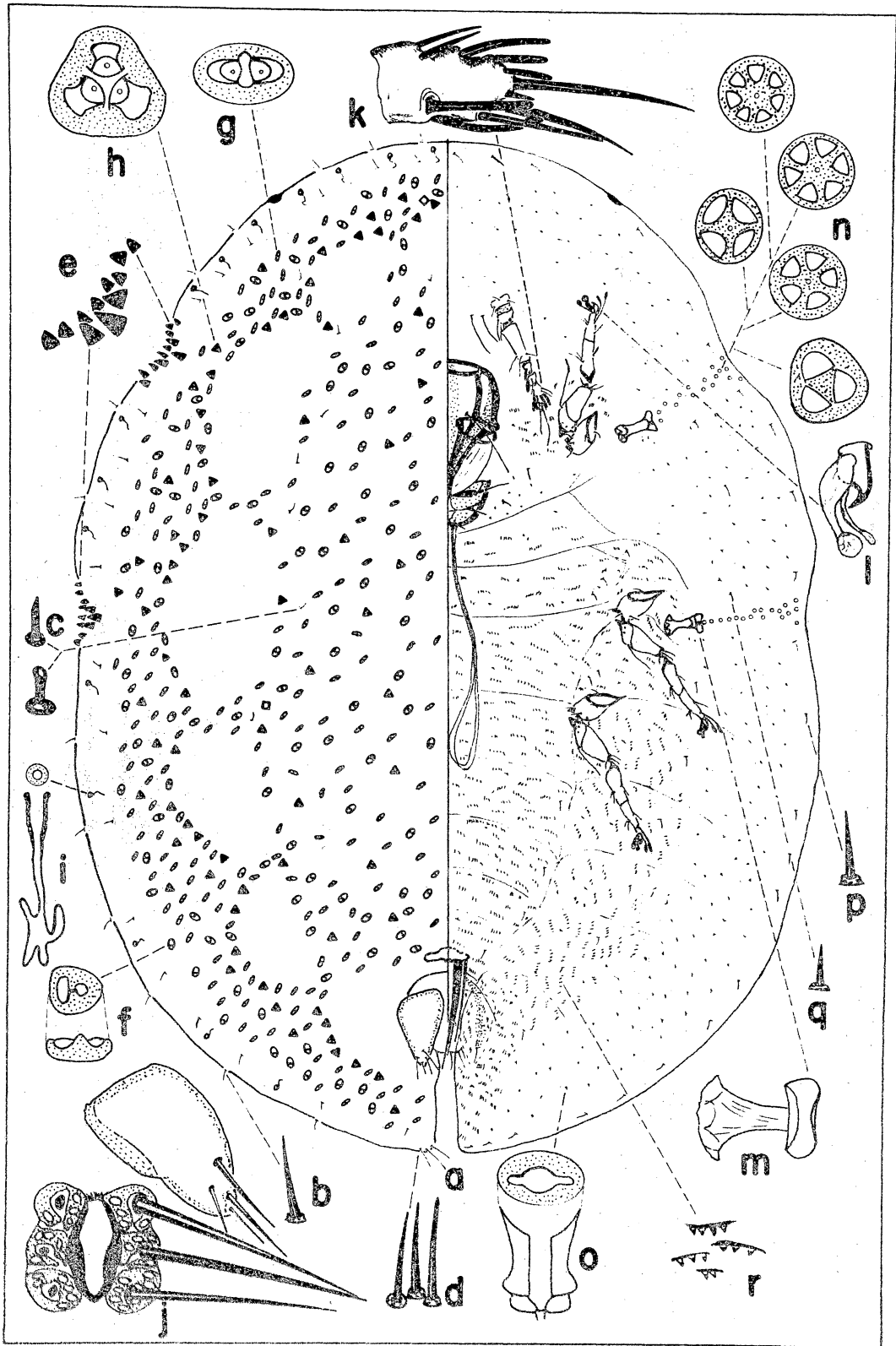


Plate 7. - *Ceroplastes ceriferus* (Fabricius), third instar nymph

Trilocular pores (fig. h): Triangular and smoothly rounded, few scattered over medial and marginal dorsal pore areas; diameter, 6.64 (5.86-6.83); various aberrant forms present, in some cases they form irregular quadrilocular pores similar to those of the adult.

Filamentous ducts (fig. i): Marginal longitudinal row, circular, 1.10 (0.98-1.22) in diameter; more prominent on cephalic margin.

Anal Plates (fig. j): Triangular; smoothly rounded and slightly notched on medial margins; 85.7 (76.6-93.9) long, 47.9 (39.5-56.8) wide; 4 stout conical apical setae on each plate.

Anal ring (fig. j): Rectangular, 44.2 (37.1-49.4) long, 44.7 (4.20-46.9) wide; 2 shallow notches on lateral margins; 6 groups of translucent pores, variable in number; 6 setae; 2 anterior, 135 (126-146) long, 2 median, 127 (121-131) long; 2 posterior, 108 (98.8-119) long; occasionally a second pair of median setae as an adult, 43.6 (42.0-44.5) long, inner margin U-shaped; ring heavily sclerotized.

VENTRAL SURFACE:

Eyes: Present and ovoid.

Antennae: 6-segmented, 112 (97.7-132) long, scape 10.2 (9.88-12.4) long; 20.7 (17.3-24.7) wide; segments II-VI, 14.8 (12.4-17.9), 41.2 (34.6-49.4), 13.0 (11.1-14.8), 12.8 (12.4-14.2), 20.4 (17.3-23.5) long, respectively; scape with 3 moderately long setae; II, 2 long hairlike setae, sensory pore on anterior margin; III, 2 long, 1 short hairlike setae; IV, 1 fleshy bluntly rounded seta; V, 1 fleshy blunt and 1 long hairlike setae; VI, 4 fleshy blunt setae, 3 short, 3 long, 1 very long hairlike seta (fig. k).

Clypeolabral shield: Length, 125 (114-136); width, 123 (106-136); 1 pair of long hairlike setae on middle of shield.

Labium: Bowl-shaped; apparently 2-segmented, 4 setae on each segment.

Legs: Tarsal digitules 23.0 (18.5-27.2) long and slender, knobbed at tips; claw digitules 16.3 (14.2-18.5) long and unequal; 1 broad, constricted at middle, expanded at tip, other slender knobbed at tip (fig. 1); 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	28.7 (27.2-29.6)	31.4 (27.2-34.6)	32.1 (27.2-34.6)
Trochanter	22.3 (19.8-24.7)	22.7 (18.5-24.7)	21.7 (19.8-22.9)
Femur	48.4 (42.0-56.8)	48.4 (42.0-56.8)	47.9 (44.5-51.9)
Tibia	39.9 (37.1-44.5)	42.0 (34.6-44.5)	45.2 (42.0-49.4)
Tarsus	33.4 (32.1-34.6)	37.8 (34.6-39.5)	37.1 (34.6-39.5)
Claw	10.3 (8.64-11.1)	11.3 (9.88-13.0)	11.9 (11.1-13.0)
Entire leg	183 (168-199)	194 (167-216)	192 (179-211)

Spiracles (fig. m): Anterior pair, 38.0 (32.1-44.5) long, atrium, 23.7 (22.2-27.2) wide; a band of 18 (15-22) pores, predominantly 5 or 6 locular, occasionally 3-4-and 7-loculars (fig. n), 2 or 3 pores wide at margin; anterior furrow extending forward; posterior pair, 40.5 (37.1-46.9) long; atrium, 26.4 (22.2-29.6) wide; band of 21 (16-26) pores, 5 or 6 locular predominantly, 3-4-and 7-locular occasionally; 3 or 4 pores wide at margin.

Cruciform pores (fig. o): Heavily concentrated in a submarginal band; few scattered over rest of ventrum, ovoid, diameter, 2.92 (2.92).

Setae: Two pairs of long hairlike setae between antennae; a ventral submarginal row of conical bristlelike setae, 5.90 (4.88-6.83) long (fig. p); 2 submedial rows of bristlelike setae 3.90 (2.92-4.88) long,

(fig. q), outer row with 12 setae, inner row with 5 setae on abdomen; 2 to 3 bristlelike setae at base of each coxa; 1 pair of hairlike setae 32.4 (29.3-36.1) long, and 1 short conical bristlelike prevulvar setae, 7.81 (5.94-9.88) long; 3 pairs of stout conical setae on fringe of vulva; 1 stout conical subapical seta.

Microspines (fig. 4): Heavy concentrations near vulva; anteriorly, medially and submedially to mouthparts; a small patch near base of each prothoracic coxa.

Material Studied: *Ilex cornuta* var. *Burfordii*: 1(1), Kilmarnock, Aug. 4, 1970, HCM; 6(16), Kilmarnock, Aug. 11, 1970, HCM; 5(16), Kilmarnock, Aug. 18, 1970, HCM; 10(21), Kilmarnock, Aug. 23, 1970, HCM; 5(7), Kilmarnock, Sept. 1, 1970, HCM; 3(6), Kilmarnock, Sept. 8, 1970, HCM; 4(4), Richmond, July 23, 1970, FRF; 7(20), Richmond, July 30, 1970, FRF; 12(39), Richmond, Aug. 6, 1970, FRF; 14(47), Richmond, Aug. 13, 1970, FRF; 9(33), Richmond, Aug. 20, 1970, FRF; 6(11), Richmond, Aug. 27, 1970, FRF; 5(22), Richmond, Sept. 9, 1970, FRF; 3(5), Danville, Aug. 3, 1971, GND; 5(32), Danville, Aug. 13, 1971, GND; 5(27), Danville, Aug. 21, 1971, GND; 7(50), Richmond, July 22, 1971, FRF; 6(107), Richmond, July 29, 1971, FRF; 4(64), Richmond, Aug. 5, 1971, FRF; 4(91), Richmond, Aug. 12, 1971, FRF; 3(64), Richmond, Aug. 19, 1971, FRF; 4(40), Richmond, Aug. 26, 1971, FRF; 1(11), Richmond, Sept. 9, 1971, FRF; 3(3), Richmond, Sept. 15, 1971, FRF.

Ilex crenata var. *rotundifolia*: 5(9), Danville, July 3, 1970, GND; 5(16), Danville, July 10, 1970, GND; 4(12), Danville, July 17, 1970, GND; 6(20), Danville, July 24, 1970, GND; 12(27), Danville, July 31,

1970, GND; 12(25), Danville, Aug. 7, 1970, GND; 1(1), Danville,
Aug. 14, 1970, GND; 1(1), Kilmarnock, Oct. 28, 1969, HCM.

Pyracantha coccinea: 1(5), Portsmouth, July 8, 1971, RHC; 3(17),
Portsmouth, July 15, 1971, RHC; 1(2), Portsmouth, July 30, 1971,
RHC; 3(7), Portsmouth, Aug. 6, 1971, RHC.

Ceroplastes sinensis Del Guercio, 1900

Adult Female

Chinese Wax Scale

Plate 8; Photoplate 2-F

Ceroplastes sinensis, Del Guercio, 1900:3, 1900:469; 1902:321; Cockerell, 1901:469; Fernald, 1903:157; Silvestri, 1919:1, 1902:3; Leonardi, 1920:364, 526; Steinweden, 1929:231; Balachowsky, 1933:80; Cottier, 1939:422; Spiller, 1944:129; Bodenheimer, 1952:113; Borchsenius, 1957:451; Simmonds, 1957:7; Ben-Dov, 1970a:83; Snowball, 1970:57; De Lotto, 1971:143; Pollet, 1971:100.

DESCRIPTION: Body (fig. a), ovoid, bluntly rounded anteriorly; length 2001.0 (1433.0-2396.0), width; 980.0 (716.0-1173.0); widest between pro- and mesothorax; anal lobes rounded; lacelike pore pattern dorsally; anal plates surrounded by heavily sclerotized ovoid shield; segmentation apparent ventrally; derm membranous.

DORSAL SURFACE:

Setae: 30 hairlike marginal setae (fig. b), 19.0 (11.7-21.5) long; 4 stout conical setae 29.5 (16.6-48.9) long on each anal lobe (fig. c); a submarginal row of blunt setae with an expanded rounded tip and occasionally with a slightly pointed apex 4.63 (3.94-4.91) long (fig. d); a variable number dispersed over the dorsal surface, more numerous on some specimens than others.

Spiracular setae (fig. e): 28 (20-36) stout conical spiracular setae arranged in 3 rows 10.9 (8.78-11.7), 17.6(14.6-20.5), 29.5 (16.6-48.9)

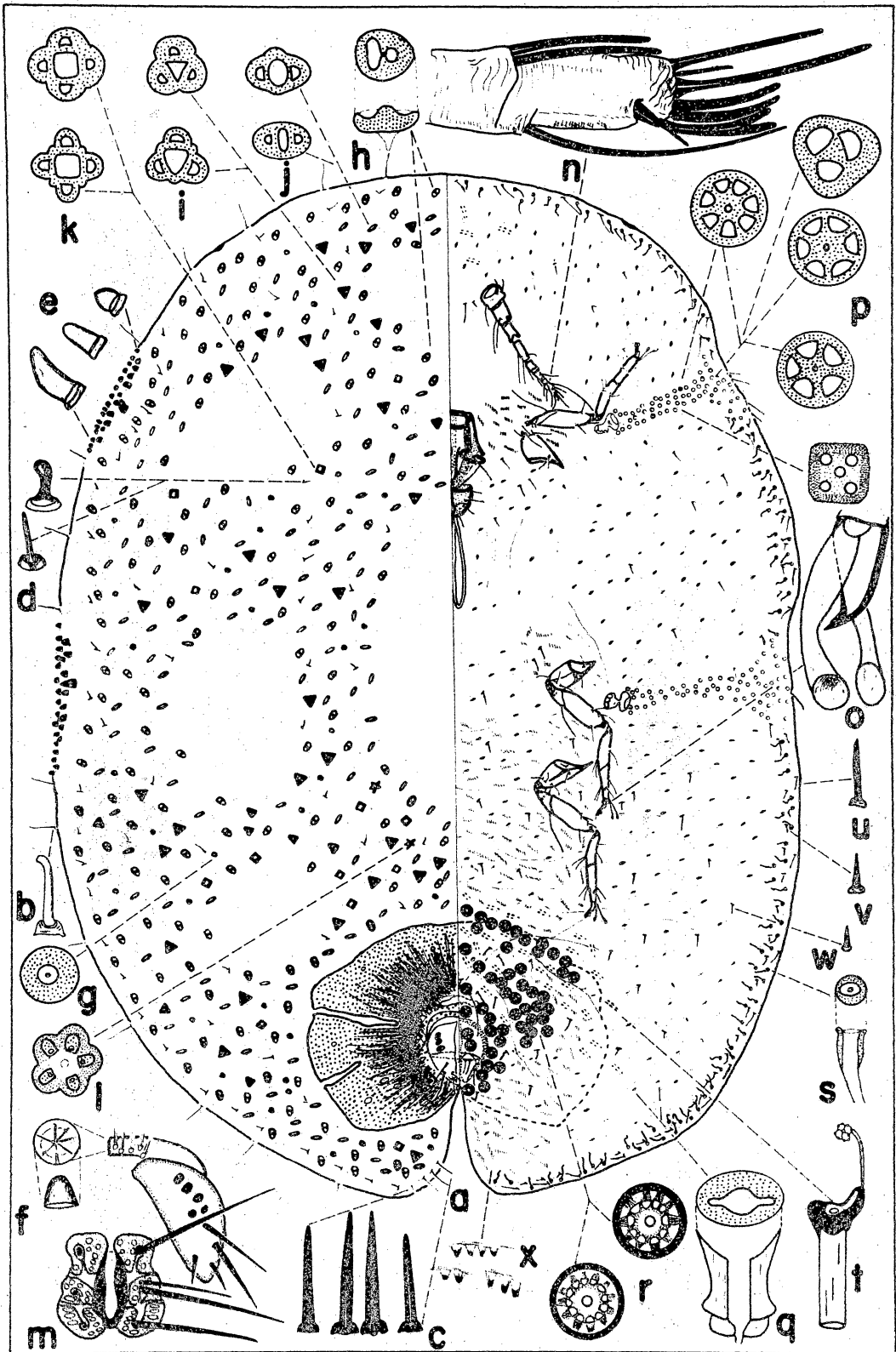


Plate 8. - *Ceroplastes sinensis* DelGuercio, adult female

long, respectively; terminating spiracular pore band of both anterior and posterior furrows; positioned at margin of dermal fold; main large setae may be forked, blunt, straight or angular (latter most common).

Pores: Arranged in a lacelike pattern with 1 cephalic, 6 lateral, and 1 median membranous area without pores or setae; clear areas in the sclerotized shield around the anal plates are pores incorporated in the shield; many aberrant forms of pores have been found, only the predominant distinct forms have been illustrated.

Conical disc pores (fig. f): 9 to 12 on lip of dermal sclerotization cephalic of anal plates; 5.33 (4.88-6.83) high, 4.14 (2.93-4.88) in diameter.

Monolocular ring pores (fig. g): Few scattered throughout pore pattern; circular; 3.74 (3.38-3.90) in diameter.

Bilocular pores (fig. h): Ovoid, scattered throughout pore pattern, occasionally in large numbers marginally; 3.81 (3.42-3.90) in diameter.

Trilocular pores: These are the primary pores on the dorsal surface; 2 different types, one triangular (fig. i), 5.48 (4.88-5.86) in diameter, the other ovoid (fig. j), 5.48 (4.88-5.86) in diameter.

Quadrilocular pores (fig. k): Square-shaped, a few scattered over derm, 5.72 (5.38-5.86) in diameter.

Quinquelocular pores (fig. l): Very few, predominantly near anal area; star shaped, 7.88 (7.51-8.04) in diameter; not present on all specimens.

Anal plates (fig. m): Triangular, broadly rounded laterally; slightly tapered apically; 151 (138-166) long, 72.7 (66.7-77.6) wide; 4 stout

conical apical setae and 3 to 5 sclerotized bars on each plate.

Anal ring (fig. m): Pentagonal, with 2 shallow depressions on each lateral margin; 62.2 (56.8-64.2) long, 63.4 (59.3-66.7) wide; 6 groups of translucent pores, numbers variable; 8 setae, 2 anterior, 209 (193-222) long; 4 median, 191 (175-203) and 100 (87.2-111) long, respectively; 2 posterior, 174 (161-185) long; inner margin U-shaped; ring heavily sclerotized.

VENTRAL SURFACE:

Eyes: Present but hardly noticeable.

Antennae: 7 segmented, 268 (232-316) long; scape 29.2 (19.8-37.1) long; 46.5 (42.0-51.9) wide; segments II to VII; 45.7 (37.1-49.4), 38.5 (34.6-49.4), 69.6 (64.2-81.5), 25.6 (19.8-32.1), 23.2 (19.8-24.7), 36.1 (37.1-42.0) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae and a sensory pore on the anterior margin, III, no setae; IV, 2 long and 1 short hairlike setae; V, 1 stout fleshy blunt seta; VI, 1 stout fleshy and 1 long hairlike seta; VII, 4 thick fleshy blunt setae, 2 short, 3 long and 1 very long hairlike setae (fig. n).

Clypeolabral shield: Length, 198 (190-203), width, 166 (161-174); 1 pair long hairlike seta on middle of shield.

Labium: Bowl-shaped, apparently 2-segmented; 4 setae on each segment.

Legs: Claw with denticle barely visible; claw digitules broad, 40.0 (37.1-46.9) long, constricted at middle, expanded at the tips (fig. o); tarsal digitules 63.0 (59.3-81.5) long and slender, knobbed at tips; 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	70.9 (59.3-79.0)	88.0 (79.3-97.4)	89.6 (86.5-91.4)
Trochanter	56.6 (54.3-61.8)	66.5 (59.3-74.1)	63.5 (54.3-74.1)
Femur	129 (111-138)	130 (119-138)	136 (119-146)
Tibia	114 (106-126)	117 (106-128)	114 (104-121)
Tarsus	79.8 (71.6-86.5)	83.5 (79.0-88.9)	81.4 (74.1-88.9)
Claw	23.2 (22.2-24.7)	25.2 (22.2-27.2)	26.0 (22.2-27.2)
Entire leg	474 (425-516)	510 (464-554)	512 (459-548)

Spiracles: Anterior pair, 40.8 (37.1-56.8) long; atrium, 46.7 (29.6-51.9) wide; a band of 60 (50 to 68) pores (fig. p), predominantly 5-locular, with 3-4- and 7-locular occasionally; 5 to 7 pores wide at margin; posterior pair, 49.9 (49.4-54.3) long; atrium, 54.1 (37.1-64.2) wide; a band of 70 (62 to 79) pores, 5-6- and 7-locular, 5 predominantly, 5 to 7 pores wide at margin.

Cruciform pores (fig. q): Scattered over ventral surface, with higher concentrations near margin; ovoid, 3.56 (2.92-3.90) in diameter.

Multilocular pores (fig. r): Arranged in 3 transverse bands near vulva; 6-8-9-10-12-14 locular, predominantly 10- and 12-locular, 6.64 (5.90-9.88) in diameter.

Filamentous ducts (fig. s): In a non-continuous marginal row, interrupted at spiracular furrows; circular; 2.23 (1.91-2.92) in diameter.

Tubular ducts (fig. t): Length, 13.6 (7.89-19.5), width, 2.64 (1.90-2.92); 2 to 10 grouped between antennae; 32 to 54 grouped around vulva.

