S
T
484

LIFE CYCLE STUDIES OF
THE FIG WAX SCALE
Ceroplastes rusci, (Linn.)

by

Abdallah Khasawinah

A Thesis Submitted to the Graduate Faculty
of the School of Agriculture in Partial Fulfillment of
The Requirements For the Degree of
MASTER OF SCIENCE IN AGRICULTURE
Split Major: Entomology - Plant Pathology

AMERICAN UNIVERSITY OF BEIRUT
SCIENCE & AGRICULTURE
LIBRARY

Approved:

A. S. Talhouk
In Charge of Major Work

A. Weltin

K. W. Hanson

Ramzi Khalidy

W. N. Dagher
Chairman, Graduate Committee

American University of Beirut

1963

The Fig Wax Scale *C. rusci*, (L.)

Khasawinah

ABSTRACT

The aim of the present work is the study of the life cycle and behavior of the Coccid Ceroplastes rusci, (Linn.) on its most important host, the fig tree, Ficus carica, L. For the above aim fig plants were grown in the laboratory and were artificially infested by this pest, and were kept under observations. In addition, records of observations were kept on the development of scales on naturally infected fig trees growing in Ras Beirut gardens.

Permanent microscopic preparations were used for the morphological studies of the different stages of the insect.

The number of generations, the threshold of development as well as the thermal constant for this species were determined.

The number of eggs laid by a female was found to be variable, but the average of the counts made was about 1200 eggs.

The role of weather conditions and parasites on populations of this scale was reviewed, and the prolificity of individual females was brought up.

ACKNOWLEDGEMENTS

I acknowledge with deep gratitude the advice, guidance, assistance and encouragement given to me in directing this study by Dr. A. S. Talhouk.

I am grateful to my colleague Mr. N. R. Jaffri who very kindly spared his valuable time for improving the rough drawings.

My thanks are also due to all those who helped to make this thesis possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Commercial fig culture is practiced in almost all countries bordering the Mediterranean sea. The list of insects that attack the fig tree or its fruit is a long one. Of the scale insects that infest the fig tree, Ceroplastes rusci, (Linn.) is the most serious pest in the Mediterranean fig districts, (Newstead 1911 and Condit 1947), although Hagan (1929) did not find it to be a serious pest in the Smyrna fig district in Turkey.

Ceroplastes rusci, (Linn.) ranks first in importance as a pest of fig trees. It infests almost all parts of the tree above the soil except the trunk and old branches. The leaves, the tender shoots and the fruits, however, are the favoured parts for this sucking insect. The injury to the tree is mainly due to the loss of the cell sap. This Coccid, like many other Coccids, excretes honeydew which is a suitable medium for the growth of sooty moulds. The black mycelia of these fungi cover the surface of leaves, young shoots, and fruits, and interferes greatly with the proper functioning of the stomata. Thus attacked leaves drop earlier, and photosynthesis is retarded..Infested fruits have a dirty appearance which renders them unmarketable. A severe infestation by the fig wax scale reduces the vigor of the tree, predisposing it to the attack of other pests, especially borers.

De Stefani (1919) considers C. rusci, (L.) as capable of disseminating the withering of fig trees which is a bacterial disease, but this is open to question, since this fact was not confirmed later.

Generally, weak fig trees are more susceptible to the fig wax scale attack. Young trees are more resistant due to the high acidity in the twigs contributed by malic acid which is toxic to C. rusci, (L)(Comes ,1918).

The purpose of the present study is to throw light on the life history and habits of this scale in relation to its host the fig tree. Such a study is necessary for a sound control program.

REVIEW OF LITERATURE

A. Taxonomy and Synonymy

Order: Homoptera

Suborder: Sternorhynchi

Superfamily: Coccoidea

Family: Coccidae

Sub family: Lecaniinae or Coccinae of various authors(but not the Coccinae of MacGillivray), distinguished chiefly by the presence of a pair of plates which form an operculum over the anal opening. It comprises the soft scales where the hard shell is not separable from the body.

Genus: *Ceroplastes* Gray. The adult female is completely enveloped in a more or less dense covering of wax. It may exhibit the form of definite plates, or it may be uniform in texture in other species. On removal of the wax, a caudal prominence is generally visible. Legs and antennae are well developed (Brain , 1920).

The synonyms used for *C. rusci* (Linn.) were compiled by Brain (1920):

Coccus rusci, Linn. Syst. Nat. Ed. X, i p. 456, 1758.

C. caricae, Bem. Mem. Acad. Marseille, p. 89, 1773.

C. artemisiae, Rossi, Mant. Ins. ii, pp. 56 and 514, 1794.

Calypticus radiatus, Costa, Faun. Reg. Nap. Cocc. p.12, 1835.