Setae: A ventral submarginal row of mixed setae, 7.95 (6.83-8.78), 12.1 (10.7-15.6) long; respectively (figs. u and v); 1 pair of long and 1 pair of short hairlike setae between antennae; conical bristle-like setae 6.74 (4.88-7.81) long, scattered over submarginal and

submedial surface (fig. w); 1 pair, 50.6 (43.9-58.6) long hairlike prevulvar setae; 4 pairs stout conical setae on fringe of vulva; 2 stout conical subapical setae; no hypopygial setae.

Microspines (fig. x): Concentrated around vulva; anterior to base of mesothoracic coxa; a small group at base of prothoracic coxa.

Material Studied: *Citrus* sp.: 1(1), San Jose, California, Oct. 30, 1970, D. Schambergor, Cal. Dept. Agr. 70 K 13-13. *Ilex aquifolium*: 1(5), Norfolk, Sept. 14, 1948, FRF; 1(5), Norfolk, Aug. 5, 1957, RNH; 1(1), Santa Clara, Calif., June 2, 1969, J. C. A. Albert. *Ilex crenata* var. *microphylla*: 1(4), Franklin, Sept. 12, 1969, DKP; 1(13), Franklin, Feb. 27, 1970, DKP; 2(3), Franklin, Aug. 31, 1970, JMP; 2(2), Franklin, Sept. 9, 1970, JMP; 2(2), Franklin, Sept. 14, 1970, JMP; 15(26), Franklin, Sept. 21, 1970, JMP; 18(18), (greenhouse) Blacksburg, Sept. 29, 1970, JMP; 15(15), Franklin, Oct. 13, 1970, DKP; 20(24), Franklin, Oct. 30, 1970, JMP; 20(23), Franklin, Nov. 23, 1970, JMP; 23(38), Franklin, Dec. 16, 1970, DKP; 2(2), Franklin, Sept. 3, 1971, JMP; 3(4), Franklin, Sept. 10, 1971, JMP; 3(11), Franklin, Sept. 17, 1971, JMP; 1(1), Franklin, Sept. 24, 1971, JMP; 1(1), Franklin, Oct. 27, 1971, JMP. *I. c.* var. *rotundifolia*: 1(5), Norfolk, Sept. 14, 1948, FRF. *Ilex* sp.: 1(1), Norfolk, April, 1938, AMW. *Syzygium* sp.: 9(9), Sydney, N.S. Wales, Oct. 19, 1970, D. P. Sands.

Notes: All previous records of *C. cirripediformis* Comstock from Virginia were found to be misidentifications of *C. sinensis* Del Guercio. These records were checked by the author, Mr. William Gimpel and Dr. Mike L. Williams through the Virginia slides in the USNM collection. Based

on this study and previous misidentifications, *C. cirripediformis* does not occur in Virginia. These two species are easily distinguished taxonomically. *Ceroplastes sinensis* has 7 antennal segments and the dorsal body seta are thickened, elongate, and slightly enlarged or pointed at the apex, while *C. cirripediformis* has 6 antennal segments and the dorsal body setae are shorter and more bulbous apically.

Ceroplastes sinensis found in Virginia is the same as *C. sinensis* found in Australia and California. The only differences noted by the author is in the coloration of the wax covering the adult female.

First Instar Nymph

Plate 9; Photoplate 2-A,B

DESCRIPTION: Body (fig. a) ovoid; length, 539 (430-669); width 301 (225-399); smoothly rounded anteriorly; widest at area of posterior spiracles, gradually tapering posteriorly; anal lobes bluntly rounded; derm membraneous and wrinkled with body segmentation showing both dorsally and ventrally.

DORSAL SURFACE:

Setae: 28 hairlike marginal setae (fig. b), 9.88 (8.80-12.7) long; 1 stout conical seta (fig. c) on each anal lobe, 15.6 (13.7-18.5) long; 1 pair stout conical setae in cephalic area (fig. d), 2.34 (1.98-3.22) long.

Spiracular setae (fig. e): 3 setae terminating spiracular pore band of both anterior and posterior furrows, positioned at margin of dermal fold, 2 outer setae, rounded and bullet shaped, 4.86 (4.14-5.45) long; median larger, slightly elongate and bluntly rounded, 6.67 (6.15-6.87) long.

Simple disc pores (fig. f): In 2 longitudinal rows; diameter, 1.22 (0.98-1.47); dorsal submarginal row with 11 pores, submedian row with 9 on each half.

Quinquelocular pores (fig. g): 1 circular pore just anterior to each eye; diameter, 2.16 (1.98-4.87).

Anal plates (fig. h): Triangular and heavily reticulated, 48.4 (42.0-54.3) long; 26.8 (24.1-29.6) wide; 4 stout conical apical setae on each

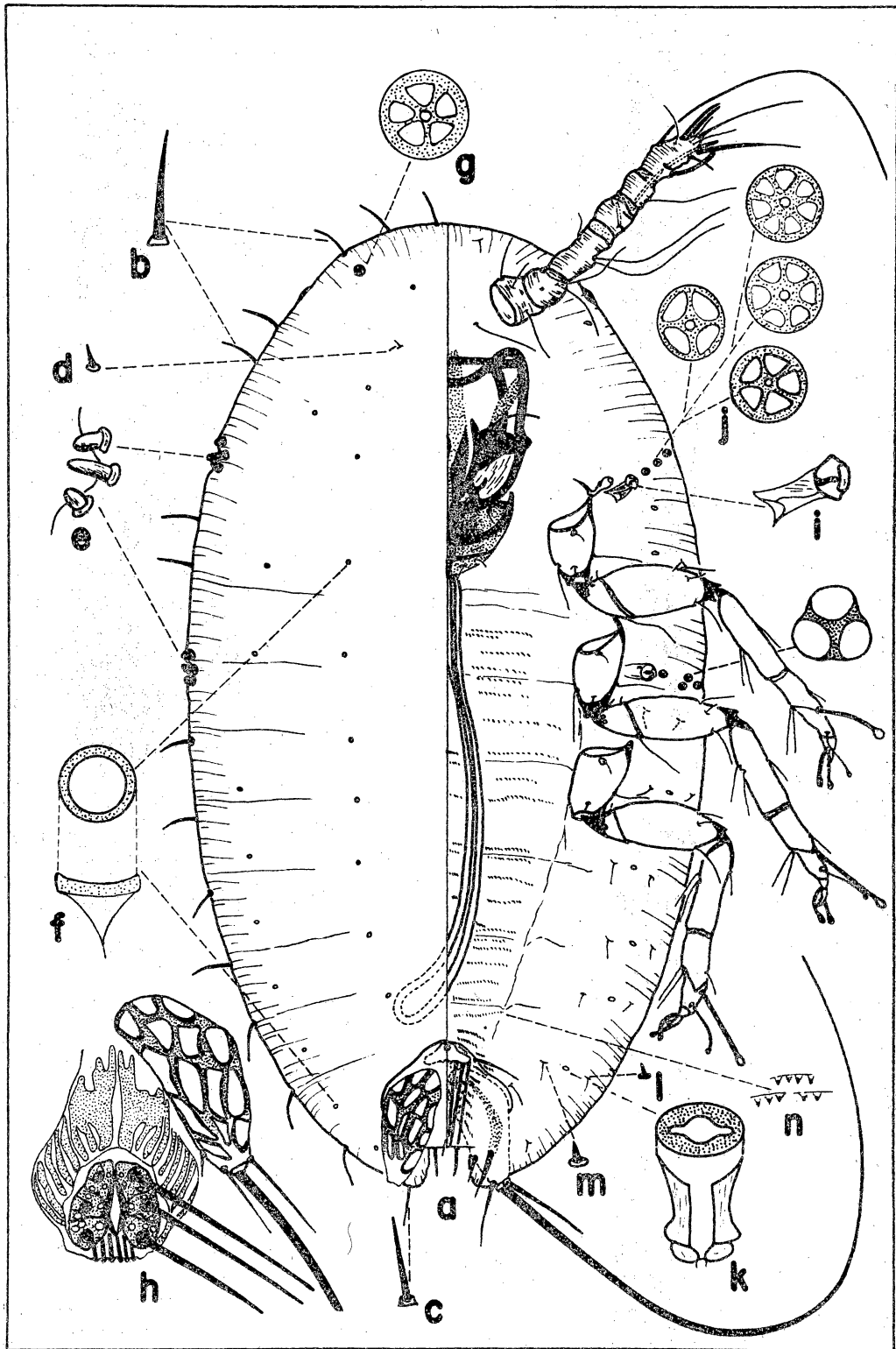


Plate 9.- *Ceroplastes sinensis* DelGuercio, first instar nymph

plate, main apical seta elongate, 306 (294-316) long, whiplike and tapering.

Anal ring (fig. h): Subcircular to ovoid 24.6 (22.2-27.2) long; 25.6 (24.7-27.2) wide; smoothly rounded and slightly notched cephalo-laterally, 6 groups of translucent pores, variable in number; 6 setae; 2 anterior, 57.6 (54.3-49.3) long; 2 median, 53.8 (46.9-56.8) long; 2 posterior, 37.6 (34.6-42.0) long; inner margin U-shaped; when everted anal ring rests on a partially sclerotized bulbous tube; ring heavily sclerotized.

VENTRAL SURFACE:

Eyes: Present and slightly convex.

Antennae: 6-segmented, 110 (93.9-129) long; scape, 11.6 (7.44-17.3) long, 15.6 (14.8-17.3) wide; segments II to VI, 15.0 (12.4-16.7), 27.2 (24.7-32.1), 9.88 (7.44-12.4), 12.7 (9.88-15.4), 33.6 (32.1-34.6) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae with a sensory pore on anterior margin; III, 2 very long and 1 short hairlike setae; IV, 1 stout fleshy blunt setae; V, 1 long hairlike and 1 fleshy blunt seta; VI, 4 stout fleshy setae, 3 short, 3 long, and 1 very long hairlike setae.

Clypeoplalbral shield: Length, 77.6 (74.1-81.5); width, 64.2 (61.8-69.2); 1 pair of long hairlike setae on middle of shield.

Labium: Bowl-shaped, apparently 2-segmented, 4 setae on each segment.

Legs: Tarsal digitules present 40.8 (37.1-44.5) long, and unequal in size; claw digitules present 20.9 (19.8-22.2) long and unequal in size, claw with denticle, 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	20.5 (19.8-27.2)	26.9 (24.7-29.6)	28.4 (22.2-32.1)
Trochanter	20.7 (19.8-22.2)	21.5 (17.3-27.2)	22.2 (17.3-27.2)
Femur	41.0 (34.6-44.5)	44.2 (37.1-49.4)	45.5 (39.5-51.9)
Tibia	43.0 (32.1-49.4)	47.7 (44.5-49.4)	44.7 (39.5-49.4)
Tarsus	34.6 (32.1-39.5)	36.1 (32.1-39.5)	36.5 (32.1-45.8)
Claw	13.0 (9.88-14.8)	13.6 (12.4-15.4)	14.7 (12.4-17.3)
Entire leg	173 (148-198)	190 (168-211)	192 (163-224)

Spiracles (fig. i): Anterior pair, 8.46 (7.44-9.88) long; atrium, 9.88 (6.24-12.4) wide; a row of 3 pores, predominantly 5-locular (occasionally 4-6-7-locular); anterior spiracle and furrow extending forward; posterior pair, 8.78 (7.44-10.5); atrium 9.88 (7.44-12.4) wide; a row of 4 pores, predominantly 3- and 5-locular (occasionally 4-6-7-locular); pore combinations variable (fig. j).

Cruciform pores (fig. k): A non-continuous submarginal row of 8 ovoid pores; diameter, 2.54 (2.22-2.93).

Setae: 2 pairs of hairlike setae between antennae; 2 longitudinal rows of bristlelike setae; 1 ventral submarginal row with 8 setae, 1.87 (1.56-2.23) long (fig. l), 7 on abdomen and 1 between spiracles; 1 submedian row with 7 setae, 3.76 (2.93-4.40) long (fig. m); all setae except those on first and last abdominal segments associated with cruciform pores; 1 pair long hairlike prevulvar setae 28.2 (20.5-32.2) long; 1 pair stout conical subapical setae; 1 pair stout conical setae on fringe of vulva.

Microspines (fig. n): Present anteriorly to base of mesothoracic coxae.

Material Studied: *Ilex crenate* var. *microphylla*: 10(34), Franklin, June 18, 1970, JMP; 8(26), Franklin, June 22, 1970, JMP; 20(58), (Greenhouse) Blacksburg, June 23, 1970, DKP; 16(40), Franklin, June 27, 1970, JMP; 9(29), Franklin, July 6, 1970, JMP; 5(16), (Greenhouse, Blacksburg, July 7, 1970, DKP; 17(52), Franklin, July 9, 1970, JMP; 11(39), Franklin, July 13, 1970, JMP; 13(28), Franklin, July 20, 1970, JMP; 7(12), Franklin, Aug. 3, 1970, JMP; 5(48), Franklin, June 23, 1971, JMP; 2(13), Franklin, July 2, 1971, JMP; 3(11), Franklin, July 7, 1971, JMP; 7(142), Franklin, July 12, 1971, JMP; 7(111), Franklin, July 21, 1971, JMP; 4(24), Franklin, July 30, 1971, JMP; 3(29), Franklin, Aug. 6, 1971, JMP.

Second Instar

Plate 10; Photoplate 2-C

DESCRIPTION: Body (fig. a) ovoid; length, 797 (714-835); width, 458 (371-497); tapering both anteriorly and posteriorly; widest behind posterior spiracles; anal lobes tapered and rounded; body segmentation showing ventrally; derm membranous.

DORSAL SURFACE:

Setae: 28 marginal hairlike setae (fig. b), 10.3 (8.68-11.7) long; 2 stout conical setae on each anal lobe 12.9 (8.80-18.5) long (fig. c).

Spiracular setae (fig. d): 3 stout elongate setae terminating the row of spiracular pores of both anterior and posterior furrows; positioned at margin of dermal fold; 2 smaller, 9.35 (8.38-12.7) long; larger, 12.8 (11.7-14.6) long; anterior furrow extending forward.

Simple disc pores (fig. e): 3 longitudinal rows of pores; 1 dorsal submarginal and 2 submedial, circular, diameter, 1.09 (0.98-1.47).

Anal plates (fig. f): Triangular, broadly and smoothly rounded laterally; 73.1 (69.2-76.6) long, 34.9 (32.1-37.1) wide; 4 stout conical apical setae on each plate; 2 or 4 sclerotized bars on each plate.

Anal ring (fig. f): Rectangular, 37.3 (34.6-39.5) long, 39.5 (34.6-42.0) wide; deeply notched on cephalolateral margins, and rounded; 6 groups of translucent pores, number of pores variable; 6 setae; 2 anterior, 86.5 (81.5-96.3) long; 2 median, 80.8 (74.1-88.9) long; 2 posterior, 67.4 (56.8-76.6) long; inner margin U-shaped; ring heavily sclerotized.

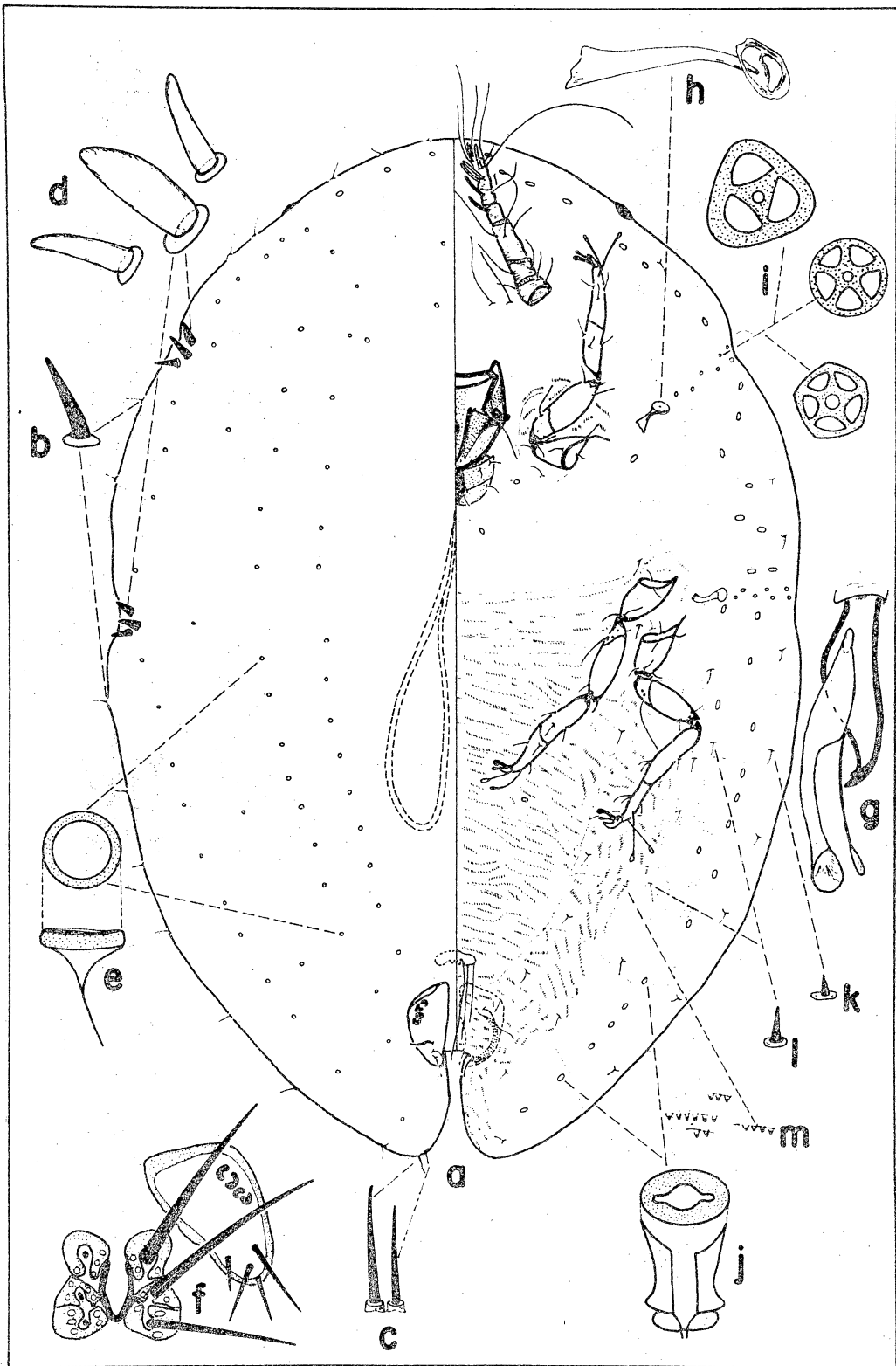


Plate 10. - *Ceroplastes sinensis* DelGuercio, second instar nymph

VENTRAL SURFACE:

Eyes: Present and ovoid.

Antennae: 6-segmented, 118 (101-133) long; scape, 12.5 (9.88-14.8) long, 22.0 (19.8-24.7) wide; segments II to VI; 16.6 (12.4-19.8), 33.4 (29.6-37.1), 13.5 (12.4-14.8), 14.6 (12.4-17.3), 27.7 (24.7-29.6) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae and a sensory pore on anterior margin, III, 2 long and 1 short hairlike setae; IV, 1 stout, fleshy, bluntly-rounded seta; V, 1 stout fleshy bluntly rounded seta and 1 long hairlike seta; VI, 4 stout fleshy setae, 3 short, 3 long, and 1 very long hairlike setae.

Clypeolabral shield: Length, 95.4 (86.5-106); width, 78.8 (74.1-81.5); one pair of long hairlike setae on middle of shield.

Labium: Bowl-shaped; apparently 2-segmented; 4 setae on each segment.

Legs: Tarsal digitules present 33.3 (29.6-39.5) long and unequal in size, 1 thickened, 1 slender, knobbed at tips; claw digitules present 20.5 (17.3-24.7) long and unequal in size; 1 broad, constricted at middle and expanded at tip, 1 slender and knobbed at tip; claw with denticle (fig. g); 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	28.4 (22.2-34.6)	26.2 (24.7-29.6)	29.4 (27.2-32.1)
Trochanter	24.6 (19.8-29.6)	24.2 (19.8-27.2)	27.9 (24.7-32.1)
Femur	49.2 (46.9-51.9)	52.6 (46.9-61.8)	50.9 (39.5-59.3)
Tibia	51.4 (46.9-54.3)	52.6 (49.4-56.8)	52.8 (44.5-56.8)
Tarsus	40.5 (37.1-44.5)	44.7 (39.5-51.8)	44.2 (42.0-49.4)
Claw	12.2 (9.88-12.4)	14.0 (12.4-15.5)	14.6 (12.4-16.8)
Entire leg	206 (183-227)	214 (193-243)	220 (190-249)

Spiracles (fig. h): Anterior pair, 23.2 (19.8-24.7) long; atrium,

13.0 (9.88-14.8) wide; a row of 5 to 8, 5-locular pores; anterior spiracle and furrow extending forward; posterior pair, 23.5 (19.8-27.2) long; atrium, 13.0 (10.5-14.8) wide; a row of 5 to 10 predominantly 5-locular (occasionally 3 locular) pores (fig. i).

Cruciform pores (fig. j): Concentrated in a submarginal pore band; few scattered in region of mouth and prothorax; diameter, 2.75 (2.48-2.93).