C. testudineus, Costa, Ibid., p.12, 1835.

C. hydatis, Costa, Ibid., p.14, 1835.

Columnea testudineus, Targ., Atti dei Georgofili, n.s.xiii p. 31, 1866.

Coccus hydatis, Targ., Studii Sul., Cocc., p.12, 1867.

Columnea testudiniformis, Targ., Ibid. pp. 8, 11, 12, 1867.

Chermis caricae, Bdv., Ent. Hort., p. 320, 1867.

Caroplastes rusci, Sign., Ann. Soc. Ent. Fr.(5)ii, p.35, 1872.

Lecanium artemisiae, Sign., Ibid., p. 37, 1872.

Balachowsky (1935) reports Ceroplastes nerii, Newst. as another synonym.*

B. Host Plants

The fig wax scale is a Coccid of the Mediterranean region living naturally on Myrtus communis, L. Its adaptation to the fig tree is very old, but is not restricted to Ficus carica, L.; it attacks other Ficus spp. used as ornamentals, such as F. nitida, Thunb., and F. macrophylla, Desf. (Balachowsky 1935)*

The list of plants that are attacked by this insect is a long one. Bodenheimer (1951)** found it on the following plants in Palestine; they fall in six different families:

Schinus terebinthifolius, Raddi - Christmas berry tree.

Nerium oleander, L.

Hedera helix, L.

Ficus carica, L.

* p. 596.
** p. 388.

F. sycomorous, L.

F. infectoria, Roxb.

Crataegus azarolus, L.

Citrus spp., L.

Silvestri and Martelli report it on the following plants in Italy: (Balachowsky)*

Ruscus aculeatus, L. - Prickly butchers broom.

Pistacia lentiscus, L.

P. terebinthus, L.

Vitis vinifera, L.

Annona cherimolia, Mill.

Ilex aquifolium, L. - Holly.

Artemisia absinthum, L. - Common willow.

Strelitzia regina, Banks.

Ficus spp.

In France Balachowsky and Mensil (1935)* observed it on the following plants:

Cydonia vulgaris, Pers., - Quince.

Cyperus alternifolius, L.- Umbrella plant.

Duranta plummieri, Jack.

Escallonia rubra, Pers.

Morus alba, L. - White mullberry.

Myoporum sp., Banks.

Nerium oleander, L.

---

* p. 597.

Phytolacca dioica, L., - Jerusalem thorn.

Pittosporum tobira, Ait.

Platanus orientalis, L.

Psidium goyave, L., - Common goyava.

Populus alba, L., - white popplar.

Schinus terebenthifolius, Raddi, - Christmas-berry tree.

Schinus molle, L., - Pepper tree.

Tamarix sp., L.

Thus C. rusci (Linn.) appears to be highly polyphagous, but this polyphagy is reduced due to the fact that it is always met on the same plants, namely: Ficus spp., Myrtus, Pistacia and oleander. On the other plants it is rarely encountered, and if found, it is only in small colonies which warrant no attention (Balachowsky 1935).

C. Life History

Data on the life history of C. rusci (L.) are reported by Zoatti (1921) and Silvestri (1927) from Italy, by Bodkin (1927) from Palestine, and by Batinica and Colic (1955) from Jugoslavia.

In Palestine it flourishes in hill districts at elevations of 1500 - 2900 feet above sea level. In the Jordan Valley (below sea level) it is quite unknown. Development starts in late April and early May. The adult insects that have successfully retained their position on the twigs during the winter months start oviposition; as many as one thousand eggs may be laid by one female. Hatching is completed in four to five days. In a week's time the crawlers settle down on veins and midribs on the upper leaf surface. About a month later, the nymphs migrate to leaf petioles and young shoots. High mortality occurs during this period, only three percent attain maturity. This is attributed to predacious insects and unsuitable environment. The first summer generation is completed in 70 - 80 days. A further generation develops, and the adults of this generation appear in late autumn. Owing to the drop in temperature these adults take longer time to become full grown. The adults of this generation overwinter, and start development in the following spring. A cold winter causes mortality among these adults, but they can withstand temperatures few degrees below zero with no apparent inconvenience (Bodkin 1927).

Zoatti (1921) and Silvestri (1927) report only one generation per year in Italy. The female starts laying eggs from May to June or even longer. About 800 - 1500 eggs are laid by one female. The incubation period is about fifteen days. The mobile larvae are carried by wind to other leaves. Mating is reported to take place in August to September. About the end of October the female migrate to branches on which they remain until death follows oviposition in the following spring. In the coastal areas of Italy, in sheltered places it may complete two generations annually.

In the Herzegovina region of Jugoslavia, Batinica and Colic (1955) report two generations per year. The females start ovipodition in May, and the first generation is completed by July. The crawlers of the second generation spread to foliage and leaves. The winter is passed in the second nymphal stage.

Balachowsky (1935) reports two generations per year in Algeria. The heavy attacks On the fig trees are caused by the second generation females. In the Cote d'Azur region of France, only one single generation is completed annually. Egg laying starts in June, and the crawlers settle on the leaves during July. Development in summer is very slow. The second stage nymphs migrate to the branches to overwinter. Development is resumed in the following spring.

Carmin and Scheinkin (1931) observed three generations of C. rusci, (L.) on Ficus sycomorus, L., in Tel-Aviv,Palestine. One starting at the beginning of November, the second one at the end of January, and the third at the end of September; the most numerous in numbrrs was the first generation.

D. Natural Enemies

Ceroplastes rusci, (Linn.) is heavily parasitized throughout the year, especially in dense dolonies. Thus in Algeria it is reported that the attack of the fig wax scale lasts for three years on the same tree after which the insect disappears,(Balachowsky 1935).

Among the most active parasites is the Pteromalid Scutellista cyanea,Motsch., the larva of which feeds on the eggs of C. rusci, (L.). It is a very common parasite of wax scales everywhere. Another parasite of importance is the Noctuid moth Coccidophaga scitula, Ramb., (Bodenheimer 1951).

Picard (1915) in France, Trabut (1923) in Italy, Delassus (1924) in Algeria, and Bodkin (1927) in Palestine report that the Coccinelid beetle, Chilocorus bipustulatus,L. feeds on the larvae of C. rusci,(L).

Cerapterocerus corniyer, Walk., a Chalcid has been bred from the Coccid C. rusci, (L.) by Masi (1917).

Habrocytus platensis, Brethes,Perissopterus caridei, Brethes, and Tetrastichus zemani, Brethes, all Hymenoptera, have been found parasitizing C. rusci, (L.)(Brethes 1920).

A chalcid, Coccophagus scutellaris, Dalm., is found throughout Europe, and has probably been introduced into America, parasitizes C. rusci, (L.) and other Coccids (Silvestri 1919).

MATERIALS AND METHODS

This Coccid was bred on young fig plants, planted in one gallon tin cans. Overwintering adult females were obtained from Ain-Rummana, a place near Aley in Lebanon, on one year old twigs on May 10, 1962. For infestation the following methods were used:

1. direct placement of eggs on the fig leaves.
2. attachement by means of a Scotch tape of ovipositing adult females on the leaves.
3. transferring second stage nymphs. For this purpose, naturally infested leaves were brought from infested fig trees in Ras Beirut gardens on July 10, 1962, and left for one to two days to dry up, so that the nymphs withdraw their stylets to facilitate the transfer without causing injury to the insect.

Ten plants were infested by the first method, but with no successful results. The eggs did not hatch. This failure might be due to the exposure of the eggs, which leads to desiccation. However successful hatching was obtained when eggs were incubated in Zwölfer type humidity chambers where relative humidity could be controlled. For obtaining the different levels of relative humidity in the moist chambers, the following saturated salt solutions were used (Busvine 1957):

Relative Humidity	Saturated Salt Solution
0 %	Phosphorous pentoxide (not in solution), P_2O_5.
33 %	Magnesium chloride, $MgCl_2.6H_2O$.52.8 gm./100 c.c. H_2O.
52.9 %	Magnesium nitrate $Mg(NO_3)_2$. $6H_2O$. 223 gm./ 100 c.c. H_2O.
75.3 %	Sodium chloride, NaCl. 35.7 gm./ 100 c.c. H_2O.
90.2 %	Barium chloride, $BaCl_2$. 39.3 gm./ 100 c.c. H_2O.
100 %	Distilled water.

Two plants were infested by the second method, and satisfactory results were obtained. Six plants were successfully infested by the third method, but the infestation was completely destroyed by the Pteromalid Scutellista cyanea, Motsch. Thus the two plants infested by the second method were the subject of observation on the development of C. rusci, (Linn.).

Besides the artificially infested stock, naturally infested fig trees in Ras Beirut gardens were examined periodically. The number of insects on such trees was quite enough to permit further study of the morphology of this Coccid. The examination of such trees proved to be of great value in the study of the seasonal cycle of the fig wax acale under natural conditions. It also afforded a basis for the study of the fertility of the female which could not have been easily studied under the limited laboratory conditions.

Permanent microscopic preparations were made by the standard procedure of boiling the specimens in 10 % potassium hydroxide for twenty minutes, washing, staining in acid fuchsin, dehydration, and mounting in Canada balsam.

RESULTS AND DISCUSSION

I. MORPHOLOGY

Because of the lack of adequate description of this Coccid given by earlier authors, it was considered desirable to carry out a morphological study of the different stages of this pest. The study was carried on individuals feeding on the fig tree, *Ficus carica*, L.