Setae: Two pairs of long hairlike setae between antennae, 3 longitudinal rows of bristlelike setae, 1-ventral submarginal row with 10 setae, 3.24 (2.76-3.90) long (fig. k); 2 submedian 2.22 (1.90-2.92) long (fig. l) (outer row with 8 setae; inner row with 9 setae); 1 pair of hairlike prevulvar setae 32.6 (28.3-36.1) long; 2 pairs of stout conical setae on fringe of vulval opening; 1 pair of stout conical subapical setae.

Microspines (fig. m): Heavily concentrated between 2 outer submedial rows of setae from vulva area to coxa of mesothoracic leg; a small patch anterior to each prothoracic coxa.

Material Studied: *Ilex crenata* var. *microphylla*: 7(10), Franklin, June 27, 1970, JMP; 1(1), Franklin, July 13, 1970, JMP; 8(14), Franklin, July 20, 1970, JMP; 19(34), Franklin, Aug. 3, 1970, JMP; 17(39), Franklin, Aug. 10, 1970, JMP; 10(20), Franklin, Aug. 17, 1970, JMP; 4(5), Franklin, Aug. 24, 1970, JMP; 1(1), Franklin, Aug. 31, 1970, JMP; 1(1), Franklin, Sept. 9, 1970, JMP; 1(3), Franklin, July 12, 1971, JMP; 1(1), Franklin, July 16, 1971, JMP; 4(17), Franklin, July 23, 1971, JMP; 4(22), Franklin, July 30, 1971, JMP; 4(29), Franklin, Aug. 6, 1971, JMP; 1(1), Franklin, Aug. 13, 1971, JMP; 3(12), Franklin, Aug. 24, 1971, JMP; 3(12), Franklin, Sept. 3, 1971, JMP.

Third Instar Nymph

Plate 11; Photoplate 2-C,D

DESCRIPTION: Body (fig. a) ovoid, tapering to a blunt point anteriorly on head and posteriorly on anal lobes; length, 943 (810-1022); width, 674 (568-815); widest behind spiracles, lacelike pore pattern showing dorsally; segmentation showing ventrally; derm membraneous.

DORSAL SURFACE:

Setae: 28 hairlike marginal setae (fig. b), 15.8 (14.6-17.6) long; a dorsal submarginal row of blunt setae (fig. c), 3.14 (2.44-4.78) long, with an expanded rounded tip and occasionally with a slightly pointed apex; 3 stout conical setae, 19.6 (11.7-30.3) long on each anal lobe (fig. d).

Spiracular setae (fig. e): 8 (7-10) stout rounded setae, 7 to 9 smaller, 9.88 (8.78-10.7) long; larger, 17.0 (15.6-17.6) long, angled apically (occasionally the large setae may be bifurcate), terminating spiracular pore band of anterior and posterior spiracular furrows, positioned at margin of dermal fold.

Pores: Arranged in a lacelike pattern on dorsum with 1 cephalic, 3 lateral and 1 caudal membraneous area without pores or setae.

Bilocular pores (fig. f): Numerous, predominant pore in dorsal pore pattern, ovoid and smoothly rounded; diameter, 2.75 (2.44-3.46).

Trilocular pores (fig. g): Scattered evenly over median and marginal areas of dorsum, ovoid and smoothly rounded; center opening of pore raised above the 2 lateral openings; diameter, 4.10 (3.68-4.91);

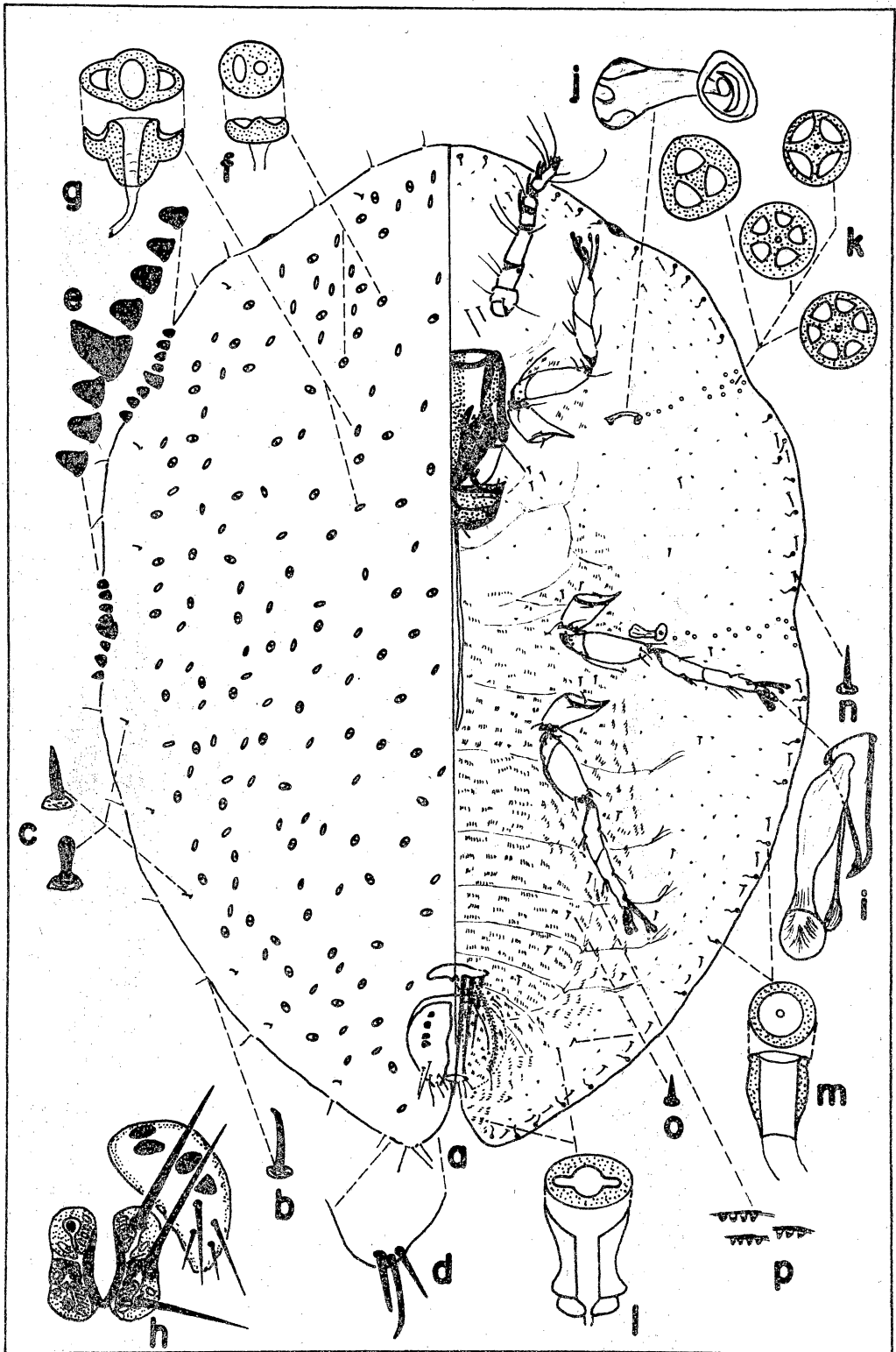


Plate II.- *Ceroplastes sinensis* DelGuercio, third instar nymph

occasionally a triangular trilocular as on adult (Plate 8; fig. 1).

Anal plates (fig. h): Triangular, broadly rounded, 98.2 (86.5-109) long; 46.5 (42.0-50.0) wide; 4 stout conical apical setae on each plate; 3 or 4 sclerotized ovals on each plate.

Anal ring (fig. h): Rectangular, 46.3 (42.0-49.6) long; 45.9 (42.0-49.6) wide, with shallow depression on lateral margins of ring; 6 groups of translucent pores present, number per group variable; 6 setae; 2 anterior, 120 (96.3-141) long; 2 median, 111 (90.7-121) long; 2 posterior, 101 (83.7-111) long; inner margin U-shaped; ring heavily sclerotized.

VENTRAL SURFACE:

Eyes: Present and ovoid.

Antennae: 6-segmented, 150 (135-166) long; scape, 12.4 (11.7-13.0) long, 23.7 (19.8-29.6) wide; segments II to VI; 22.1 (19.8-24.7), 52.1 (46.9-56.8), 16.1 (14.8-19.8), 16.6 (12.4-19.8), 30.6 (29.6-32.1) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae, sensory pore on anterior margin; III, 2 long, 1 short hairlike setae; IV, 1 fleshy, bluntly rounded setae; V, 1 fleshy bluntly rounded seta, 1 long hairlike seta; VI, 4 fleshy blunt setae, 3 short, 3 long, 1 very long hairlike setae.

Clypeolabral shield: Length, 117 (111-124); width, 103 (101-106); 1 pair long hairlike setae on middle of shield.

Labium: Bowl-shaped; apparently 2-segmented, 4 setae on each segment.

Legs: Tarsal digitules present and unequal in size, 1 thickened and 1 slender, 42.8 (37.1-46.9) long, both with knobbed tips; claw digitules

present and unequal in size, 27.8 (24.7-29.6) long, 1 broad and expanded at tip and 1 slender and knobbed at tip; claw with denticle (fig. i); 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	31.9 (24.7-42.0)	39.6 (34.6-49.4)	41.8 (37.1-49.4)
Trochanter	30.4 (24.7-39.6)	37.4 (29.6-44.5)	34.8 (27.2-42.0)
Femur	66.2 (56.8-76.6)	69.2 (59.2-84.0)	68.9 (56.8-79.0)
Tibia	60.3 (51.9-66.7)	64.0 (56.8-76.6)	57.3 (51.6-61.8)
Tarsus	50.2 (46.9-54.3)	54.6 (49.4-59.2)	53.9 (49.4-59.3)
Claw	16.1 (14.8-17.3)	18.4 (17.3-19.8)	18.5 (14.8-22.2)
Entire leg	255 (220-297)	283 (247-334)	275 (237-314)

Spiracles (fig. j): Anterior pair, 29.0 (24.7-34.6) long; atrium, 19.8 (17.3-22.2) wide; band of 12 (11-15) pores, primarily 4- and 5-locular (occasionally 3- and 6-locular) (fig. k), 2 to 3 pores wide at margin, anterior furrow extending forward; posterior pair, 30.9 (24.7-37.1) long; atrium, 20.0 (17.3-22.2) wide; band of 14 (12-17) pores, predominantly 5 locular (occasionally 3-4- and 6-locular), 3 to 4 pores wide at margin.

Cruciform pores (fig. l): Ovoid, concentrated in a submarginal band, few scattered over cephalothoracic region; diameter, 2.98 (2.91-3.14).

Filamentous ducts (fig. m): Circular, marginal row of ducts, opening on border between dorsal and ventral surface, diameter, 1.33 (1.04-1.74).

Setae: Two pairs of hairlike setae between antennae, 1 long, 1 short; 3 longitudinal rows of setae; 1 ventral submarginal row of conical bristlelike setae 6.46 (3.90-6.78) long (fig. n); 2 submedial rows of bristlelike setae 3.44 (2.93-3.90) long (fig. o); (outer row with

11 setae, inner row with 6 setae); 2 setae at base of meso- and meta-thoracic coxae; 3 setae at base of prothoracic coxa; 1 pair hairlike prevulvar seta 38.5 (29.3-48.8) long, 3 pairs of stout conical setae on fringe of vulva; 1 pair stout conical subapical setae.

Microspines (fig. p): Heavily concentrated on abdomen and thorax to mesothoracic coxa and in small patch near base of prothoracic coxa.

Material Studied: *Ilex crenata* var. *microphylla*: 1(1), Franklin, Aug. 3, 1970, JMP; 3(3), Franklin, Aug. 10, 1970, JMP; 6(8), Franklin, Aug. 17, 1970, JMP; 9(23), Franklin, Aug. 24, 1970, JMP; 12(31), Franklin, Aug. 31, 1970, JMP; 12(34), Franklin, Sept. 9, 1970, JMP; 5(5), Franklin, Sept. 14, 1970, JMP; 7(13), Franklin, Sept. 21, 1970, JMP; 3(32), Franklin, Aug. 13, 1971, JMP; 3(8), Franklin, Aug. 24, 1971, JMP; 3(13), Franklin, Sept. 3, 1971, JMP; 3(12), Franklin, Sept. 10, 1971, JMP; 1(3), Franklin, Sept. 24, 1971, JMP.

Ceroplastes floridensis Comstock, 1881

Adult Female

Florida Wax Scale

Plate 12; Photoplate 3-D

Ceroplastes floridensis Comstock, 1881:331; 1883:131; 1888:143; 1916:480; Voyle, 1883:20; Hubbard, 1885:56; Riley and Howard, 1889:325; 1890:367; Cockerell, 1893:80; 1895:5; 1899:191; Morgan, 1893:66; Riley, 1894:69; Howard, 1897:39; 1911:276; Green, 1899:191; 1900:8; 1907:200; 1909:277; 1921:258; Gossard, 1900:117; Hempel, 1900:462; Marlatt, 1900:277; King, 1901:193; Fernald, 1903:152; Carnes, 1907:155; Green and Mann, 1907:340; Saunders, 1909:1883; Ballou, 1912:453; 1926:14; Herrick, 1911:10; Berger, 1917:72; Watson, 1918:170; 1926:322; Morrison, 1921:637; Hall, 1923:38; Merrill and Chaffin, 1923:256; 1923:87; Steinweden, 1929:231; Balachowsky, 1933:79; Bodenheimer, 1935:3; 1952:112; Cheo, 1935:95; Dozier, 1935:183; Matorell, 1939:193; 1945:396; Ferris, 1950:75; Merrill, 1953:85; Dickson and Heschner, 1955:614; Brimblecombe, 1956:5; 1962:224; Borchsenius, 1957:459, Simmonds, 1957:7; LePelley, 1959:36; Das and Ganguli, 1961:245; Ezzat and Hassein, 1962:359; Dekle, 1963:1; Ezzat and Rawhy, 1966:24; Gilio-mee, 1966:419; Rosen, 1967:252; 1967:1422; Ali, 1968:120; Amitai, 1969:89; 1969:168; 1970:15; Ben-Dov, 1970a:84; 1970b:273; 1970c:1998; Pollet, 1971:100; Misidentifications: *C. rusci*: Ashmead 1880:252; *Cerostegia floridensis*: De Lotto, 1969:211.

DESCRIPTION: Body (fig. a) ovoid, bluntly rounded anteriorly, slightly notched at spiracular margins; length, 1996 (1416-2643);

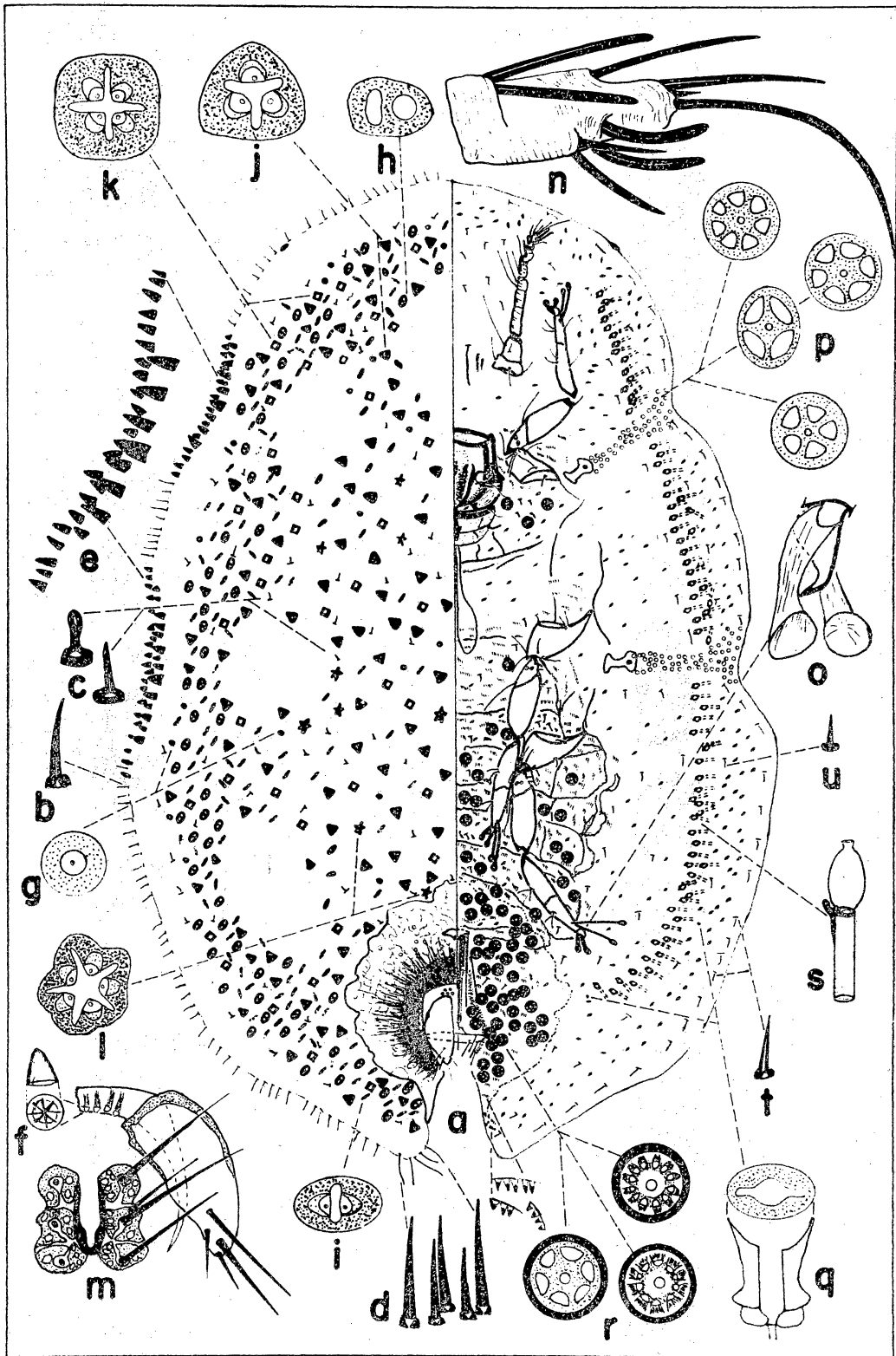


Plate 12. - *Ceroplastes floridensis* Comstock, adult female

width, 1230 (1101-1556); widest behind posterior spiracles; anal lobes tapered and rounded; lacelike pore pattern on dorsal surface; anal plates surrounded by sclerotized dermal shield; segmentation distinct and a noncontinuous band of tubular ducts visible on ventral surface; derm membranous except in older or dead specimens.

DORSAL SURFACE:

Setae: 118 to 140 hairlike marginal setae (fig. b), 18.5 (14.6-21.5) long; 1 submarginal and 1 submedian row of blunt setae (fig. c), 3.67 (2.92-4.91) long, with an expanded rounded tip and occasionally with a slightly pointed apex; few scattered over rest of dorsal surface; 3 to 5 stout conical setae 49.6 (39.0-58.6) long (fig. d), on each anal lobe, number may vary between lobes of same specimen.

Spiracular setae (fig. e): 29 (26-37) anterior and 34 (29-42) posterior, stout conical spiracular setae in 3 rows, terminating spiracular pore bands of anterior and posterior furrows, positioned at margin of dermal fold; 11.3 (9.88-12.7), 15.0 (13.7-17.6), 20.1 (19.5-22.5) long, respectively.

Pores: Arranged in a lacelike pattern dorsally with 1 cephalic and 6 lateral membranous areas without pores or setae.

Conical disc pores (fig. f): 6 to 10 on lip of sclerotized shield cephalid of anal plates, 3.54 (2.92-4.46) high, 3.11 (2.92-3.90) wide.

Monolocular ring pores (fig. g): Few scattered throughout pore pattern; circular, with thick sclerotized margin and small central opening; 2.67 (1.91-3.90) in diameter.

Bilocular pores (fig. h): Numerous in marginal area of pattern,

occasionally found in median area; ovoid; 2.92 (2.92) in diameter.

Bilocular-barred pores (fig. i): Numerous, scattered over derm; ovoid, 4.67 (3.90-4.91) in diameter.

Trilocular pores (fig. j): Prominant, scattered throughout pattern; triangular, 5.68 (4.88-5.86) in diameter; this pore and bilocular-barred pores are the most common types on specimens, either one or the other predominates.

Quadrilocular pores (fig. k): Numbers variable on specimens; scattered over derm; square, 4.91 (3.90-5.86) in diameter.

Quinquelocular pores (fig. l): Very few, not found in all specimens, usually in caudal area of pore pattern; star-shaped, 7.81 (7.81) in diameter.

Anal plates (fig. m): Triangular, tapered apically; 118 (114-121) long, 50.9 (49.4-54.3) wide; 4 stout conical apical setae on each plate.

Anal ring (fig. m): Ovoid, notched twice on each lateral margin, 59.8 (56.8-64.2) long, 60.6 (56.8-61.8) wide; 6 groups of translucent pores, number of pores variable; 8 setae, 2 anterior, 193 (187-203) long; 4 median, 175 (146-198) and 112 (104-124) long; 2 posterior, 157 (136-181) long; inner margin U-shaped; open apically; ring heavily sclerotized.

VENTRAL SURFACE:

Eyes: Present and slightly ovoid.