A. Egg

The egg is oval, yellow when newly laid (Fig. 1, C). It changes to pink or even to red near hatching. The average length is 0.27 mm. ranging from 0.25 to 0.32 mm., and the average width is 0.15 mm., ranging from 0.14 to 0.18 mm. *En masse* the eggs often appear pink.

B. First Stage Nymph

The first stage nymph (crawler) is oval, flat, and is narrower at the posterior ~~end~~ than at the anterior end (Fig. 1, A). Its general color is light brown. The segmentation of the body is distinct. The larva averages 0.18 mm. in width, and 0.32 mm. in length excluding the antennae and the caudal setae. Its antennae are six-segmented; the basal one being the broadest, and the distal one being the narrowest (Fig. 1, B). The first and second antennal segments lack setae at this stage. One seta arises from each of the third, fourth, and fifth segments. The sixth segment is equipped with two long terminal setae, and three shorter lateral ones.

The legs are well developed. The coxa, trochanter, and femur lack setae, while the tibia is provided with two, and tarsus which is composed of one segment, bears three lateral setae and two terminal tenent hairs.

Biometric measurements of taxonomic value are tabulated below. They include measurements of antennae, metathoracig legs, and other body parts (Table 1).

Laing of the British Museum (Bodkin 1927) reports that the length of the larva is 0.45 mm., and its width 0.26 mm. These measurements are slightly larger than what was found in this study.

The larva has one pair of simple eyes(ocelli), dome-shaped, red, and comparatively bigger than in any other subsequent stage. They are placed on either side of the margin of the head in front of the antennae.

As in other Coccids, the larva has two pairs of ventral spiracles; a pair on either side near the insertion of the coxae of the prothoracic, and metathoracic legs. Abdominal spiracles are lacking. It has one pair of very long caudal setae, about three fourths the length of the body. These are lost when the larva settles.

The mouth parts are well developed, and are

Table 1. Representative Measurements of the First Stage Nymph in mms.

Specimen	1	2	3	Average
Length of larva	0.324	0.312	0.324	0.320
Width of larva	0.192	0.180	0.192	0.188
Antenna	0.096	0.108	0.108	0.104
first segment	0.018	0.018	0.016	0.017
second segment	0.018	0.018	0.014	0.016
third segment	0.012	0.024	0.024	0.020
fourth segment	0.012	0.012	0.016	0.013
fifth segment	0.012	0.012	0.014	0.012
sixth segment	0.024	0.030	0.030	0.028
Metathoracic leg	0.120	0.120	0.144	0.128
coxa	0.012	0.018	0.024	0.018
trochanter and femur	0.048	0.042	0.054	0.048
tibia	0.036	0.036	0.036	0.036
tarsus	0.024	0.024	0.024	0.024
claw	0.006	0.006	0.006	0.006
Caudal setae	0.240	0.240	0.264	0.248

described in connection with the second stage nymph. The anal opening is slightly dorsal, surrounded by the anal ring which is divided into two kidney-shaped halves.

C. <u>Second Stage Nymph</u>

This stage is characterized by the star shape that it acquires through the formation of fifteen marginal, white, conical waxy processes, and one dorsal process divided into two conical halves (Fig. 2, A). Such a shape distinguishes it from other related species. At the same time, a deep red - purple waxy shield starts to be slightly differentiated. In the young nymphs, the shield measures 1.0 mm. in length, and 0.8 mm. in width, while in older ones it measures about 2 mm. in length, and 1.2 mm. in width. When the waxy shield is removed, the insect is seen to be oval, and broadest in the spiracular region (Fig. 2, B). Biometric measurements of this stage are given in Table 2.

Table 2 shows clearly that as the nymph advances in age, it grows in size. The antennal segments show variation in length, but in spite of this, they follow more or less a certain ratio in respect to each other. Such a relationship can be expressed by the antennal formula. Examination of Table 2 reveals that the antennal formula is: 3,(1, 2, 6), (4, 5), where the numbers show the segments' number, and those between brackets are more or less of equal length arranged in decreasing order according to their length. At this stage more setae are seen on the antennae, as shown in

Table 2. - Representative Measurements Of the Second Stage Nymph in mms.