Antennae: 6-segmented, 216 (198-240) long; scape, 22.5 (17.3-27.2) long, 35.1 (32.1-39.5) wide; segments II to VI, 32.1 (29.6-34.6), 98.1 (93.9-106), 16.6 (12.4-19.8), 16.1 (14.8-17.3), 30.9 (29.6-34.6) long,

respectively; scape with 3 moderately long setae; II, 1 long, 1 short hairlike setae, and a sensory pore on anterior margin, III, 2 long and 1 short hairlike setae; IV, 1 thick fleshy blunt setae; V, 1 thick fleshy blunt and 1 long hairlike setae; VI, 4 thick fleshy blunt setae and 3 short, 2 long and 1 very long hairlike seta (fig. n).

Clypeolabral shield: Length, 134 (121-148); width, 132 (124-136); 1 pair long hairlike setae on middle of shield.

Labium: Bowl-shaped; apparently 2-segmented, 4 setae on each segment; Koteja (Personal communications, 1971) reported 2 additional setae at apex; on examining 25 specimens these setae were not observed.

Legs: Tarsal digitules, 43.2 (34.6-49.4) long, slender, both knobbed at tips; claw digitules, 28.7 (27.2-32.1) long, broad, expanded at tips (fig. o); 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	55.1 (49.4-64.2)	62.5 (56.8-66.7)	66.8 (61.8-69.2)
Trochanter	42.0 (37.1-49.4)	47.7 (41.9-54.3)	47.2 (42.0-49.4)
Femur	93.4 (79.0-98.8)	95.1 (86.5-98.8)	96.8 (86.5-104)
Tibia	92.6 (91.4-96.4)	95.5 (91.4-98.8)	96.4 (91.4-101)
Tarsus	56.6 (49.4-59.3)	62.3 (56.8-66.7)	61.8 (54.3-66.7)
Claw	15.5 (14.8-17.3)	18.1 (17.3-19.8)	18.8 (17.3-19.8)
Entire leg	355 (321-385)	381 (351-405)	388 (353-410)

Spiracles: Anterior pair, 36.3 (32.1-49.4) long; atrium, 36.4 (32.1-39.6) wide; a band of 46 (36-56) pores, predominantly 5- and 6-locular (occasionally 4- and 7-locular) (fig. p); 3 to 5 pores wide at margin; anterior furrow extending forward; posterior pair, 38.3 (34.6-41.9) long; atrium, 39.1 (37.1-42.0) wide; a band of 59 (41-72) pores, 5

locular predominantly (occasionally 4-6- and 7-locular); 3 to 5 pores wide at margin.

Cruciform pores (fig. q): Concentrated in a marginal band, few scattered over remainder of ventral surface; ovoid, 3.00 (2.92-3.41) in diameter.

Multilocular pores (fig. r): Heavy concentrations near vulva area 6.76 (5.82-7.78) in diameter; few scattered over medial and submedial area of ventrum, no consistent number or arrangement of pores; 6-10- and 12-locular.

Tubular ducts (fig. s): Noncontinuous, submarginal band of ducts; 24.0 (15.6-37.1) long; 3.74 (2.92-4.91) wide; with everted inner filament; 10.3 (8.81-12.7) long, 6.45 (5.86-6.78) wide.

Setae: 3 pairs variable length hairlike setae between antennae; a longitudinal ventral submarginal row of conical setae 8.91 (7.87-11.7) long (fig. t); spikelike setae scattered over rest of ventral surface 6.14 (4.91-6.86) long (fig. u); 1 pair long hairlike prevulvar setae, 60.9 (54.7-64.4) long, 3 pairs stout conical setae on fringe of vulva; 2 or 3 pairs bristlelike hypopygial setae; 1 pair stout conical subapical setae.

Microspines (fig. v): Concentrated around vulva; anterior to base of mesothoracic coxae; a small patch at base of each prothoracic coxa.

Material Studied: *Brassalia* sp.: 5(5), Fairchild Gardens, Ga., March 21, 1968, MLW. *Citrus mitis*: 1(4), greenhouse Burke Ave., Baltimore, Md., Oct. 30, 1961, C. W. McComb. *Gardenia* sp.: 1(2), Richmond, Mar. 12, 1941, FRF. *Ilex cornuta* var. *Burfordii*: 4(4), VPI greenhouse, Blacksburg, Jan. 16, 1968, MLW; 4(8), VPI greenhouse,

Blacksburg, March 3, 1969, MLW; 6(6), Richmond, Sept. 15, 1970, FRF; 6(7), (greenhouse) Blacksburg, Oct. 28, 1970, DKP; 8(15), (greenhouse) Blacksburg, Nov. 12, 1970, DKP; 13(14), (greenhouse) Blacksburg, Nov. 30, 1970, DKP; 9(15), (greenhouse) Blacksburg, Dec. 30, 1970, DKP. *Ilex vomitoria*: 8(21), Baton Rouge, La., March 20, 1970, A. D. Oliver. *Ilex* sp.: 1(1), Spalding Co., Ga., Oct. 21, 1966, H. H. Tippens.

Notes: *Ceroplastes floridensis* is a non-established species in Virginia, periodically brought into the state on nursery stock. Although prolific and having more than one generation a year, it is apparently unable to survive the winter in Virginia.

De Lotto (1969) in a partial revision of the genus has changed the Florida wax scale from *Ceroplastes* to *Cerostegia*.

First Instar Nymph

Plate 13; Photoplate 3-A

DESCRIPTION: Body (fig. a) ovoid, blunt anteriorly, length, 471 (341-622); width, 262 (178-350); slightly tapering posteriorly, widest between meso- and metathoracic segments; anal lobes bluntly rounded; derm membranous and wrinkled marginally; body segmentation apparent both dorsally and ventrally.

DORSAL SURFACE:

Setae: 26 hairlike marginal setae (fig. b), median pair cephalic marginal setae, 10.9 (9.88-11.7) long, remainder, 7.35 (6.78-7.84) long; 1 stout conical seta (fig. c) on each anal lobe; 10.9 (10.7-11.7) long.

Spiracular setae (fig. d): 3 stout setae terminating the row of spiracular pores of both anterior and posterior furrows, positioned at margin of dermal fold; 2 outer setae, 0.98 (0.98) long, rounded and bullet shaped; middle seta, 1.90 (0.98-2.19) long, bullet shaped, and slightly curved.

Simple disc pores (fig. e): 2 longitudinal rows of pores, 1.10 (0.98-1.22) in diameter; 1 row submedian, with 7 pores; other row submarginal, with 12 pores.

Trilocular pores (fig. f): 1 triangular in shape, just anterior to eye; diameter, 1.64 (1.53-1.79).

Anal plates (fig. g): Triangular and smoothly rounded, 37.1 (37.1) long, 18.3 (17.3-19.8) wide; tapering caudolaterally, apex blunt, 4 stout conical apical setae on each plate, main apical seta elongate,

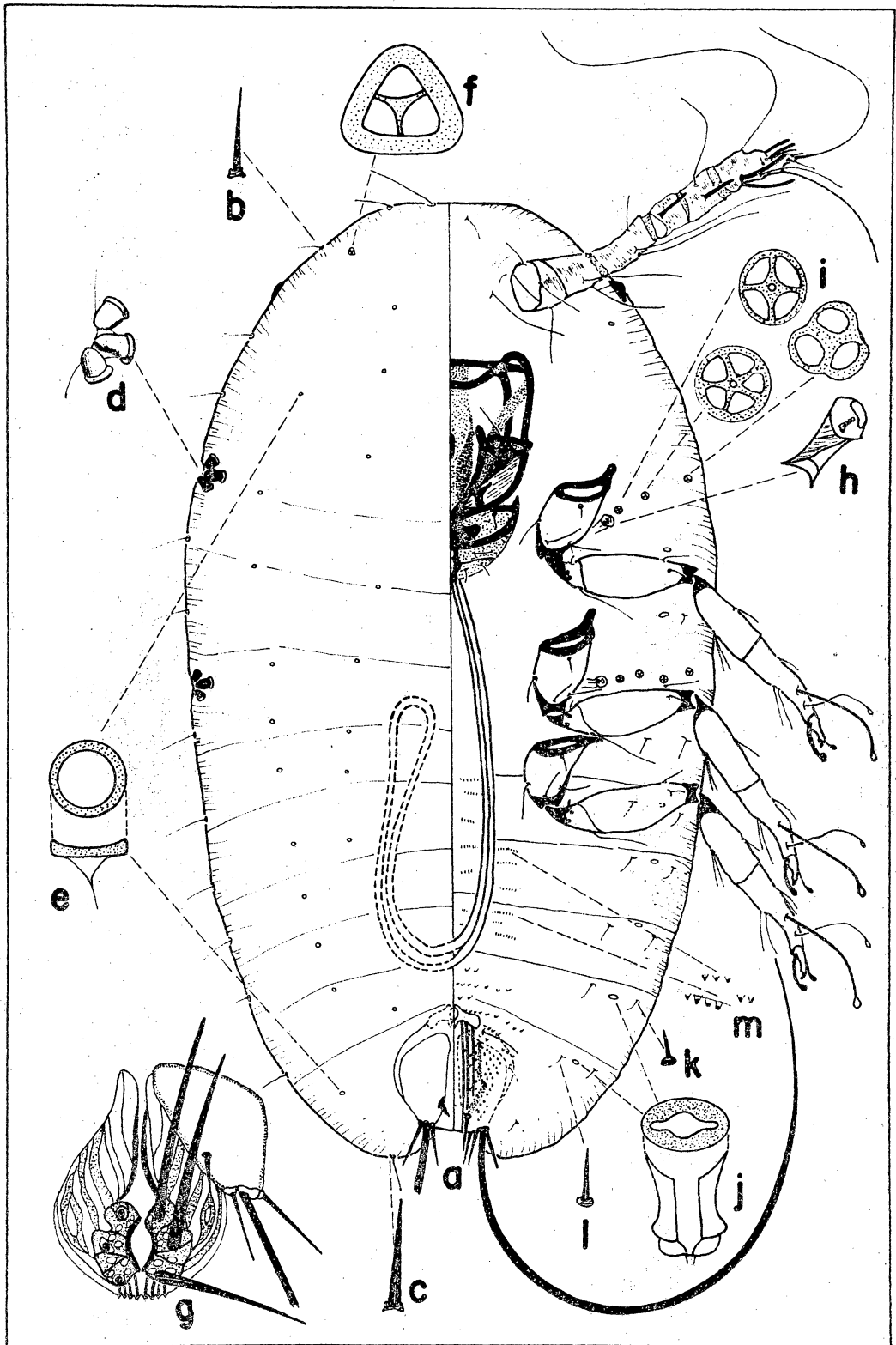


Plate 13.- *Ceroplastes floridensis* Comstock, first instar nymph

221 (206-230) long, whiplike and tapering.

Anal ring (fig. g): Slightly elliptical, 20.1 (19.8-22.2) long, 19.5 (17.3-19.8) wide, deeply notched on cephalolateral margins; 6 groups of translucent pores, variable in number; 6 setae, 2 anterior, 42.5 (42.0-44.5) long; 2 median, 40.0 (39.5-42.0) long; 2 posterior, 25.0 (22.2-24.7) long; inner margin U-shaped, open apically, closed basally, and heavily sclerotized; when everted anal ring rests on a lightly sclerotized eversible tube.

VENTRAL SURFACE:

Eyes: Present and slightly conical.

Antennae: 6-segmented, 91.7 (84.0-106) long; scape, 10.4 (9.88-12.4) long, 18.5 (17.3-19.8) wide; segments II to VI, 12.6 (12.4-14.8), 23.3 (22.2-24.7), 8.65 (7.41-9.88), 11.9 (9.88-14.8), 25.0 (22.2-29.6) long, respectively, scape with 3 moderately long setae; II, 2 long hairlike setae and a sensory pore on anterior margin; III, 2 very long and 1 short hairlike setae; IV, 1 thick fleshy blunt seta; V, 1 thick fleshy blunt seta and 1 moderately long hairlike seta; VI, 4 fleshy blunt setae and 3 short, 3 long and 1 very long hairlike setae.

Glypeolabral shield: Length, 64.2 (64.2); width, 54.4 (54.4); 1 pair of long hairlike setae on middle of shield.

Labium: Bowl-shaped; apparently 2-segmented, 4 setae on each segment,

Legs: Tarsal digitules present, 33.1 (29.6-34.6) long, and unequal in size; claw digitules present, 17.3 (14.8-19.8) long, and unequal in size; claw with denticle; 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	20.5 (19.8-22.2)	23.7 (22.2-24.7)	23.5 (22.2-24.7)
Trochanter	16.8 (14.8-17.3)	16.5 (14.2-17.3)	16.8 (14.8-17.3)
Femur	34.6 (32.1-37.1)	36.1 (34.6-42.0)	38.5 (34.6-44.5)
Tibia	35.3 (34.6-37.1)	37.1 (34.6-39.5)	36.3 (34.6-37.1)
Tarsus	27.2 (24.7-29.6)	27.2 (24.7-29.6)	27.2 (24.7-29.6)
Claw	9.88 (7.41-12.4)	10.3 (9.88-12.4)	10.1 (9.88-12.4)
Entire leg	144 (138-151)	151 (140-161)	152 (142-163)

Spiracles (fig. h): Anterior pair, 9.88 (9.88) long; atrium, 4.94 (4.94) wide; a row of 3 pores, 3- and 5-locular predominantly (occasionally 4-locular) (fig. i); anterior furrow extending forward slightly; posterior pair, 8.26 (7.41-9.88) long; atrium, 4.24 (2.47-4.90) wide; a row of 4 pores, predominantly 3- and 5-locular (occasionally 4-locular); pore combinations variable.

Cruciform pores (fig. j): In a noncontinuous submarginal row of 8 ovoid pores; diameter, 2.14 (1.98-2.93).

Setae: 2 rows of hairlike setae between antennae; 2 longitudinal rows of bristlelike setae; 1 ventral submarginal row with 8 setae, 2.22 (1.48-2.93) long (fig. k), 1 submedian row with 6 setae, 4.26 (2.93-4.90) long (fig. l); all except those of first abdominal segment associated with cruciform pores; 1 pair stout conical subapical setae; 1 pair stout conical setae on fringe of vulva; 1 pair of hairlike prevulvar setae, 23.9 (21.5-26.4) long.

Microspines (fig. n): Heavily concentrated near vulva, becoming lighter anteriorly to base of hind coxae.

Material Studied: *Ilex cornuta* var. *Burfordii*: 16(51), (greenhouse)

Blacksburg, Sept. 15, 1970, DKP; 2(4), (greenhouse) Blacksburg, Oct. 1, 1970, DKP.

Note: First instar nymphs of both *C. floridensis* and *C. ceriferus* are very similar. The median pair of cephalic marginal setae are longer than the remaining marginal setae in *C. floridensis* and equal in *C. ceriferus*.

Second Instar Nymph

Plate 14; Photoplate 3-B

DESCRIPTION: Body (fig. a) ovoid, slightly tapering both anteriorly and posteriorly; length, 674 (655-835); width, 422 (390-511); widest between meso- and metathoracic segments; anal lobes tapered and bluntly rounded; body segmentation not showing dorsally or ventrally, based on ventral setal arrangements 7 segments can be visualized.

DORSAL SURFACE:

Setae: 26 marginal hairlike setae (fig. b), 8.24 (6.78-9.88) long, 2 stout conical setae on each anal lobe, 13.6 (10.7-16.6) long (fig. c).

Spiracular setae (fig. d): 3 large elongate setae terminating rows of spiracular pores of both anterior and posterior furrows, positioned at margin of dermal fold; 2 smaller, 9.54 (8.78-10.7) long; larger, 14.1 (13.7-15.6); anterior furrow extending forward.

Simple disc pores (fig. e): 3 irregular longitudinal rows of circular pores, 1.22 (0.98-1.47) in diameter; 1 submarginal and 2 submedian, 6 transverse rows of 1 or 2 pores connecting the submarginal and outer submedian rows of pores.

Anal plates (fig. f): Triangular, broadly rounded laterally, 50.9 (49.4-51.9) long, 27.4 (24.7-29.6) wide; 4 stout conical setae on each plate.

Anal ring (fig. f): Ovoid; 29.1 (27.2-32.1) long, 30.1 (27.2-32.1) wide; slightly notched on cephalolateral margins; 6 groups of translucent pores, pore numbers variable; 6 setae; 2 anterior, 82.5

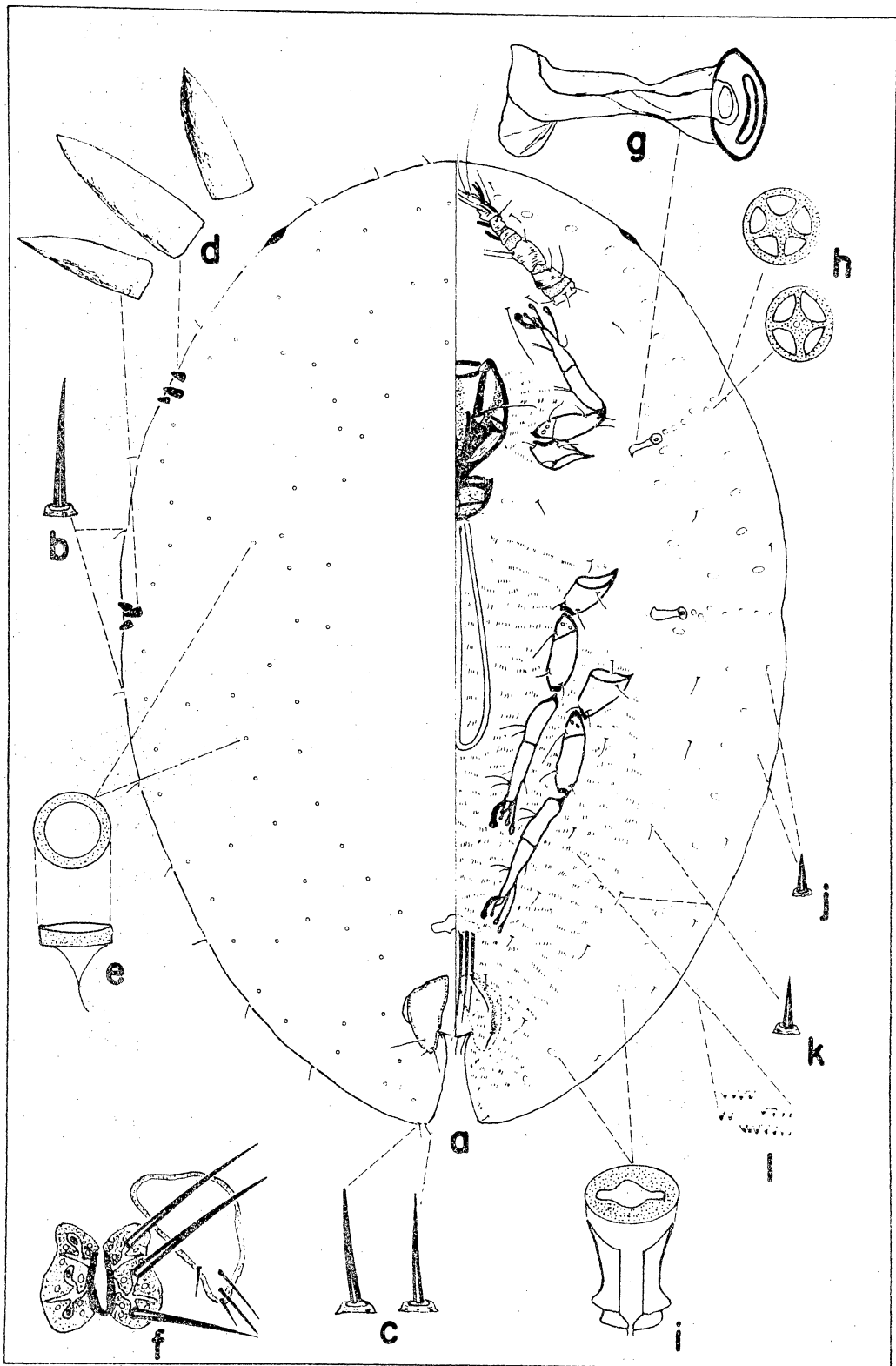


Plate 14.- *Ceroplastes floridensis* Comstock, second instar nymph

(71.6-88.9) long; 2 median, 68.2 (69.2-79.0) long; 2 posterior, 56.8

(49.4-71.6) long; inner margin U-shaped; ring heavily sclerotized.

VENTRAL SURFACE:

Eyes: Present and ovoid.

Antennae: 6 segmented, III (96.4-126) long; scape, 11.1 (9.88-12.4) long; 15.6 (12.4-17.3) wide; segments II to VI; 13.8 (12.4-14.8), 27.9 (24.7-29.6), 8.45 (7.41-9.88), 9.14 (7.41-14.8), 24.7 (22.2-27.2) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae and sensory pore on anterior margin; III, 2 long hairlike setae and sensory pore on anterior margin; IV, 1 stout fleshy seta; V, 1 stout fleshy and 1 long hairlike seta; VI, 4 stout fleshy setae and 3 short, 3 long, and 1 very long hairlike setae.

Clypeolabral shield: Length, 85.0 (81.8-86.5); width, 77.3 (69.2-79.0); 1 pair of long hairlike setae on middle of shield.

Labium: Bowl-shaped; apparently 2 segmented, 4 setae on each segment.

Legs: Tarsal digitules present, 25.2 (19.8-32.1) long and unequal in size, 1 thickened, 1 slender, both knobbed on tips, claw digitules present, 14.8 (12.4-17.3) long and unequal in size; 1 broad and expanded at tip, 1 slender and knobbed at tip; 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	23.5 (19.8-24.7)	24.7 (22.2-29.6)	23.9 (19.8-24.7)
Trochanter	19.3 (17.3-24.7)	22.7 (22.2-24.7)	21.2 (17.3-24.7)
Femur	37.8 (37.1-42.0)	36.1 (27.2-39.6)	40.1 (34.6-42.0)
Tibia	39.8 (37.1-42.0)	43.0 (42.0-46-9)	43.2 (42.0-44.5)
Tarsus	36.1 (34.6-37.1)	40.1 (37.1-44.6)	38.1 (37.1-42.0)
Claw	8.24 (7.41-9.88)	10.7 (9.88-12.4)	10.2 (7.41-12.4)
Entire leg	165 (153-180)	177 (161-198)	177 (158-190)

Spiracles (fig. g): Anterior pair, 23.5 (22.2-24.7) long; atrium, 10.6 (9.88-12.4) wide; a row of 5 to 8 pores, predominantly 5-locular, occasionally 4-locular (fig. h); poster pair, 22.2 (19.8-24.7) long; atrium, 10.4 (9.88-12.4) wide; a row of 6 to 8 pores, primarily 5-locular, occasionally 4-locular.

Cruciform pores (fig. i): A submarginal row of ovoid pores, with 1 or 2 near labium; diameter, 2.54 (2.23-2.93).

Setae: 1 long and 1 short hairlike setae between antennae; 3 longitudinal rows of setae; 1 ventral submarginal row with 9 setae 3.85 (3.44-3.90) long (fig. j); 2 submedial rows 2.23 (1.98-2.93) long, inner row with 8 setae, outer row with 9 setae (fig. k); 1 pair long hairlike prevulvar setae 84.6 (61.8-96.3) long; 2 pairs stout conical fringe setae; 1 pair of stout conical subapical setae.

Microspines (fig. l): Heavy concentrated near vulva; anterior to mesothoracic coxae; a small patch near base of prothoracic coxae.

Material Studied: *Ilex cornuta* var. *Burfordii*: 13(25), (greenhouse) Blacksburg, Oct. 1, 1970, DKP; 4(4), (greenhouse) Blacksburg, Oct. 14, 1970, DKP.

Third Instar Nymph

Plate 15: Photoplate 3-C

DESCRIPTION: Body (fig. a) ovoid, rounded anteriorly and posteriorly; length, 922 (839-1016); width, 648 (600-730); widest in area of posterior spiracles; lacelike pore pattern showing dorsally; segmentation distinct ventrally; anal lobes rounded.

DORSAL SURFACE:

Setae: 60 to 68 marginal hairlike setae (fig. b), 11.9 (9.88-13.7) long; 1 longitudinal submarginal row of blunt setae (fig. c), 3.00 (1.98-3.90) long, with an expanded rounded tip and occasionally with a slightly pointed apex; 3 stout conical setae, 25.5 (24.4-27.3) long, on each anal lobe (fig. d).

Spiracular setae (fig. e): 12 (10-14) anterior and 13 (10-16) posterior stout conical spiracular setae; large seta, 16.4 (14.6-18.5) long, may be forked or toothed apically; 9 to 15 smaller setae, 11.6 (9.88-13.7) long; terminating the spiracular pore bands of both anterior and posterior furrows, positioned at margin of dermal fold.

Pores: Arranged in a lacelike pattern dorsally with 3 cephalic, 1 caudal, and 8 lateral membraneous areas without pores or setae.

Monolocular ring pores (fig. f): Few scattered in pore pattern, circular; diameter, 2.46 (1.98-2.93).

Bilocular pores (fig. g): Numerous over dorsal surface; ovoid; diameter, 3.14 (2.92-3.91).

Bilocular barred pores (fig. h): Many in pore pattern; ovoid;

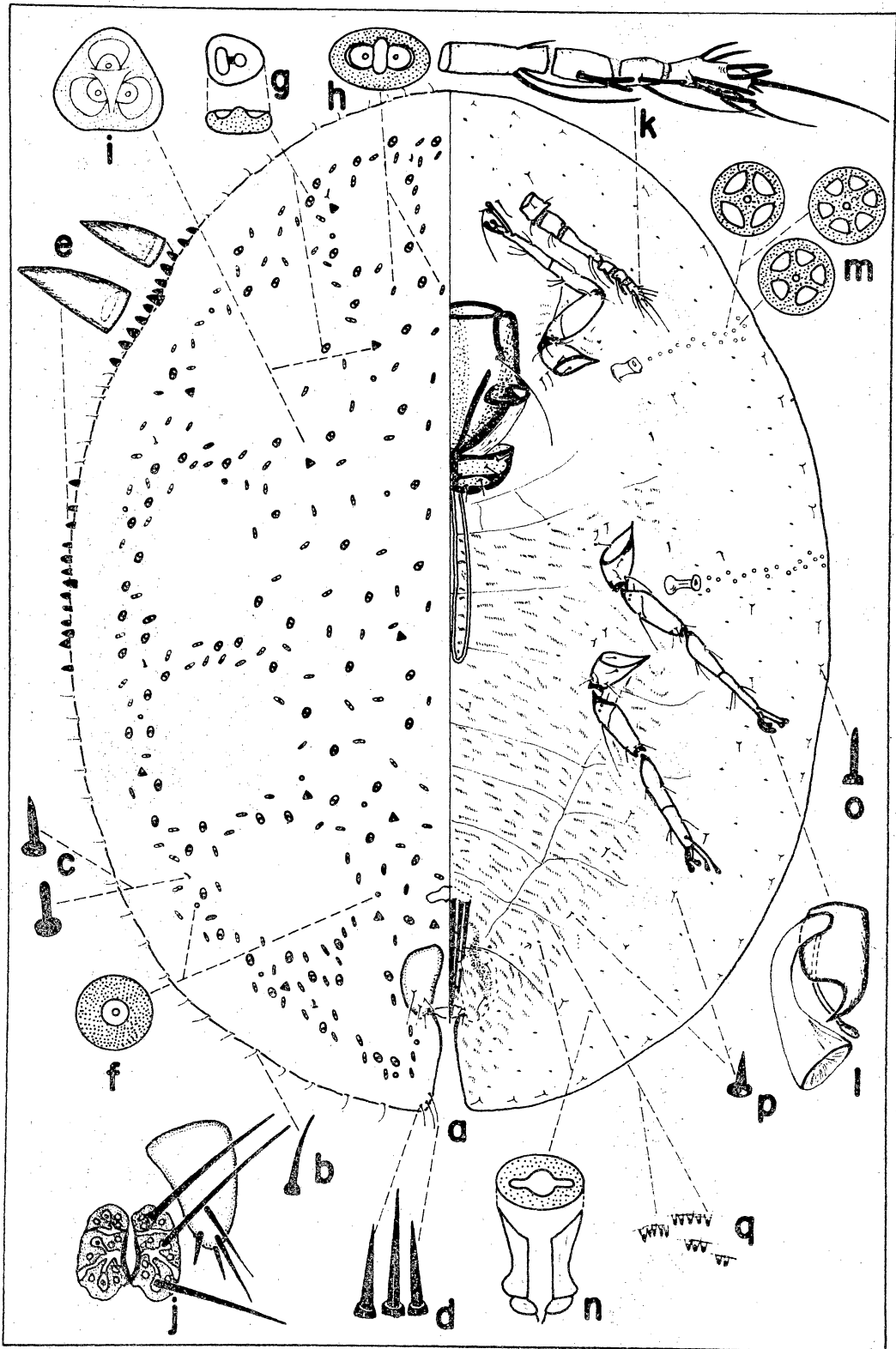


Plate 15.- *Ceroplastes floridensis* Comstock, third instar nymph

diameter, 4.46 (3.91-4.88).

Trilocular pores (fig. i): Few scattered over derm; triangular; diameter, 4.86 (4.52-4.91).

Anal plates (fig. j): Triangular, tapering apically, 76.9 (74.1-79.0) long, 36.0 (34.6-39.5) wide; 4 stout conical apical setae on each plate.

Anal ring (fig. j): Ovoid, 38.1 (37.1-41.9) long, 36.6 (32.1-39.6) wide; rounded on outer margin, open apically; inner margin U-shaped and heavily sclerotized; 6 groups of translucent pores, pore numbers variable; 6 setae, 2 anterior, 123 (119-128) long; 2 median, 112 (106-119) long; 2 posterior, 103 (99.0-109) long.

VENTRAL SURFACE:

Eyes: Present and slightly ovoid.

Antennae: 6-segmented, 138 (129-162) long; scape, 11.6 (9.88-12.4) long, 19.7 (17.3-21.6) wide; segments, II to VI; 18.0 (9.88-22.2), 49.4 (46.9-51.8), 10.4 (9.88-12.4), 15.5 (12.4-17.3), 23.7 (22.2-24.7) long, respectively; scape with 3 moderately long hairlike setae; II, 2 long hairlike setae and a sensory pore on the anterior margin, III, 2 long and 1 short hairlike setae; IV, 1 stout, fleshy, blunt seta; V, 1 stout fleshy blunt and 1 long hairlike setae; VI, 4 stout, fleshy, blunt setae and 3 short, 2 long, and 1 very long hairlike setae (fig. k).

Clypeolabral shield: Length, 90.3 (86.5-93.5); width, 88.3 (86.5-91.3); 1 pair long hairlike setae on middle of shield.

Labium: Bowl-shaped, apparently 2-segmented, 4 setae on each segment.

Legs: Tarsal digitules, 38.3 (34.6-41.9) long and slender, knobbed at the tips; claw, digitules (fig. 1), 18.8 (17.3-19.8) long and unequal in size; 1 broad, expanded at tip, 1 slender knobbed at tip; 4 sensory pores on trochanter of each leg.

Part of leg	Lengths prothoracic	Lengths mesothoracic	Lengths metathoracic
Coxa	25.2 (24.7-27.2)	27.9 (27.2-29.6)	29.2 (24.7-32.1)
Trochanter	23.2 (22.2-24.7)	26.1 (22.2-29.6)	26.7 (22.2-29.6)
Femur	48.2 (44.5-51.9)	51.4 (49.4-51.9)	52.1 (49.4-54.3)
Tibia	50.2 (49.4-51.9)	52.1 (49.4-54.3)	51.9 (49.4-54.3)
Tarsus	38.7 (37.1-41.9)	41.8 (37.1-44.5)	41.6 (39.6-46.9)
Claw	11.5 (9.88-12.4)	11.4 (9.88-12.4)	12.3 (9.88-14.8)
Entire leg	197 (188-210)	211 (195-222)	214 (195-235)

Spiracles: Anterior pair, 24.4 (22.2-27.2) long; atrium; 15.3 (12.4-17.3) wide; a band of 15 (12-17) pores, primarily 5-locular (fig. m), (occasionally 4- and 6-locular, 1 or 2 pores wide at margin; anterior furrow extending forward; posterior pair, 25.2 (24.7-29.6) long; atrium, 17.3 (14.8-19.8) wide; a band of 18 (17-22) pores, predominantly 5-locular, occasionally 4- and 6-locular; 1 or 2 pores wide at margin.

Cruciform pores (fig. n): Primarily in a marginal band; few scattered over rest of ventral surface; ovoid; diameter, 2.46 (1.98-2.93).

Setae: 1 pair long and 1 pair short hairlike setae between antennae; 3 longitudinal rows of conical bristlelike setae, 1 submarginal with 21 setae 4.54 (2.93-4.90) long (fig. o); 2 submedial rows, 3.00 (2.93-3.40) long, (fig. p) (inner row with 5 setae, outer row with 10 setae); 2 bristlelike setae at base of each coxa; 1 pair of hairlike prevulvar setae 135 (124-148) long; 3 pairs of stout conical fringe setae; 1

pair of stout conical subapical setae.

Microspines (fig. q): Around vulva anterior to base of mesothoracic coxae; a small patch at the base of the prothoracic coxae.

Material Studied: *Ilex cornuta* var. *Burfordii*: 10(15), (greenhouse) Blacksburg, Oct. 1, 1970, DKP; 13(23), (greenhouse) Blacksburg, Oct. 14, 1970, DKP; 16(26), (greenhouse) Blacksburg, Oct. 28, 1970, DKP; 4(5), (greenhouse) Blacksburg, Nov. 12, 1970, DKP.

C. BIOLOGY AND LIFE HISTORY

Life History

Ceroplastes ceriferus, the Japanese wax scale, and *Ceroplastes sinensis*, the Chinese wax scale, overwinter as adult females in Virginia. The overwintering populations produce the annual generation the following summer. Maturity of the adults in the spring is concluded by oviposition in April and May. Hatching occurs in June and occasionally in dense populations as late as mid-July. Development of the immatures progresses through the summer, with the adult stage developing in late summer or early fall. The young adult females continue feeding and growing through the fall until winter temperatures force them into dormancy.

Overwintering adults complete feeding in the spring and begin preparations for oviposition as soon as temperatures permit. Five to 10 days prior to oviposition the ventral white layer of wax is secreted (Photoplate 3-F), the dermal body wall anterior to the vulva invaginates and the fine powdery dry wax which coats the eggs is produced. Oviposition in Virginia for *Ceroplastes ceriferus* occurred between April 27-May 15, 1970; April 28-May 15, 1971, and began April 5, 1972, with an average oviposition of 1897 eggs per female. In dense populations eggs were oviposited as late as June 20th and in many instances were fewer in number. *Ceroplastes sinensis* began oviposition May 10, 1970, and May 13, 1971, laying an average of 1383 eggs per female. In five specimens of each species, observed in the laboratory oviposition occurred for 10 to 18 days for *C. ceriferus* and 10 to 15 days for

C. sinensis. Oviposition was also found to vary as to location within a given area. Freund (personal communication 1971) reported that in Richmond *C. ceriferus* hatched June 1st, near his downtown office, June 3rd, at Virginia Commonwealth University, and June 7th at a residence in the city suburbs.

The eggs incubate beneath the old females for 3 to 5 weeks in both species concerned. As the eggs approach maturity they become darker and the eye spots and occasionally the legs are observable through the egg shell. *Ceroplastes ceriferus* initially hatches in Virginia from June 1st to June 23rd in various localities. In dense populations hatching has been observed as late as July 15th. The population of *C. sinensis* studied hatched June 18, 1970, and June 23, 1971.

Fecundity

The number of eggs laid by a species appears to vary from location to location. Bodenheimer (1935) states the extremely variable numbers of eggs produced by *C. floridensis* is influenced by environmental conditions. He reports an average of 415 eggs and a range of 45 to 1278 eggs in Palestine and Watson (1926), 75 to 1000 eggs in Florida. Silvestri (1920) reported *C. sinensis* laid about 2000 eggs and Snowball (1970) counted an average of 2121 eggs per female. Smith (1971) reported *C. ceriferus* laid from 1000 to 2000 eggs per female.

Counts in my studies in Virginia show that *C. ceriferus* lays an average 1897 eggs per female with a range from 777 to 3955. It is also interesting to note the great variability in egg production of *C. ceriferus* which settle on the leaves. These adults in most cases appear

to be a large third nymphal instar, as the wax development is not sufficient to give the scale the appearance of the females on the stems.

Ceroplastes sinensis laid an average of 1383 eggs per female but the number ranges from 461 to 2390. The great variation observed between the egg counts here and in Australia and Italy may be attributable to the host. In Australia and Italy *C. sinensis* is found mostly on citrus while here it is found on woody ornamentals.

Ceroplastes floridensis was recorded as laying an average of 415 eggs per female by Bodenheimer (1935). The range 94 to 472 eggs is also approximately half the number counted by Watson (1926). It is also possible that the host has played a role in these variations. Both previous counts were made on citrus and these counts on woody ornamentals.

Tables 3 and 4 show the number and color of the eggs of each species.

Oviposition

The principal factor in survival of a species is its ability to reproduce. There are three signs that a young adult female is about to start laying eggs. The secretion of a thin layer of opaque or milky white wax appears on the venter (Photoplate 3-E-F). It is thicker around the lateral margins of the body but appears thinner at the apex of the head and near the vulval area. In *C. ceriferus* the layer is usually attached to the stem or branch of the host; occasionally it is not attached to the host as is characteristic in *C. sinensis* and *C. floridensis* and forms a sheet-like layer across the venter of the scale

Table 3. Egg count for *Ceroplastes* of Virginia.

<i>Ceroplastes</i>		<i>ceriferus</i>			<i>sinensis</i>			<i>floridensis</i>		
Location	Year	Avg #/ ^{1/}	# ^{2/} ctd.	Range	Avg #/ ^{1/}	# ^{2/} ctd.	Range	Avg #/ ^{1/}	# ^{2/} ctd.	Range
Franklin	1970				1246	12	461-2144			
	1971				1519	15	975-2390			
Portsmouth	1970	1921	9	777-2698						
	1971	1978	15	1480-2971						
Kilmarnock	1970	851 ^{3/}	12	207-1464						
	1971	2064	15	995-2916						
Danville	1970	2105	15	1108-3955						
	1971	2064	15	1240-2930						
Newport News	1970	1837	20	817-3637						
	1971	1872	15	1072-2318						
Richmond	1970	2025	13	1556-2684				224	20	94-472
	1971	2027	15	1691-2583				198 ^{4/}	20	97-316
Norfolk	1971	2128	15	1620-2762						
Norfolk ^{5/}	70-71	280	20	23-895						
Overall Avg		1897			1383			211		

^{1/} Average number of eggs per female.

^{2/} Number females counted.

^{3/} Highly crowded population, females were small compared to other areas.

^{4/} Count of *C. floridensis* eggs taken from greenhouse colony moved from Richmond nursery.

^{5/} Count represents *C. ceriferus* females which matured and laid eggs on the leaves of host, collected over 2 year study.

Table 4. Egg hue and value/chroma records for the *Ceroplastes* of Virginia.

<i>Ceroplastes:</i>			<i>ceriferus</i>	<i>sinensis</i>	<i>floridensis</i>
Location					
Richmond	Hue:	value/chroma	5R ^{1/} :7/8		10R:7/6-2.5YR ^{2/} :7/10
Portsmouth	"	"	5R :7/8		
Danville	"	"	5R :7/6		
Kilmarnock	"	"	5R :7/6		
Norfolk	"	"	5R :7/6		
Newport News	"	"	5R :7/6		
Franklin	"	"		7.5R:4/10-5/12	

^{1/}R = Red.

^{2/}YR = Yellow red.

above the host surface. The invagination or contraction of the dermal wall forms in front of the vulva and the secretion of a white powdery wax secreted by the multilocular pores develops around the vulva area and on the abdomen in *C. ceriferus* and *C. floridensis*. High concentrations were found only around the vulval area of *C. sinensis* as no multilocular pores are found on the abdomen. By the action of rhythmic contractions which begin anteriorly and move across and down the abdomen in zig-zag fashion to the vulva the eggs are laid individually. Upon emergence from the vulva the egg is coated with the dry white waxy powder. There appears to be some fine thread like attachment to each egg as it is laid from which it is released shortly after being laid. These threads accumulate around the vulva and occasionally are intermixed with the eggs; their function is unknown.

The ventral body wall of the female gradually constricts as the eggs are laid; allowing the eggs to be pushed forward. In reproduction the female commits physiological suicide, utilizing all of her body resources for the continuance of her species. At the completion of oviposition the female is merely a dried convexed hull sheltering the incubating eggs.

Hatching, Emergence, and Settling

Removing an old female during the hatching period reveals the convex hollow hull of the female to be a boiling mass of life; the pink to reddish-pink crawlers among the white egg shells and unhatched eggs. On hatching the chorion splits longitudinally and through expansion and contraction of predominantly the abdominal area the

crawlers emerge from the eggs. Movements in the struggle to hatch appear worm-like as the body appendages are folded flat beneath the body of the crawler. The shed egg shell is usually readily lost but occasionally it becomes stuck to the anal plate setae. The hatching process is the same for the two established species in Virginia and for the introduced *C. floridensis*.

Emergence from the female was observed from both the cephalic and caudal areas. It appears that the thin wax layer which supports the eggs is easily broken in these two areas. Upon removal of an egg laden female from the stem the wax layer usually ruptures in either or both of these areas.

Natural mortality is usually very high in the early stages of development. It is even greater in crowded populations where crawlers, because of the population density are unable to find suitable feeding sites or emerge from under the adult female. Many females have been removed from plants with their entire broods dead under them.

Ceroplastes ceriferus upon emerging settles in a short time almost exclusively on the stems of the host. Only in times of dense populations will they settle on the leaves and fruits of the host in any numbers. Occasionally one or two crawlers will settle on the leaves; these specimens if they survive are usually reduced in size and lay a reduced number of eggs. Orientation on the host is longitudinal with the head in either direction.

Ceroplastes sinensis settles predominantly on the leaves, although a number of specimens do settle on the stems. Orientation is usually

along the midrib and other large veins of the leaf. There is apparently no preference for either the dorsal or ventral surface of the host leaf. Settling on the stems is usually random.

Observations of *C. floridensis* have shown no preference; the crawlers will settle on the leaves as well as the stems. Those settling on the leaves appear to prefer the dorsal surface, although a number of specimens do settle on the ventral surface. Orientation again is parallel to the midrib and the larger leaf veins. Those settling on the stems orient longitudinally with the head in either direction.