Specimen	1	2	3	4	5	6	7
Nymph length	0.720	0.720	0.996	1.140	1.260	1.260	1.272
Nymph width	0.480	0.480	0.720	0.876	0.840	0.960	0.996
Antenna	0.204	0.132	0.180	0.252	0.264	0.280	0.264
first segment	0.036	0.024	0.024	0.036	0.048	0.036	0.036
second segment	0.036	0.024	0.024	0.036	0.048	0.036	0.036
third segment	0.060	0.036	0.072	0.108	0.108	0.132	0.120
fourth segment	0.024	0.012	0.012	0.024	0.024	0.036	0.024
fifth segment	0.024	0.024	0.024	0.024	0.024	0.024	0.024
sixth segment	0.036	0.024	0.024	0.036	0.030	0.036	0.036
Metathoracic leg	0.348	0.250	0.306	0.474	0.486	0.516	0.513
coxa	0.084	0.060	0.072	0.132	0.120	0.120	0.132
troch. and femur	0.108	0.070	0.096	0.156	0.180	0.168	0.163
tibia	0.072	0.060	0.072	0.108	0.108	0.120	0.120
tarsus	0.072	0.048	0.048	0.060	0.060	0.084	0.072
claw	0.012	0.012	0.018	0.018	0.018	0.024	0.024

(Fig. 2, C). The first segment bears two, the second bears three, the third bears two, the fourth and fifth each bears one, while the terminal segment is equipped with five setae arranged as in the first stage nymph. The third antennal segment shows a marked elongation.The legs are more or less equal in length. The setae arising from the different segments of the leg are exactly the same as in the first stage nymph (Fig.2,F). Spiracles (Fig.2,G) are present practically in the same position as in the first stage nymph, but are accompanied with spiracular furrows with a row of stigmatic derm pores (Fig.2, B and E). These pores secrete a powdery waxy secretion which is very clear in living specimens of Eulecanium corni, Bouché. The secretion accumulates in clusters around the stigmatic setae (Habib, 1957). Such waxy secretion was also observed in the nymphs and adults of C. rusci, (L.). Derm pores are scattered irregularly all over the body in the young nymphs (Fig.2,B), while in older nymphs they are arranged more or less regularly (Fig.2,E). These pores when seen under high magnification are shaped like a figure of 8.

Marginal setae surround the whole body. They are irregularly spaced. The sub-marginal setae are fewer in number and shorter. There exists two pairs of setae between the antennae termed inter-antennal setae. Setae on the anal cleft are spaced closer, and are longer than other marginal setae.

The stigmatic clefts are four in number corresponding to the spiracles. About 8-24 stigmatic spines are borne on each stigmatic cleft.

The anal opening is invaginated. The anal ring is distinctly divided into two kidney-shaped plates.They are heavily sclerotized. From these plates arises a tendon like structure which extends anteriorly. It is probable that this structure helps in holding the anal plates in position as Habib (1957) suggested in his work on E. corni, Bouche'.

The endoskeleton of the head which is a typical Coccid "chitinized box" (Habib 1957) includes the pharynx mandibles, and maxillary bases (Fig,2,D). The apodemes are on the sides and are heavily chitinized.They are attached anteriorly at right angles to one another. These form the ventral and dorsal arms of the tentorium, connected by the dorsal transverse arms, and supported posteriorly by two levers on each side, united together to form a membraneous sheathing cone. The labium is semicircular, heavily chitinized and holds the mouth parts. It has three pairs pairs of labial setae.

The eyes are retained in this stage, and are in the same position as in the first stage nymph.

D. Adult Female Stage

The second stage nymph transforms into the adult through moulting. This step could not be clearly followed, because of the considerable thickness of the waxy shield which adheres closely to the body throughout life.

The adult stage is characterized by the division of the waxy shield by means of distinct red furrows into eight marginal rectangular plates; one anterior, three on each side,one medianally posterior, and one octagonal dorsal plate with an oval depression in its center containing a deposit of white wax (Fig.1,D). The color of the whole shield is dirty white to pale pink,or buff. In the preoviposition period it is slightly convex and is somewhat oval in shape. When oviposition begins, the waxy shield becomes darker in colour, transforming to brown. The dorsal plate becomes highly raised, while the marginal ones remain proportionately smaller. The furrows which seperate the plates become almost indistinct. The shape of the scale becomes semicircular. The average dimensions of the ovipositing adult are 4.0 mm in length with a range of 2.5-5.0 mm., 3.5 mm. in width with a range of 2.0-4.0 mm., and 3 mm. in height with a range of 1.5-3.8 mm. Brains (1920) mentiones that the waxy shield of adult females of C. rusci, (L.) collected from South Africa on stems of quince measures about 7.5 mm. in length, 5.2 mm. in width, and 5.0 mm. in height. This difference might be due to the effect of the host plant on the insect, as was found by Habib (1957) in the polyphagous Coccid, Eulecanium corni, Bouche'. This latter Coccid shows a great variety of sizes, colors and forms when bred on different plants, and this effect was mostly pronounced in the adult stage. It is appropriate to mention that C. rusci, (L.) bred on fig plants showed variation in size, those settled on the twigs grow larger than those on the veins of the leaves. The effect of the host plant on the development of C. rusci, (L.) deserves more study.

The adult females grow rapidly. Table 3 shows the measurements of legs, antennae and other aspects of the prevopositing adult females. This table shows that the legs, and antennae, do not grow larger than those in old nymphs of the second stage, while the stylets become smaller. These measurements are in agreement with those reported by Brain (1920). He reports the antennae are six-jointed, ranging in micra: (1) 34 - 40, (2) 37 - 40, (3) 114- 120, (4) 17 - 24, (5) 20 - 27, (6) 44 - 57. He also reports the measurements of the metathoracic leg: coxa 102, femur and trochanter 170, tibia 120, tarsus 85, and claw 20.

The anal plates are heavily chitinized. They have a perforated appearance, and are circular in shape (Fig. 1,E). The pores are less numerous than in the second stage nymph and are smaller. Other aspects are similar to those in the second stage nymph. It is worth to add that ovipositing adult females lose their appendages, namely; the legs, the antennae and mouth parts.

E. Male

Attempts to find the males in this study were futile.

Table 3. - Representative Measurements of Preovipositing Adults in mms.

Specimen	1	2	3	4	Average
Body length	2.280	2.520	2.040	2.880	2.430
Body width	1.680	2.040	1.500	1.920	1.785
Antenna	0.240	0.288	0.270	0.276	0.269
first segment	0.036	0.048	0.042	0.048	0.043
second segment	0.036	0.036	0.036	0.036	0.036
third segment	0.108	0.120	0.108	0.108	0.111
fourth segment	0.015	0.020	0.024	0.024	0.020
fifth segment	0.021	0.028	0.024	0.024	0.024
sixth segment	0.024	0.036	0.036	0.036	0.033
Metathoracic leg	0.486	0.504	0.474	0.500	0.491
coxa	0.120	0.144	0.120	0.144	0.132
troch. & femur	0.156	0.156	0.156	0.156	0.156
tibia	0.123	0.108	0.108	0.108	0.111
tarsus	0.072	0.072	0.072	0.072	0.072
claw	0.018	0.024	0.018	0.020	0.020

Balachowsky (1935)*, however, described the male as being a typical Coccid male, having one pair of front wings, and a red body. It lacks mouth parts, and has a needle-shaped aedeagus. Other workers failed in their search to demonstrate the presence of males (Bodenheimer 1951)#.

II. LIFE HISTORY

The development of a small group of the fig wax scale was studied in the laboratory. On the 17th of May, 1962, an ovipositing adult female was attached to a leaf on the fig plant by means of a Scotch tape. The plant was kept in the laboratory for closer observation, and was exposed to the sunlight as much as possible in the morning hours. The first crawlers appeared on June 8, 1962. By June 13, that is five days after hatching, few crawlers began to settle on the upper surface of fig leaves. On the 19th of June, 18 crawlers have settled, and already attained the star shape of the second stage nymph. Their position on the leaf was marked and plotted so as to permit a closer study of their future development. A marked growth in size was noticed by the 30th of June, and on July 12, three nymphs had already moved to the underside of the leaf, while the rest remained in place. On the 14th of the same month the third stage preovipositing adults began to appear. After seven days a rapid rate of development was noticed, and on

---

* p. 598.
# p. 388.

the 29th of July, the first ovipositing adult females appeared. A total of ten females have attained this stage by that time. Another eight were found to be abortive and did not develop beyond the second stage nymph. This generation, therefore, was completed in approximately 73 days.

On August 5, crawlers of the second generation started to appear and continued to do so until August 17. These larvae were seen crawling over the leaves in search for suitable spots. Some settled on leaf petioles, others on the twigs. But most of them settled on the veins of the upper surface of the leaves, while very few have settled on the lower surface of the leaves. On August 11, the second stage nymphs appeared. Some crawlers have walked about 50 cms. from their hatching point before settling, although most of them have settled near their hatching place. The third stage (adults) started to appear on September 10, and by the 30th of the same month, the first ovipositing females appeared. Development seems not to be very uniform, since on the 25th of September many second stage nymphs were still seen.

On October 12, the crawlers of the third generation started to appear and continued to do so until October 30, 1962. By the 20th of October the crawlers have started to settle. A large number of the crawlers have settled by November 10, on almost all parts of the plant, and attained the star-shape of the second stage nymph. The third or adult stage started to appear on the 24th of November, but most of the nymphs were by that time in the second stage. Even these were not uniform; some were young and some were old. Even few nymphs were seen still migrating to the twigs on the 24th of November.

Infested leaves started to drop on December 12, carrying many insects, mostly second stage nymphs. As of that date rate of development started to slow down.