Moulting

Moulting is indicated by the ventral exuviae being pushed out caudally. The old cuticle separates along the margin above the spiracular setae and long the body margin. The ventral cuticle is then folded beneath the body and pushed out caudally. Observations by Cilliers (1967), indicate that the spiracular setae, anal plates, legs, antennae, and mouthparts of the previous instar may be observed in this shed skin. In addition the author's studies show also the anal ring and anal ring setae. After moulting the shed skin is either blown away by wind or eaten by Psocids (personal observation 1971).

The dorsal shed skin according to Bedford (1968) becomes incorporated in the wax structure on the dorsal surface. This is believed to occur in all three species studied in this text.

Population Development

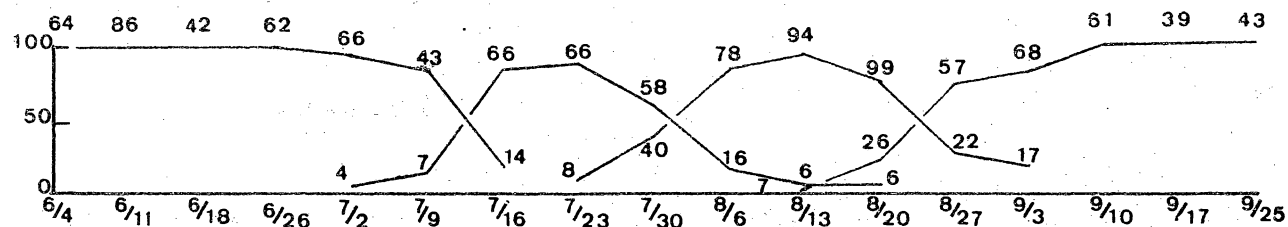
Ceroplastes ceriferus: Five populations of *C. ceriferus* located in

Danville, Richmond (2), Portsmouth, and Kilmarnock aided in determining the seasonal cycle of this species in Virginia. The development of the populations (I to V) are shown graphically in Graph 1. The date of each observation is marked on the base line of each graph. The percent value shows what portion of the population is represented by that instar at that sample date. The numerical values above the points in the graph represent the number of specimens of that instar upon which the percentage is based. A total count of each sample may be obtained by adding these numerical values at each observation date for each population. The amount of error due to sampling techniques for any instar is the same for all instars in the population as all samples of each population were randomly taken by the same individuals.

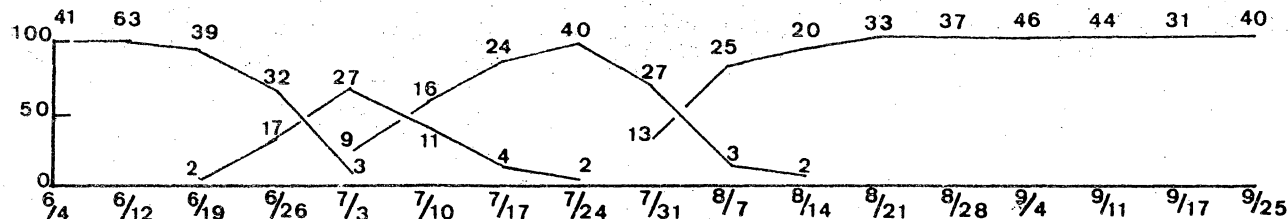
Observations on populations I, II, IV, and V show approximately the same initial hatching date while population III initially hatched two weeks later. The duration in days of the first and second nymphal instars divide the 5 populations into 2 different groups, populations I, III, and IV and populations II and V. The duration of the first nymphal instars is 42, 40, and 45 days and 29 and 35 days, respectively. The second nymphal instars show a closer relationship between the populations as they were observed for 49, 51, and 49 days and 36 and 36 days in populations I, III, IV, and II and V, respectively. This group relationship is greatly changed in the third nymphal instar. The instars in this period of development are divided into three groups. In populations I and II the third nymphal instar lasted 42 days; 35 and 36 days in populations III and V and 55 days in population IV.

Graph I. Seasonal cycle of the three nymphal instars and the adult stage in 5 populations of *Ceroplastes ceriferus* in Virginia during 1970 and 1971.

Richmond 1970

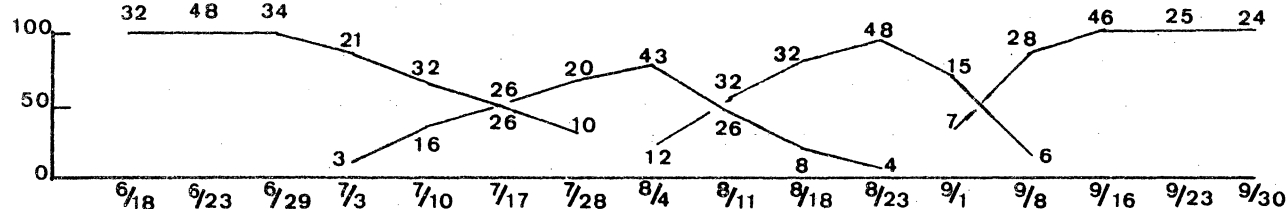


Danville

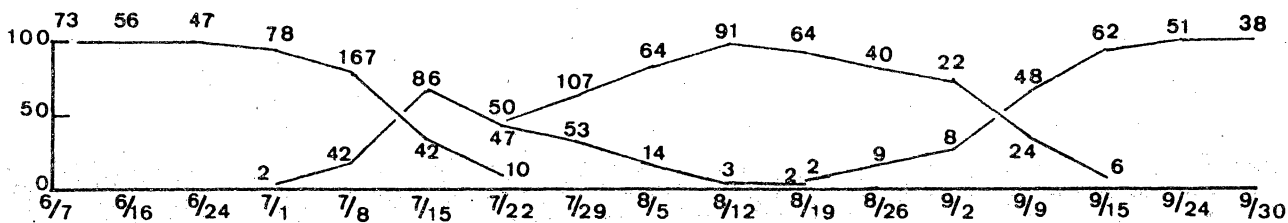


Kilmarnock

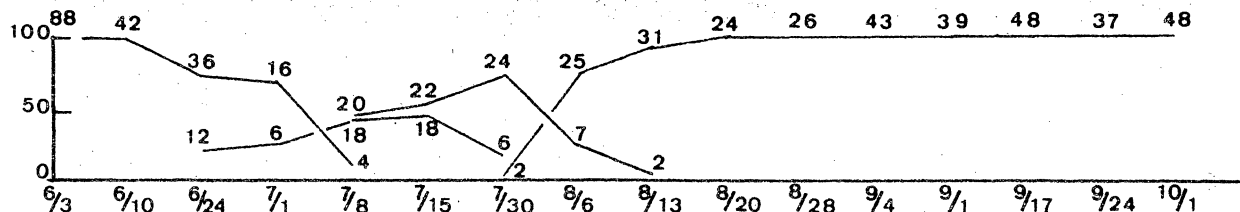
PERCENT



Richmond 1971



Portsmouth



TIME

The time interval in days between the observation of an instar and the first observation of the succeeding instar represents the time required for development of that instar (Table 5).

These time intervals show that based on development of the first nymphal instar the populations are divided into three groups, population I, populations II and III, and populations IV and V. The second instar also divides the populations into three groups, populations I and IV, populations II and V, and population III. The third nymphal instars are divided into two groups, populations I and V and populations II, III, and IV. Grouping of the individual instars was inconsistent so the relationships between the populations was based on the total time interval from crawler to the adult stage (Table 6). Based on the time required for 5 populations to complete development of a generation, the populations were divided into 2 distinct groups; populations I, III, and IV and populations II and V.

Although all populations except population III hatched early, the time interval in which it developed was equal to population IV and only slightly longer than population I. The delay in hatching time in population III was possibly caused by its location near the coast, probably due to cooler climatic conditions. This hypothesis is supplemented by the observations that populations in the Norfolk-Virginia Beach areas have hatched a week to 10 days later than populations in Richmond. Although population III hatched late, its time interval for development is the same as populations I and IV.

Table 5. The time of development recorded between the initial observations of successive nymphal instars of *Ceroplastes ceriferus* from 5 populations in Virginia.

Population	I	II	III	IV	V
Location	Richmond	Danville	Kilmarnock	Richmond	Portsmouth
Time Interval	Days	Days	Days	Days	Days
Instars					
First	28	15	15	24	21
Second	21	14	31	21	14
Third	21	28	28	28	22

Table 6. Time in days recorded for 5 populations of *Ceroplastes ceriferus* to develop from the crawler to the adult stage.

Populations	I	II	III	IV	V
Days	70	57	74	73	57

Populations II and V had very similar time intervals in their development. Population V is the same as population II in total time of development but having a longer first instar, a shorter third instar and equal second instars.

The similarity between the populations grouped is representative of their locations and is based on the total time interval for development from the crawler to the first adult. Populations I, III, and IV were located in suburban areas while populations II and V were located in the center of towns. It is hypothesized that because of their locations and the similarity in their development each population within a group was subjected to similar environmental conditions. As populations II and V were in urban areas it is possible that they may have been influenced by higher thermal conditions causing the quicker overall development observed. Populations I, III, and IV being located in rural and suburban areas were possibly subjected to more variable climatic conditions causing the greater total interval for development observed. These results indicate that the total time interval for development is consistent within a type locality, although the time interval for the different instars may vary between the populations in similar localities.

The time interval of the development of the first nymphal instar was found to be 15 to 28 days. Smith *et al.* (1971) reported the time interval as 2 to 3 days. Smith gives the duration of the 'crawler stage' as the time interval for the first nymphal instar. The crawler stage as recorded previously is the initial part of the first nymphal instar. A combination of the active crawler and the settled nymph prior

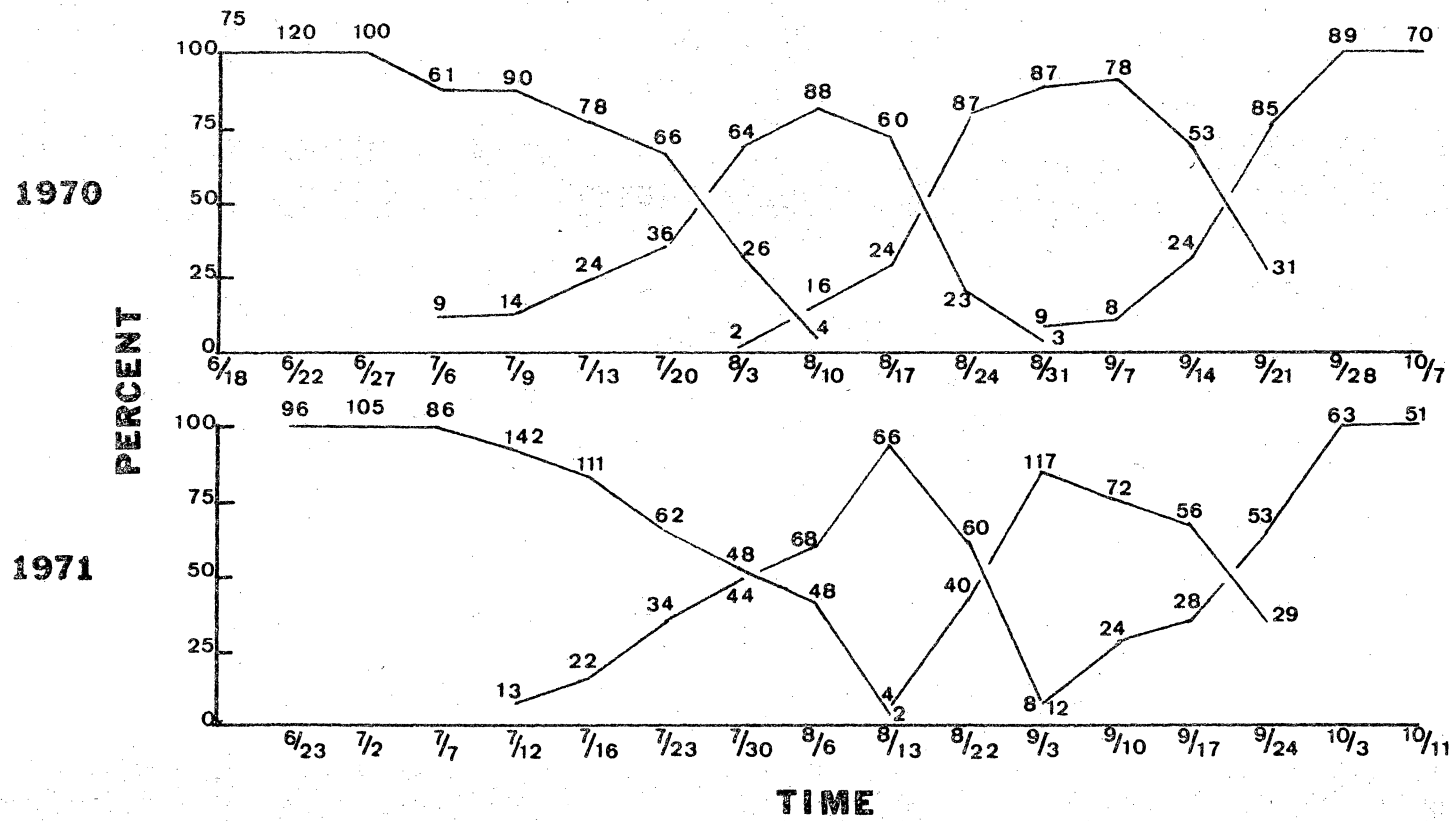
to the first molt after hatching is the first nymphal instar and requires 15 to 28 days.

Ceroplastes sinensis: A study of the life history of *C. sinensis* was based on a two year study of a single population. The data collected are illustrated graphically in Graph 2. Observations on hatching and the time interval of development and duration of the instars showed a consistent pattern in development. Hatching of the population during the study period occurred within a five day period. The first nymphal instar was observed for 52 and 50 days; the second for 56 and 53 days; and the third nymphal instar for 49 and 42 days, during 1970 and 1971, respectively.

The time interval in days between the observation of an instar and the first observation of the succeeding instar represents the time required for that instar to develop. The sum of these intervals provides the total number of days required for development from hatching to the first adult (Table 7).

The instar and total time intervals show that the population was consistent in its development over the two year study period. Since only one population was found prior to March 1972 it was impossible to evaluate the development of *C. sinensis* in different localities or under different climatic conditions.

During the early third instar stage *C. sinensis* migrates from the leaves to the stems of the hosts. This migration occurred over a 3 to 4 day period from August 18 to August 22, 1970, and from August 19 to



Graph II. Seasonal cycle of the three nymphal instars and the adult stage of *Ceroppleastes sinensis* in Franklin, Virginia, during 1970 and 1971.

Table 7. The time of development recorded between the initial observation of successive nymphal instars and the total time in days required for development of *Ceroplastes sinensis* in Virginia during 1970 and 1971.

Instars	First	Second	Third	Total
Days 1970	18	28	28	74
Days 1971	19	32	21	72

August 21, 1971. These records are in opposition to migration records recorded by Snowball (1971), who stated that the migration occurred primarily after the development of the adult stage. He also noted that all scales which remained on the leaves after migration were males. Records here indicate that only a few dead scales remained on the leaves.

The adult females of both species are usually well developed by mid-October. These young adults continue to feed and grow until winter forces them into dormancy.

Survival Potential

The main purpose of any species is to reproduce itself so that it may continue to exist. The potential of *C. ceriferus* is very massive.

Individual adult females were removed from the host plants and placed on the soil surface at the margin of pots containing uninfested plants. The scales began ovipositing 10 to 15 days later and hatching began 2 to 3 weeks thereafter. Shortly after hatching settled crawlers were observed on the lower third of all test plants. It was found that the settling was indiscriminant as crawlers settled on exposed plant roots as well as the stems and twigs of the host. Similar results were obtained when egg laden females were tested.

Ceroplastes sinensis tested in the same manner would not lay eggs after removal from the plant. Females with or starting to lay eggs when tested showed results similar to above. Although in *C. sinensis* the first and second instars are usually on the leaves the majority of those crawlers reaching the plants settled on the stems and twigs with a few reaching the lower leaves.

The onset of oviposition may also be initiated by the death of the host. Young females of *C. ceriferus* which have only recently become adults as well as older females will begin laying eggs once the plant begins to die. This was also found to be true in *C. sinensis* and *C. floridensis* but only with older females.

Changes in temperature may also cause oviposition to begin. All surviving scales in the overwintering study had either begun laying eggs or were preparing to lay eggs at the time they were counted. This was substantiated either by the presence of eggs or by the presence of the fine powdery wax which coats the eggs and the thin wax layer formed between the scale and the stem of the host. This is further demonstrated by the fact that *C. ceriferus* and *C. sinensis* which have one generation a year in the field have 2 generations a year in the greenhouse.

Overwintering

Although populations have spread and do overwinter east of the Blue Ridge mountains, the only populations west of the Blue Ridge were those set outdoors to study their survival throughout the winter at VPI&SU.

Tests to check the survival potential of *C. ceriferus* outdoors west of the Blue Ridge mountains in winter were conducted in 1970 and 1971. Twenty-four plants were infested with scales and maintained under greenhouse conditions until they matured in September. The scales were then individually counted on each plant, the plants numbered consecutively and set out in 4 rows of 6 plants. Sawdust was used as a bedding material to prevent the roots from freezing. The plants were

set out in September to give them an opportunity to gradually become accustomed to the outdoor temperatures prior to winter. At the beginning of each winter month and the first of March, six plants were randomly selected, brought indoors, and 30 days later the surviving scales were counted.

Table 8 shows that although a few scales were able to survive through December no scales were able to survive through the month of January.

Based on average monthly temperatures the tests have shown that the scale potential for survival decreases as the temperature approaches freezing. The data shown in Table 8 for 1970 and 1971 illustrates this point. The average monthly temperatures from September to December was 53.9°F and there was 82 and 88 percent survival in 1970 and 1971, respectively. The December temperatures and percent scale survival were 34.9°F and 28 percent and 41.4°F and 60 percent, respectively, for 1970 and 1971.

Survival counts on field populations in March of 1972 revealed that some *Ceroplastes* populations in Virginia were greatly reduced. Two population counts (count based on 50 scales) in Charlottesville showed 100 percent mortality in that area. In Danville a count showed 68 percent mortality. A count in Franklin showed 41 percent mortality. In the coastal area the percent mortality varied greatly and in most cases was less than other areas. Newport News recorded from 4 to 44 percent mortality, Norfolk from 16 to 76 percent mortality, and Virginia Beach recorded 9 to 15 percent mortality in various *C. ceriferus* populations.

Table 8. Survival counts on overwintering populations of *Ceroplastes ceriferus* in Blacksburg, Virginia, during 1970, 1971, and 1972.

Date collected	Average monthly ^{1/} temperature	# live scales on plant before test	# scales surviving	# survivors laying eggs	Year
Dec. 1	53.9°F	14	10	8	1970
		69	53	34	
		49	45	4	
		18	15	3	
		51	47	4	
		14	7	4	
Jan. 1	34.9°F	71	17	14	1971
		77	13	11	
		32	11	9	
		48	20	16	
		52	19	13	
		25	5	3	
Feb. 1	28.4°F	20	0	0	1971
		22	0	0	
		22	0	0	
		46	0	0	
		81	0	0	
		25	0	0	
Mar. 1	31.5°F	63	0	0	
		25	0	0	
		197	0	0	
		32	0	0	
		34	0	0	
		85	0	0	

Table 8. (Continued)

Date collected	Average monthly ^{1/} temperature	# live scales on plant before test	# scales surviving	# survivors laying eggs	Year
Dec. 1	53.9°F	97	92	88	1971
		13	6	5	
		28	20	17	
		38	37	36	
		35	31	25	
		6	4	2	
Jan. 1	41.4°F	58	48	28	1972
		78	54	15	
		30	2	1	
		36	23	10	
		15	5	1	
		10	5	1	
Feb. 1	33.8°F	73	0	0	
		35	0	0	
		71	0	0	
		56	0	0	
		135	0	0	
		11	0	0	
March 1	29.6°F	96	0	0	
		38	0	0	
		83	0	0	
		39	0	0	
		15	0	0	
		28	0	0	

^{1/} Average monthly temperatures represent the average monthly temperatures from the previous month(s) to the date the samples were collected. Ex.: 53.9°F average temperature from Sept. 1 to Nov. 31; 34.9°F average temperature from Dec. 1 to Dec. 31.

Parasites and Predators

Coccophagus fraternus Howard (Photoplate 3-G), was the primary parasite collected from the first and second instars of all three species of *Ceroplastes* in Virginia. *Anicetus toumeyellae* Milliron (Photoplate 2-G) was collected from adult *C. sinensis* in Virginia Beach. This is the first record of this parasite on the genus *Ceroplastes*. These two species represent the only parasites found attacking *Ceroplastes* in Virginia.

A parasite of *C. ceriferus* collected in Maryland was *Coccophagus lycimnia* (Walk.). This species has also been recorded as a parasite of *Ceroplastes* in other countries. The secondary parasite *Marietta pulchella* (Howard) was also collected in Maryland.

Weather has proved to be a decisive factor on parasite populations. In 1970, some 300 parasites were collected from *C. ceriferus* and *C. sinensis* and in 1971 only 2 parasites were found. Early spring and summer of 1970 were very warm and allowed for parasite build-up, while 1971 had a cool spring and late summer which held the parasite populations down allowing the scales to develop into unpreferred stages.