A. Life Cycle and Habits

The eggs hatch under their mother scale. The larva pushes its way from the anterior part of the egg after removal of the cap. The minute crawlers remain for about two to four days under the scale, then crawl out to find a suitable spot on the host plant to settle down. These crawlers are very active especially during hot weather. They can travel a distance of about 10 - 60 cms. from the mother scale. Some may even pass from leaf to leaf, and in nature from tree to tree if their leaves come in contact. Many individuals, however, show a tendency to settle in the immediate neighbourhood of their hatching place. Their dispersal in nature is extensive enough to allow them to infest the young shoots and leaves. Wind seems to be an important factor in their dissemination. The spread of infestation of thoroughly clean trees, in the neighbourhood of infested ones is an evidence to that effect. This was observed in the writer's own garden, where seven years old fig trees free from infestation by this scale in 1961 got slightly infested in 1962. The only possible source of infestation in this case were the infested old trees some 50 - 150 meters away.

The crawlers settle mostly on the upper surface of the leaves, although few settle on the lower surface. Observations of naturally infested trees show that the crawlers settle in all four directions.

The crawler's stage is a very weak one. In spite of the very large number of eggs produced per female, and in spite of the high percentage of hatching, only few crawlers are able to settle successfully on the leaves. On the artificially infested fig plants many crawlers of the second and third generation got drowned so to speak in the plant exudation (gum formation and guttation water) during their active movement and could not develop further. In nature mortality of crawlers is brought about by unfavourable weather conditions, such as cold winds in the month of May, and by predators. Also large numbers of crawlers that are carried by wind die because they land on unsuitable spots. No attempt was undertaken to count the percentage of crawlers that succeed in settling, because of their minute size, and the unnatural environment that would be created in case the leaf area were to be limited.

Eggs were incubated in Zwölfer type humidity chambers at 28^{o}C and relative humidities as specified on page 11. Hatching began four days after incubation and continued for 15 days. Hatching percentages were : 0,25, 75,and 52 at 0,33, 53, and 75.3 % relative humidities, and there was less than 20 % hatching at 90 and 100 % relative humidities. The larvae in these chambers remained alive for about four days, after which they die due to the absence of food material.

The crawlers stage extends for about 5-10 days, after which the insect settles. Immediately the settled larva begins to push its stylets into the plant tissue and sucks the cell sap. Small quantities of honey dew are secreted during this stage. The duration of the second stage nymph varies under different conditions. In the laboratory, this stage of the first and the second generation took 30-40 days to be completed. During this stage the insect overgrows many times its original size.

The waxy processes of the second stage nymph are lost gradually, but their rudiments persist, and the insect is transformed to the third stage(the adult). Growth in size is very rapid during this stage. The insect may double or triple the size it had at the beginning of this same(adult) stage. The adult secretes copious amounts of honey dew that could be seen glistering in the sunlight on the anal end of the insect.On the artificially infested plants the honey-dew attracted ants, and adults of Ceratitis capitata, (Wied.) that escaped from rearing cages. Bodkin (1927) similarly observed adults of C. capitata, (Wied.) feeding on the honey-dew secreted by C. rusci, (L.) infesting fig trees in Palestine. Bodenheimer (1951) similarly observed that adults of C. capitata were attracted by honey-dew secretions of Ceroplastes floridinsis, Comstock in citrus groves in Palestine. In nature, this honey-dew encourages the growth of sooty mould fungi. The mycelia of these fungi cover a large area of the leaf surface, thus interfering with the processes of respiration and photosynthesis. This results in lower yields and unmarketable fruits.

Egg maturity causes the body of the female to become highly convex by bulging dorsally. The scale becomes deep brown in color, smooth and shiny. The dorsal plate becomes highly enlarged. The third stage lasts for about 30 - 40 days.

B. Number of Annual Generations

On the artificially infested plants, three generations were completed. The first one, the spring generation, took from mid-May to the end of June for completion, thus required 70 - 75 days.

The second generation, or the summer generation, began early in August, and was completed by the begining of October; it thus required 60 - 65 days.

The third or overwintering generation began in mid-October, and required longer time for complete development due to the retarding effect of low temperature.

The average temperature during the development of the first generation was 26.3°C, and during the second generation it was 28.2°C. Considering the first generation to be completed in 74 days and the second generation in 63 days, and applying Blunck's Formula:

$$74\,(26.3 - x) = 63\,(28.2 - x)$$

where x is the threshold of development in degrees -Centigrade, and solving for x we get the threshold of development to be 15.4 degrees Centigrade. The thermal constant which is the product of effective temperature in degrees - Centigrade above the threshold of development and the number of days taken for complete development was calculated to be 806 day -degrees Centigrade. Usually there is an overlapping of generations. It would be interesting to find out how many generations it can complete in the region of Aley in Lebanon.