Predators belonging to the families Coccinellidae and Pyralidae have been found on the two established species of *Ceroplastes* in Virginia. The beetles include *Chilocoris* sp. found on *C. sinensis* and *Hyperaspis* sp.; *Cycloneda munda* (Say) and *Coleomegilla maculata* (DeGeer) found feeding on *C. ceriferus*. Unidentified coccinellid larvae were also found under the adult female feeding on the eggs and first instars of *C. sinensis*.

Photoplate 4

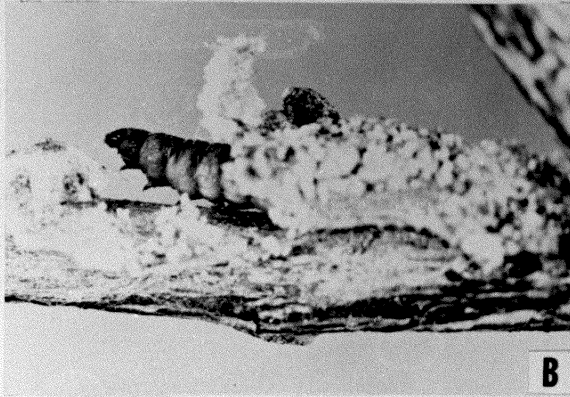
Laetilia coccidivora Photos A-D

Photo A: Frass covered stem indicating feeding site
of larva. Arrow indicates silken tunnel
spun by larva. (3X)

Photo B: Larva under frass and silk covering. (3X)

Photo C: Live adult at rest. (6X)

Photo D: Pinned adults. (7X)



Photoplate 4

The predominant predator found is the lepidopteran, *Laetilia coccidivora* (Comstock) (Photoplate 4-A-D). The predator overwinters as a larva and develops through 1-1/2 generations a year in Virginia, adults emerging in May and June and again in late fall. Greenhouse and field studies show that the larvae are very thorough in their activities, boring through the wax, feeding on the scale, and leaving only the wax hull or only a frass covered silk tunnel (Photoplate 4-A). A single larva has been observed to completely destroy all scales on a six-inch infested cutting. The larva's head is black, the body is purplish black dorsally, sparsely covered with setae and is light gray ventrally. They are not easily disturbed and may be moved from one feeding site to another and without coaxing will burrow into the nearest scale. The larva builds a silken tunnel connecting the wax masses as it feeds. In areas where scale populations are dense the larva is hard to detect without removal of the scales. In light infestations the silken tunnel built between individual and groups of scales is easily observed. It usually bears excrement and small pieces of wax broken from the host. At maturity the larva pupates in the silken tunnel usually under a wax covering.

Few of the field collected or lab reared specimens mated. When mating occurred larvae developed and adults emerged by September. Subsequent matings and oviposition were evidenced by young larvae in December.

This is the first record of this predator on *Ceroplastes*. It has previously been recorded on a number of scale genera, Heinrich (1956)

and was found on *Lecanium* by Williams (Personal communication, 1970).

Pediobius sp., *Apanteles* sp. and *Dichrogaster* sp. were reared from field collected *L. coccidivora* larvae. The parasitized larvae appeared sluggish and darker in color, the parasites emerging just prior to or shortly after the development of the pupal stage.

A small population of *Tetrastichus ceroplastae* (Girault) imported from Israel was obtained from Mr. Floyd Smith at the USDA Research Center at Beltsville. These 12 parasites were caged with third instars of *C. sinensis*, but parasitization did not occur. It was assumed that the nymphal instars were too old. Additional tests with younger material may prove beneficial.

Attendants

The association between 2 different insects where both species involved receive some benefit is mutualism. The Formicidae listed were observed in the field tending *Ceroplastes* populations. *Iridomyrmex pruinosus* (Roger), *Lasius neoniger* Emery, *Monomorium minimum* (Buckley), *Paratrechina melanderi arenivaga* Wheeler, and *Tetramorium caespitium* (Linnaeus) were found in association with *C. ceriferus* populations. *Camponotus nearcticus* Emery, *Crematogaster ashmeadi* Mayr, *Formica pullidefulva* Latreille, and *Lasius aliensus* (Foerster), were collected from a population of *C. sinensis*.

It is assumed that in return for the honeydew the ants received, parasites and predators were deterred.

Honeydew Excretions

Honeydew is a sugary material excreted anally as waste or as excess food taken up by the scale during feeding. The anal plates open transversely and the anal tube is protruded during excretion. At the end of the anal tube is the anal ring with six elongate setae (8 in the adult) each coated with a heavy wax covering. The everted setae lay flat and form a star pattern marginally over the anal ring. Honeydew is then excreted through the median opening of the anal ring in a globular drop. The anal ring setae then snap shut and the honeydew is expelled from the anal ring, the tube retracts and the anal plates close. This process appears to function most in the second and third instars when growth and development are at a critical time. Very little honeydew is secreted by either the first instar or adult. It is assumed that initially all energy sources are used by the first instar nymph for development and wax secretion. In the adult stage most all food and nutrient materials are required for egg development.

Sooty Molds

The presence of saprophytic sooty mold fungi that develop on honeydew excretions have been reported in association with wax scales. The black mycelial growth develops into a matlike covering which coats the stems, leaves, and fruits of infested plants. It is hard to remove and detracts from the beauty, growth, and development of heavily-coated plants. Observations to determine the fungi associated with wax scale excretions were made during the study of the biology of *C. ceriferus*.

Three orders including 16 genera were present in the fungal complex associated with the honeydew excretions of *C. ceriferus* (Table 9).

Table 9. Sooty molds associated with honeydew excretions of *Ceroplastes ceriferus*.

Genera	Occurrence at ^{1/} location		Order
	1	2	
<i>Cladosporium</i> sp. Link ex Fr.	129	77	Moniliales
<i>Alternaria</i> sp. Nees ex Wallr.	107	89	Moniliales
<i>Hormiscium</i> sp. Kunze ex Wallr.	87	83	Moniliales
<i>Pullularia</i> sp. Berk.	71	132	Moniliales
<i>Penicillium</i> spp. Berk.	36	8	Moniliales
<i>Candida</i> sp. Berk.	30	80	Moniliales
<i>Hormodendrum</i> sp. Bon.	25	7	Moniliales
<i>Epicoccum</i> sp. Link ex Wallr.	19	17	Moniliales
<i>Nigrospora</i> sp. Zimm.	17	3	Moniliales
<i>Curvularia</i> sp. Boedijn	4	0	Moniliales
<i>Cylindrocephalum</i> sp. Bon.	3	3	Moniliales
<i>Spondylocadium</i> sp. Mart ex Corda	3	0	Moniliales
<i>Phoma</i> sp. Desm. or <i>Phoma</i> -like spp.	2	0	Sphaeropsidales
<i>Trichoderma</i> sp. Pers. ex Fr.	0	2	Moniliales
<i>Didymobotryium</i> sp. Sacc.	1	0	Moniliales
<i>Cylindrosporium</i> sp. Unger	1	0	Melanconiales

^{1/}Location 1 - Admiralty Motor Hotel, sampled 1970-71;

Location 2 - Park Towne Apartments, sampled 1971-72;

Both sites are at Norfolk, Virginia.

D. CONTROL

Insecticide Control Tests on *Ceroplastes ceriferus*

Field test plots in 1970 and 1971 provided an evaluation of insecticidal control that simulated practical treatments such as would be carried out by custom spray applicators. Seventeen treatments involving 12 insecticides including those which showed promise in screening tests (Smith *et al.* 1971) were compared when applied as a single annual application, as two applications and three applications at 2-week intervals. Timing of applications was designed to begin at initial egg hatch and crawler activity.

The data collected from these tests are compiled in Tables 10 and 12. Each figure represents the average number of scales counted on 10 six inch cuttings. The June column represents the egg-laying adults present on the plants prior to treatment. The August column shows the number of scales remaining after all treatments were applied. The December column shows the number of young adults which were successful in reaching adult stage. By taking samples periodically from August until the following spring, the long term effects of the treatments could be evaluated when scales were exposed to natural environmental influences through an entire life cycle. The treated populations must be reduced to zero or near zero for satisfactory control. This requirement is based on: 1) the scales high reproductive potential; 2) the effect on plant growth of scale feeding; and 3) its polyphagous habit.

In Tables 11 and 13 are presented the statistical analyses of the data in Tables 10 and 12 showing the significant differences between the treatment means within each sampling date, i.e., June, August, December, and March. The June counts indicate the number of egg-laying adults present prior to treatment. Analysis of variance was used to test the hypothesis of equal effects of the treatment. When rejected, Duncan's New Multiple Range Test was used to group the treatment means. The difference between any two treatment means with the same letter was not significant at $\alpha = 0.01$. The statistical analyses of the differences between treatment means is based on the comparison of the treatment means in each sampling column. It does not consider, however, the difference between the treatment means in the initial samples, prior to treatment, and the subsequent samples after treatment. Example: 2 applications of carbaryl (2 pounds) in 1971 reduced the population treated from an average of 13.4 to 0 by December but this is not significantly different from ethion (0.67 pounds) which had no effect on the population treated.

1970 Insecticide Treatments - Admiralty Motor Hotel

In 1970 the timing of one, two and three applications was arranged in the following manner. The plots receiving three applications were treated June 7, June 21, and July 6. The plots receiving two applications were treated June 21 and July 6. Those plots treated once were sprayed July 6. In 1971 the applications were reversed. Applications were made with a 3-gallon, back-pack sprayer with a built-in piston pump.

The results in Table 10 show that when single applications were applied 1 month after hatching (July 6) all materials except Imidan^R (9.08 gm) and carbophenothion had caused observable reductions in the number of adults. Carbaryl (11.34 gm), carbofuran (2.34 ml), malathion, malathion plus Nufilm 17[®] and ethion showed the best control reducing the average population to less than 1. Although all the materials showed some control with a single late application because of the high reproductive potential it is evident that a single application, applied at this late date will not satisfactorily control the populations.

Two applications of the material, 2 and 4 weeks after hatching, achieved better control of the populations treated. The treatment using carbaryl and carbofuran reduced the populations treated to zero. Of the remaining treatments, Imidan[®] (9.08 gm), ethion (76 ml), and monitor (2.34 ml) reduced the treated populations to 0.3, 0.8, and 0.9, respectively. Except for carbaryl and carbofuran, the overall results of two applications compared to a single application are much better, but still did not control wax scale populations to the desired level.

Plots which received 3 applications showed the greatest reductions in scale infestations. Carbaryl, carbofuran, and Imidan[®] at both rates applied reduced the treated populations to zero. Carbophenothion and diazinon reduced the population counts to 0.7 and 0.3, respectively. The remaining treatments severely reduced their populations, but only the carbaryl, carbofuran, and Imidan[®] treatments achieved the desired level of control.

Table 10. Average population counts of *Ceroplastes ceriferus* before and after treatments, 1970.

		Average number of live scales found on 10-six-inch cuttings											
Treatments ^{1/}	% AI	1 application				2 applications				3 applications			
		4 weeks after hatch				2 & 4 weeks after hatch				at hatch and 2 & 3 weeks after hatch			
		June ^{2/}	Aug. ^{3/}	Dec. ^{3/}	April ^{3/}	June	Aug.	Dec.	April	June	Aug.	Dec.	April
Carbaryl	0.24	17.3	1.7	1.0	0.8	13.8	0.0	0.0	0.0	19.3	0.0	0.0	0.0
Carbaryl	0.12	15.6	4.0	4.1	3.8	9.0	0.0	0.0	0.0	28.1	0.0	0.0	0.0
Carbofuran	0.06	12.9	2.8	0.5	0.9	19.1	0.2	0.0	0.0	13.2	0.0	0.0	0.0
Carbofuran	0.03	10.7	1.8	2.3	2.3	16.1	0.0	0.0	0.0	5.6	0.0	0.0	0.0
Imidan	0.24	17.8	57.0	18.6	17.7	14.3	2.7	0.8	0.3	17.7	0.0	0.0	0.0
Imidan	0.12	7.7	8.4	2.6	2.0	15.6	24.4	6.0	2.7	17.3	0.0	0.0	0.0
Malathion ^{4/}	0.14	6.1	6.4	1.1	0.4	32.2	11.0	3.2	2.6	24.3	16.9	4.8	0.0
Malathion ^{4/}	0.14	3.4	2.9	1.6	0.6	30.0	12.8	2.0	2.0	21.9	4.1	6.1	4.5
Diazinon ^{4/}	0.12	18.8	35.7	14.8	7.3	18.6	10.1	2.7	2.4	23.4	4.6	0.3	0.3
Diazinon ^{4/}	0.12	28.2	26.6	15.6	8.6	12.3	19.8	8.4	6.6	17.9	11.7	5.1	2.9
Ethion	0.08	5.7	11.6	0.3	0.4	12.5	6.6	2.1	0.8	17.7	13.4	9.7	6.7
Ethion	0.12	9.3	3.3	0.7	0.2	11.1	22.3	7.2	3.7	16.1	11.2	6.4	3.7
Carbopheno- thion	0.12	17.1	36.4	15.2	10.9	14.8	38.4	8.0	5.8	5.0	2.9	0.8	0.7
Carbopheno- thion	0.12	25.4	23.2	8.2	8.2	16.1	32.0	3.8	3.4	15.6	14.1	7.1	4.3
Oxydementon- methyl	0.03	22.3	29.7	12.9	5.3	21.9	8.3	7.6	5.3	26.9	5.7	5.9	5.3
Monitor	0.09	30.6	13.6	9.1	8.2	19.4	9.6	1.8	0.9	27.8	8.8	8.7	8.2
Supracide	0.06	23.4	22.5	4.2	3.4								
Control		23.7	42.9	13.5	13.6	28.6	40.7	14.3	11.8	20.1	57.6	24.4	15.4

^{1/} See Table 1 for additional information.^{2/} Counts of egg-laying females prior to treatment.^{3/} Counts after treatments.^{4/} Insecticide plus the wetting agent Nufilm-17[®].

Table 11. Statistical evaluations of control on *Ceroplastes ceriferus*, 1970.

Treatments	% AI		1 application				2 applications				3 applications			
			4 weeks after hatch				2 & 4 weeks after hatch				at hatch and 2 & 3 weeks after hatch			
			June ^{1/}	Aug. ^{2/}	Dec. ^{2/}	April ^{2/}	June	Aug.	Dec.	April	June	Aug.	Dec.	April
Carbaryl	0.24	B-G	a	a	a		AB	a	a	a	B-F	a	a	a
Carbaryl	0.12	A-F	a	ab	abc		A	a	a	a	F	a	a	a
Carbofuran	0.06	A-E	a	a	a		A-C	ab	a	a	AB	a	a	a
Carbofuran	0.03	A-D	a	a	a		AB	a	a	a	A	a	a	a
Imidan	0.24	AB	a	a	a		AB	def	abc	abcd	B-E	a	a	a
Imidan	0.12	B-G	f	f	e		AB	ab	a	ab	B-D	a	a	a
Malathion ^{3/}	0.14	AB	a	a	a		E	abcd	abc	abcd	C-F	e	b	ab
Malathion ^{3/}	0.14	A	a	a	a		DE	abcd	ab	abc	B-F	ab	bc	bc
Diazinon	0.12	B-G	de	ef	bc		A-C	abcd	abc	abcd	C-F	ab	a	a
Diazinon	0.12	FG	cd	ef	cd		AB	bcde	c	e	B-E	de	b	ab
Ethion	0.08	AB	ab	a	a		AB	abc	ab	ab	B-E	de	d	cd
Ethion	0.12	A-C	a	a	a		AB	cdef	bc	bcde	BC	cde	bc	b
Carbopheno- thion ^{3/}	0.12	A-G	de	ef	d		AB	fg	bc	de	A	ab	a	a
Carbopheno- thion ^{3/}	0.12	E-G	bed	be	bc		AB	efg	abc	abcde	BC	de	bcd	bc
Oxydementon- methyl	0.03	G	abc	cd	bc		A-C	abcd	ab	ab	EF	bcd	cd	d
Monitor	0.09	C-G	de	cde	abc		B-D	abcd	bc	cde	D-F	abc	bc	bc
Supracide	0.06	D-G	bcd	ab	ab									
Control		D-G	e	de	e		C-E	g	d	f	B-F	f	e	e

^{1/} Counts of egg-laying females prior to treatment.^{2/} Counts after treatment^{3/} Insecticide plus the wetting agent Nufilm-17[®].

1971 Insecticide Treatments - Park Towne Apartments

In addition to the materials tested in 1970 the following materials were included in the 1971 trials: carbaryl (41.8% F), Orthene[®] (75% WP), and dimethoate (23.4% EC) sprays and phorate, aldicarb, disulfoton and carbofuran granules. Monitor was deleted from the 1971 tests.

The timing of one, two or three applications was set up in reverse of the 1970 applications in order to determine the effectiveness of a single application at the time of egg hatch. Those plots receiving one application were treated June 7. Those plots receiving 2 applications were treated June 7 and June 21. Plots receiving 3 applications were treated June 7, June 21, and July 6. Two late applications of carbaryl (1 & 2#) were made July 6 to previously untreated plants. Those plots receiving applications with Nufilm[®] were all treated initially on June 7. Those plots receiving a second application were sprayed July 6. Applications were made with a John Bean, Royalette 5 pump sprayer powered by a Briggs and Stratton engine.

The granular materials were applied once in a weight per area relationship in early April. Comparisons between the June and December columns were used to determine the effectiveness of the treatments because of a severe cold spell which occurred prior to spring sampling which greatly reduced the populations.

The results show that a single application at emergence obtained 100% control with carbaryl, Imidan[®], and Orthene[®] and reduced populations to 1 or less when treated with carbofuran spray or granules. The

Table 12. Average population counts of *Ceroplastes ceriferus* before and after treatments, 1971.

Treatment ^{1/}	% AI	Average number of live scales found on 10-six-inch cuttings											
		1 application at hatch				2 applications at hatch and 2 weeks after hatch				3 applications at hatch and 2 & 3 weeks after hatch			
		June ^{2/}	Aug. ^{3/}	Dec. ^{3/}	March ^{3/}	June	Aug.	Dec.	March	June	Aug.	Dec.	March
Carbaryl	0.24	3.9	0.0	0.0	0.0	13.4	0.0	0.0	0.0	7.4	0.0	0.0	0.0
Carbaryl	0.12	5.2	0.0	0.0	0.0	9.2	0.0	0.0	0.0	7.9	0.0	0.0	0.0
Carbaryl	0.24	4.7	0.0	0.0	0.0	5.3	0.0	0.0	0.0	14.4	0.0	0.0	0.0
Carbaryl ^{4/}	0.12	2.8	1.0	0.0	0.0	3.5	0.0	0.0	0.0	18.3	0.0	0.0	0.0
Carbaryl ^{4/}	0.24	6.9	0.0	0.0	0.0								
Carbaryl ^{4/}	0.12	8.5	7.0	5.8	1.7								
Carbofuran	0.06	20.7	0.0	1.0	0.0	20.1	0.0	0.0	0.0	2.5	0.0	0.0	0.0
Carbofuran	0.03	3.0	1.7	0.6	0.0	2.8	0.0	0.0	0.0	11.2	0.0	0.0	0.0
Imidan	0.24	3.9	0.0	0.0	0.0	11.3	0.0	0.0	0.0	8.3	0.0	0.0	0.0
Imidan	0.12	1.4	0.0	0.0	0.0	3.8	0.0	0.0	0.0	1.8	0.0	0.0	0.0
Supracide	0.06	5.8	2.6	2.8	0.9	1.6	0.0	0.0	0.0	3.7	0.0	0.0	0.0
Orthene	0.15	2.6	1.6	0.0	0.0	1.7	1.0	0.6	0.2	4.7	0.2	1.2	0.3
Malathion ^{5/}	0.14	2.0	3.3	1.7	0.7	1.0	9.5	1.2	0.0	9.8	20.8	23.0	11.7
Malathion ^{5/}	0.14	3.3	1.9	6.0	0.2	3.0	1.4	1.0	0.0	1.1	1.4	0.0	0.0
Diazinon ^{5/}	0.12	11.9	54.2	41.7	10.3	3.8	14.1	2.9	1.0	4.6	18.8	8.8	3.4
Diazinon ^{5/}	0.12	4.7	4.1	3.8	0.7	14.6	31.1	14.2	6.9	2.8	15.3	5.8	1.5
Ethion	0.08	2.9	28.0	7.7	0.0	10.9	7.1	2.2	1.7	7.2	16.5	9.6	2.6
Ethion	0.12	13.8	79.0	24.9	6.9	5.0	8.9	6.1	1.1	8.8	12.1	6.7	0.6
Carbopheno- thion	0.12	2.0	1.7	1.8	0.0	1.8	1.0	0.2	0.0	6.8	6.4	3.2	1.0
Carbopheno- ^{5/} thion	0.12	6.2	19.6	4.7	1.1	4.4	2.5	2.0	0.0	6.2	1.2	0.6	0.5
Oxydemeton- methyl	0.03	3.1	1.0	3.2	0.2	2.6	1.3	1.5	0.0	4.3	3.1	2.4	1.2

Table 12. Continued.

Treatment ^{1/}	% AI	Average number of live scales found on 10-six-inch cuttings											
		1 application at hatch				2 applications at hatch and 2 weeks after hatch				3 applications at hatch and 2 & 3 weeks after hatch			
		June ^{2/}	Aug. ^{3/}	Dec. ^{3/}	March ^{3/}	June	Aug.	Dec.	March	June	Aug.	Dec.	March
Dimethoate	0.06	3.1	2.2	1.9	1.3	1.2	20.0	11.0	5.8	2.5	3.6	0.0	0.0
	AI/sq ft												
Carbofuran ^{6/}	0.32gm	11.8	7.3	0.5	0.5								
Phorate	0.32gm	11.9	18.8	16.4	1.1								
Aldicarb	0.32gm	12.5	55.0	10.6	1.7								
Disulfoton	0.32gm	8.2	23.8	19.2	6.5								
Control		26.6	45.3	18.6	5.6	21.1	34.1	10.3	2.8	13.0	64.8	31.6	9.7

^{1/} See Table 1 for additional information.

^{2/} Counts of egg-laying females prior to treatments.

^{3/} Counts after treatments.

^{4/} Single application of carbaryl applied July 6.

^{5/} Insecticide plus wetting agent Nufilm-17[®].

^{6/} Granules.

Table 13. Statistical evaluations of control on *Ceroplastes ceriferus*, 1971.

Treatments ^{1/}	% AI	1 application at hatch				2 applications at hatch and 2 weeks after hatch				3 applications at hatch and 2 & 3 weeks after hatch			
		June ^{2/}	Aug. ^{3/}	Dec. ^{3/}	March ^{3/}	June	Aug.	Dec.	March	June	Aug.	Dec.	March
Carbaryl	0.24	A	a	a	a	D	a	a	a	B-F	a	a	a
Carbaryl	0.12	A-C	a	a	a	B-D	a	a	a	C-G	a	a	a
Carbaryl	0.24	AB	a	a	a	A-C	a	a	a	HI	a	a	a
Carbaryl ^{4/}	0.12	A	a	a	a	AB	a	a	a	I	a	a	a
Carbaryl ^{4/}	0.24	A-C	a	a	a								
Carbaryl ^{4/}	0.12	A-D	a	ab	a								
Carbofuran	0.06	E	a	ab	a	EF	a	a	a	A-C	a	a	a
Carbofuran	0.03	A	a	a	a	AB	a	a	a	F-H	a	a	a
Imidan	0.24	A	a	a	a	CD	a	a	a	C-G	a	a	a
Imidan	0.12	A	a	a	a	AB	a	a	a	AB	a	a	a
Supracide	0.06	A-C	a	ab	a	A	a	a	a	A-D	a	a	a
Orthene	0.15	A	a	a	a	A	a	a	a	A-E	a	ab	ab
Malathion	0.14	A	a	ab	a	A	ab	a	a	E-H	d	e	c
Malathion	0.14	A	a	ab	a	AB	a	a	a	A	a	a	a
Diazinon ^{5/}	0.12	B-D	c	f	c	AB	bc	ab	ab	A-E	cd	cd	b
Diazinon ^{5/}	0.12	AB	a	ab	a	ED	d	d	c	A-D	cd	bcd	ab
Ethion	0.08	A	b	abc	a	CD	ab	a	ab	B-F	cd	d	ab
Ethion	0.12	D	d	e	b	A-C	ab	b	ab	D-G	bc	bcd	ab
Carbopheno- thion	0.12	A	a	ab	a	A	a	a	a	A-F	ab	abc	ab
Carbopheno- thion	0.12	A-C	b	ab	a	AB	a	a	a	A-F	a	ab	ab
Oxydementon- methyl	0.03	A	a	ab	a	AB	a	a	a	A-E	a	ab	ab
Dimethoate	0.06	A	a	ab	a	A	c	cd	c	A-C	a	a	a

Table 13. Continued.

Treatments ^{1/}	% AI	1 application at hatch				2 applications at hatch and 2 weeks after hatch				3 applications at hatch and 2 & 3 weeks after hatch			
		June ^{2/}	Aug. ^{3/}	Dec. ^{3/}	March ^{3/}	June	Aug.	Dec.	March	June	Aug.	Dec.	March
	AI/sq ft												
Carbofuran ^{6/}	0.32gm	B-D	a	a	a								
Phorate	0.32gm	B-D	b	cde	a								
Aldicarb	0.32gm	CD	c	bcd	a								
Disulfoton	0.32gm	A-D	b	de	b								
Control		E	c	de	b	F	d	c	b	GH	e	f	c

^{1/} See Table 1 for additional information.

^{2/} Counts of egg-laying females prior to treatments.

^{3/} Counts after treatments.

^{4/} Single application of carbaryl applied July 6.

^{5/} Insecticide plus wetting agent Nufilm-17[®].

^{6/} Granules.

remaining materials had no observable effect on the populations treated.

The single applications of carbaryl applied July 6 showed results similar to the treatment applied June 7. Carbaryl (2 pounds) applied in a single application on July 6 was observed to be toxic to 100% of the existing population. A one pound application was observed to reduce the population by 80%.

Two applications with carbaryl, carbofuran, Imidan[®], and Supracide[®] showed 100% control of the populations treated. Orthene[®], malathion plus Nufilm-17[®], ethion, and carbophenothion showed a slight reduction in the population as compared to the control. The remaining materials showed little control of the populations treated.

Plots receiving three applications showed similar results to the plots receiving 2 applications. One hundred percent of the populations were killed when treated with 3 applications of carbaryl, carbofuran, Imidan[®], Supracide[®], malathion plus Nufilm-17[®], and dimethoate. Of the remaining plots those treated with Orthene[®], carbophenthion, carbophenthion plus Nufilm-17[®], and oxydementonmethyl showed slight reductions in the populations treated. Plots tested with malathion, diazinon, diazinon plus Nufilm-17[®], and ethion showed increases rather than decreases in the populations treated. Use of carbaryl, carbofuran, and Imidan[®] consistently achieved control of the populations throughout the 1971 tests.

Discussion

To obtain an overall evaluation of the treatments applied one must understand the potential and adaptability of *Ceroplastes ceriferus*.

The reproductive potential of this scale is enormous. Each female lays on the average 1897 eggs but has the potential of laying up to 4000 eggs. This potential in combination with its polyphagous habit, enables the scale to spread rapidly. In Virginia alone, 122 species of plants are recorded as hosts, including ornamentals, trees, and weeds. This high reproductive potential and polyphagous habit allow only one or two adult scales on a single plant to produce 3600 to 8000 crawlers which may be transported by birds or man, or blown by the wind to neighboring plants. Although the wax scale populations are not as damaging as the soft brown scale, or oyster shell scale, their feeding does retard plant growth and does promote and allow possible entrance sites for secondary invaders. The retardation of plant growth and the growth and development of sooty molds on their honeydew excretions are of primary concern. Sooty molds development on the leaves of the plant reducing their photosynthetic function which in conjunction with scale feeding causes the plant to grow spindly and unevenly. Wax scale infestations are unsightly to the homeowner, detracts from the beauty of landscape plantings and prohibits the sale of ornamental plantings from nurseries and stores. It is for these reasons that populations should be controlled to the greatest extent possible.

These field plot tests were conducted to evaluate the insecticides tested as to the time of application relative to the life history of the scale and the quantity and number of applications required to effectively control the wax scales in Virginia.

The results of all tests indicate that the most effective time to

treat the populations is at crawler emergence or shortly thereafter. This is confirmed by the timing of applications in both 1970 and 1971 in Tables 10 and 12. The crawlers have no wax covering and therefore are at their most susceptible stage.

Carbaryl, carbofuran, and Imidan[®] have consistently shown 100% effectiveness in controlling the wax scale populations upon which they were tested. Carbaryl is effective when applied as long as a month after hatching and is usually effective with one application. To obtain satisfactory results carbofuran, Imidan[®], and Supracide[®] must be applied at hatching or within two weeks after hatching. These insecticides may be safely used around home and municipal areas when the correct dosages and precautions are taken in application. In the granular applications only carbofuran showed evidence of some control. Additional testing is required before any definite conclusions can be made as to its effectiveness.

The remaining materials were ineffective in controlling the wax scale although some treatments have been inconsistent in their effects. One spray of ethion (76 ml) in 1970 gave better results when applied 1 month after hatching than it did with 3 applications beginning at hatching. In 1971, one application of ethion (76 ml) was more toxic at hatching than one followed by 1 or 2 additional sprays. Nufilm-17[®] did not improve the controlling ability of the materials with which it was tested.

The reason for these variations in effects is unknown, however, the following factors may be partial answers: 1) lack of available

feeding spots on the host, 2) natural mortality, and 3) parasites and predators.

The mortality in the scale populations due to winter was not readily observable in the 1970 spring counts as the reduction in overwintering populations was low. In 1971 the effect of 4°F for 36 to 48 hours on the wax scale populations was observable. Based on the comparison of December and spring counts of the control plots, the populations were reduced between 50 and 80%. Although not a consistent factor in the control of wax scales in Virginia, it demonstrated the potential of severe weather conditions to affect the wax scale populations.

Greenhouse Tests with Carbaryl on *Ceroplastes ceriferus*

Tests to determine the effectiveness of carbaryl in preventing or eliminating wax scale infestations were conducted in 1971. Plants obtained from infested nursery stock were disinfested, transplanted, fertilized, and divided into 11 groups of 10 plants each (5 *Ilex*, 5 *Euonymus*).

Applications of carbaryl at 1 pound actual per 100 gallons (5.67 gm 80% WP/gallon) of water were applied to groups I through V prior to infestation at 10 day intervals beginning April 23, 1971. On June 10 all plants were infested by tying a 3-inch cutting with egg-laden females to each plant, treated and untreated. Group VI was treated 8 days after infestation and the remaining 4 groups were treated at 10 day intervals thereafter. Group XI, the control, was sprayed with water only. The experiment was terminated December 20, 1971.

The plants were then individually checked. Each scale found was

Table 14. Results of greenhouse tests with carbaryl^{1/} on *Ceroplastes ceriferus*.

Date sprayed	Plant group	1 ^{2/}	2	3	4	5	6 ^{3/}	7	8	9	10
IV-23-71	I	0	0	0	0	0	0	0	0	0	0
V-3-71	II	0	0	0	0	0	0	0	0	0	0
V-13-71	III	0	0	0	0	0	0	0	0	0	0
V-23-71	IV	0	0	0	0	0	0	0	0	0	0
VI-2-71	V	0	0	0	0	0	0	0	0	0	0
VI-18-71	VI	0	0	0	0	0	0	0	0	0	0
VI-28-71	VII	0	0	0	0	0	0	0	0	0	0
VII-8-71	VIII	0	0	0	0	0	0	0	0	0	0
VII-18-71	IX	0	0	0	0	0	0	0	0	0	0
VII-28-71	X	0	0	0	0	0	0	0	0	0	0
Control	XI	32	28	20	32	82	109	282	237	254	531

^{1/}Carbaryl 80% wettable powder using 5.67 grams per gallon (equivalent= 1 pound per 100 gallons water).

^{2/}Plants 1 through 5, *Ilex glabra*.

^{3/}Plants 6 through 10, *Euonymus japonicus*.

removed from the plant and checked for survival. Survival was determined by the issuance of red or pink body fluids upon rupture of the derm.

Table 14 shows the results of the counts taken on December 20. All applications were applied at the same rate with the same applicator and no other materials were applied to the plants except a single application of Omite® 7 months prior to treatments. Groups I through V did not have a single crawler to settle on the plants, whereas dead crawlers were observed on the leaves and stems of most plants. Groups VI through IX did not have a single live scale, but numerous first and second nymphal instars were checked on each plant. Only group X, treated 50 days after infestation, had a few live scales.

The control group showed three results: 1) the scales did hatch and infested the plants, 2) carbaryl is effective in controlling wax scales, 3) *Ilex glabra* is not a preferred host as individual counts show.

The results show that carbaryl has a much longer effect than reported previously and it has the potential of killing a wax scale population 40 days after hatching.

Insecticide Control Test on *Ceroplastes sinensis*

In June, 1970, 1-1/2 gallons of water with carbofuran (2.34 ml/gal) was applied to the base of each of two plants infested with *Ceroplastes sinensis*. A third infested plant was used as a control.

Soil drenching was used because *C. sinensis* crawlers settle primarily on the leaves of the host, and it provides a demonstration

of the systemic effectiveness of carbofuran.

All samples and averages shown in Table 15 were taken in the same manner as those for *C. ceriferus*. The results show that the treated populations are greatly reduced. Based on the counts of the individual cuttings and observation of the plants it appeared that the survivors were all located on a single section of each treated plant. It is probable that the treatment was not thoroughly applied or taken up by the plant as both of the sections bearing survivors were on the part of the plants which faced the building.

Table 15. Results of soil drench tests with carbofuran^{1/} on *Ceroplastes sinensis*.

	June ^{2/}	Aug. ^{3/}	Dec. ^{3/}	April ^{3/}
Plant 1	6.0	26.0	1.67	0.67
Plant 2	6.67	24.0	1.30	0.33
Plant 3	8.83	165.3	51.7	37.00

^{1/} Carbofuran (43.8%F) using 2.34 ml per gallon.

^{2/} Population counts prior to treatments.

^{3/} Population counts after treatments.

V. SUMMARY AND CONCLUSIONS

Ceroplastes sinensis, discovered in Norfolk in 1938, is the first record of wax scale in Virginia. *Ceroplastes ceriferus* was first recorded in Norfolk in 1942. In the past decade *C. ceriferus* has built up enormous populations to become one of the primary pests of ornamentals in the Commonwealth. A third species, *C. floridensis*, is occasionally brought into Virginia on nursery stock, but has not yet become established in the state.

Ceroplastes ceriferus, the Japanese wax scale, has been recorded from 40 countries in Virginia from the Blue Ridge mountains eastward. The heaviest infestations occur in Charlottesville, Danville, and Richmond and along the coastal region from Norfolk to Arlington. It is highly prolific; laying an average of 1897 eggs per female with a potential of 3 to 4 thousand. Its polyphagous habit is evidenced by the recorded 122 species of host plants, primarily ornamentals, some of which are shade trees and several weeds. This high reproductive potential and polyphagous habit have aided the wax scales in their spread and build-up. They overwinter as adult females and a single generation is produced each year. Eggs are laid in late April or early May. Hatching occurs at various times throughout the state from June 1 to June 18 depending on the locality of the infestation. In dense populations hatching may occur as late as July 15. The scale develops through 3 nymphal instars. The second of which is called the cameo stage and the third called the duncecap stage. Development into

the adult female is completed by late September or October, requiring a period of seventy-five days from the date of initial egg hatch.

Males of *C. ceriferus* were found for the first time in the United States in greenhouse colonies in Maryland and Virginia. The male population is so small it is doubtful that it serves any function in the reproductive cycle. No males were observed or collected in any field populations. The females are, therefore, considered parthenogenic.

Ceroplastes sinensis, the Chinese wax scale, has been recorded in 3 southeastern counties from four species of *Ilex*. Populations have been found in only 2 localities at present, the third recorded by previous researchers and identified through slides at the U. S. National Museum. This species begins oviposition in May. Hatching occurs in late June. The first and second nymphal instars develop on the leaves. They migrate back to the stems in mid August during the third instars and then complete development. The parasite, *Anicetus toumeyellae* Milliron was collected infesting the adults of this species. This is the first record of it infesting any *Ceroplastes*.

The morphology of each instar of both the established and the introduced species are included in the text. The characters which separate the instars and the species were carefully illustrated (Plates 4-15), described, and measured. Based on these characters, keys have been prepared to identify the different instars of each species.

Wax development was also found to be characteristic of the different instars and species. Illustrations (Plates 1-3) and descriptions

for the wax development of the different female instars of each species and the adult male of *C. ceriferus* are presented.

Laetilia coccidivora (Comstock) is the primary predator of *Ceroplastes* in Virginia. This is the first record of this pyralid on *Ceroplastes*. Greenhouse rearing has shown that it will develop through at least 1-1/2 generations and possibly more in the field.

Coccophagus fraternus Howard was the primary parasite of all three species of *Ceroplastes* recorded in Virginia. It was collected from only first and second nymphal instars. This parasite was found to be severely affected by climatic factors.

Carbaryl, carbofuran, Imidan[®], monitor, diazinon, malathion, ethion, carbophenothion, Supracide[®], oxydementonmethyl, dimithoate and Orthene[®] sprays and carbofuran, aldicarb, phorate, and disulfoton granules were field tested for the control of *Ceroplastes*.

Carbaryl, carbofuran, Imidan[®], and Supracide[®] were the materials which consistently provided satisfactory control. The best results were obtained when sprayed at hatching and again two weeks later. These insecticides are relatively non-toxic and are safe for use around homes and municipal areas.

A single application of Imidan[®] applied at hatching or crawler emergence provides adequate control. While a single application of carbaryl may be applied as late as two weeks after hatching and still provides 100% control. Two applications of Supracide[®] and carbofuran were required to obtain the control desired.

Greenhouse tests conducted to check carbaryl's effectiveness in preventing and eliminating wax scale populations showed carbaryl to be very toxic. Treatments killed 100% of the populations when applied 50 days prior to infestation and up to 40 days after infestation.

The results of the field and greenhouse tests show carbaryl to be the best treatment for wax scale control.

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VII. APPENDIX

COOPERATIVE EXTENSION SERVICE
Virginia Polytechnic Institute
Extension Division
Blacksburg, Virginia 24061

Please provide the following information for each sample collected.
Each sample submitted must be accompanied by a separate data form.
Collection and mailing of samples must be done according to directions
provided.

Collector's Name _____ Date submitted _____
Agency _____ Sample number _____

LOCALITY City or Town _____ County _____

Owner's Name _____
Address _____
City or Town _____ Zip _____

Nursery __, Residence __, Commercial __, City or Town __, State __ Federal __

SAMPLE _____ Date collected _____

Host: Common name _____
Genus _____ Species _____ Variety _____
Identification by _____ Questionable _____ Certain _____

Infestation: Light __, Medium __, Heavy __; One plant __, Few __, Many __
Infested area: One host __, Few __, Many __; One property __, Few __, Many __
Origin of plant material if known _____

OTHER

Adequate infested plants for study or control tests: Yes __ No __
Good potential cooperator for field investigations: Yes __ No __
Insecticides have been applied in previous year or two: Yes __ No __

NOTES Use back of sheet for additional information

Do Not Write Below This Line

Date received _____ Condition _____ Sample No. _____

John A. Weidhaas, Jr.
Extension Specialist,
Entomology

**The vita has been removed from
the scanned document**

THE MORPHOLOGY, BIOLOGY AND CONTROL OF CEROPLASTES CERIFERUS
(FABRICIUS) AND CEROPLASTES SINENSIS DEL GUERCIO IN VIRGINIA
INCLUDING A REDESCRIPTION OF CEROPLASTES FLORIDENSIS
COMSTOCK (HOMOPTERA:COCCOIDEA:COCCIDAE)

by

Dale Keith Pollet

(ABSTRACT)

Populations of the wax scales, *Ceroplastes ceriferus* (Fabricius) and *Ceroplastes sinensis* Del Guercio, have become established in Virginia. A third species, *Ceroplastes floridensis* Comstock, is periodically brought into the state but is apparently unable to overwinter.

Ceroplastes ceriferus, the primary species in Virginia, was originally found in Norfolk in 1942. In the past 30 years *C. ceriferus* has spread into 40 counties. All infestations are east of the Blue Ridge Mountains, the majority of which are in the Piedmont area from Charlottesville, Richmond and Danville eastward. Its host range encompasses 122 species of plants in 46 families, primarily ornamentals, some shade trees, and several weeds.

Ceroplastes sinensis, a minor species in Virginia, was originally found in Norfolk in 1938. It has been recorded in three southeastern counties from four species of *Ilex*.

Each instar of the three species of *Ceroplastes* found in Virginia is characterized in this study including measurements and illustrations. Of these, *C. ceriferus* and *C. floridensis* are completely described for the first time. Keys are provided for separation of the instars for each species. Mounting techniques are given.

The biologies of the established species were recorded from oviposition to development of the adult stage. Both species have three instars, overwinter in the adult stage and produce one generation a year. Males of the Japanese wax scale were collected for the first time in the United States from greenhouse colonies in Virginia and Maryland. *C. ceriferus* oviposits in April and May; hatching begins in June and in dense populations may occur as late as July; settling occurs primarily on the stems of the host. The time required for seasonal development of populations varies with the location of the infestation. In rural and suburban areas infestations required approximately 72 days to complete development from egg to adult while infestations in urban areas required only 52 days. *C. sinensis* begins oviposition in May; hatching begins in late June. The first and second instars settle and develop on the leaves in July and the third nymphal instar migrates back to the stems in late August to complete development. This species requires 75 days for development from egg to adult in a suburban area.

Laetilia coccidivora (Comstock) and *Coccophagus fratermus* Howard are the primary predator and parasite, respectively, of *Ceroplastes* in Virginia. *Laetilia coccidivora* and *Anicetus toumeyellae* Milliron, a parasite of adult *C. sinensis*, are here recorded on *Ceroplastes* for the first time.

Carbaryl, carbofuran, Imidan[®], malathion, diazinon, ethion, carbo-phenothion, monitor, Supracide[®], Orthene[®], dimethoate and oxydementon-methyl, sprays and phorate, disulfoton and aldicarb granules were the materials tested for control of *C. ceriferus*. The additive Nufilm-17[®]

was tested with malathion, diazinon, and carbophenothion. Results showed that applications of insecticides at hatching produced the best results. Carbaryl, Imidan[®] and carbofuran showed the most consistent and effective control of the wax scales.