C. <u>Fertility</u>

The number of eggs laid per female is not constant. It seems to be influenced to a marked extent by the size of the adult female. If the shape of the scale insect is considered to be a semiellipsoid or even a hemispheroid, then the volume of the insect would be equal to

$\frac{1}{2} \cdot \frac{4\pi}{3} \cdot \frac{L}{2} \cdot \frac{W}{2} \cdot H$, where L is the length, W is the width, and H is the height. In other words the volume would be equal to $\frac{1}{6}$. TT. L. W.H. Table 4 shows the volume of each of 16 individual females and the number of eggs produced by each individual. The egg counts were obtained by emptying the eggs only from mature females (see page 20). Those females that were still ovipositing, or those that had hatching larvae under their scales were discarded. The eggs were spread on a sheet of graph paper. A binocular microscope was then used to count the number of eggs in each square centimeter on the graph paper, then adding them together to get the total number of eggs.

Table 4 shows that there is a somewhat direct relationship between the size of the female and its fertility. The small specimens produced only few eggs, while the large ones produced substantially more. This is shown graphically in Fig. 3, This correlation is even better shown by computing the coefficient of correlation. The following formula is used:

$$r = \frac{E\,xy - n\bar{x}\bar{y}}{\sqrt{(E\,x^2 - n\bar{x}^2)(E\,y^2 - n\bar{y}^2)}}$$

where r is the coefficient of correlation, x is the volume of the scale insect, y is the number of eggs corresponding to a given x, $\bar{x}$, and $\bar{y}$ are averages of x and y, and n is the number of individuals which is 16.

Substituting their values, we get r equals 0.898. This shows that there is a high degree of positive correlation.

Table 4. - Volume of Females vs. the Number of Eggs Laid per Female

Female Number	Dimensions of the Waxy Shield L x W x M mm.	Volume $\frac{1}{6} \cdot \pi \cdot L \cdot W \cdot H$. mm. cu.	Number of Eggs
1.	3.0 x 2.0 x 2.0	6.3	500
2.	3.0 x 1.5 x 1.5	3.5	150
3.	4.0 x 3.0 x 2.8	17.6	1600
4.	4.0 x 3.0 x 3.0	18.9	1600
5.	4.0 x 3.0 x 2.5	15.7	1400
6.	3.0 x 2.0 x 2.0	6.3	900
7.	3.0 x 2.5 x 2.0	7.8	1100
8.	3.0 x 2.5 x 2.0	7.8	1200
9.	3.0 x 2.8 x 2.0	8.8	950
10.	3.0 x 2.8 x 2.4	10.6	1100
11.	4.0 x 3.0 x 2.4	15.1	1200
12.	3.0 x 2.8 x 2.4	11.3	1300
13.	3.5 x 3.0 x 2.3	12.6	1000
14.	4.8 x 3.5 x 3.0	26.4	1800
15.	4.0 x 3.0 x 2.5	15.7	1700
16.	5.0 x 3.8 x 3.2	31.8	1950

Specimens No. 14, 15, and 16 were overwintering adults collected on branches from naturally infested fig trees from Ain-Rummana, near Aley on May 10, 1962, while the rest of the sixteen females were adults collected from leaves of infested fig trees in Ras Beirut on July 28, 1962. Unfortunately the small number of specimens does not justify any conclusion, although one is led to think that the overwintering females lay more eggs, at any rate these females are more plump and larger in size, probably because they get better nourishment since they are found infesting twigs. This might be of some advantage to the insect, since only few females survive the winter. Since the overwintering female is the only source of infestation in the following spring, it has to lay more eggs to compensate for the high mortality of the crawlers in the spring.

Egg laying is gradual, the eggs are laid singly. The female body shrinks with the progress of oviposition, so that at the end of oviposition period, only the scale is left with a pink mass of hundreds of eggs.

After the larvae crawl out, the scale of the insect becomes very thin and deep brown. It remains attached for some time, and is empty except for the mass of white egg-shells.

D. <u>Fluctuation of the Fig Wax Scale Population</u>

Picard (1915) reports that this soft scale infests the fig tree to such an extent as to endanger the crop. However, a period of high infestation is mostly followed by another one where only few scales would be found on the leaves and twigs. This is due to the effect of natural enemies.

Observations of some naturally infested fig trees in the Ras Beirut area on July 14, 1962 revealed that the rate of infestation by the second stage nymphs of C. rusci, (L.) was about 25 - 50 individuals per leaf. At the same time, upto 90 percent of these scales were parasitized by an unidentified Hymenopteron*, so that only few females were able to reach the adult stage. Even those adults were then parasitized by the Pteromalid, Scutellista cyanea, Motsch.; actually all females examined were parasitized. Consequently no second generation developed, and the trees were freed from infestation.

The destruction of individuals of C. rusci, (L.) by parasites and predators is expected when the fig wax scale population is high.

Recorded instances of survival through extremes of cold are reported by Poutiers (1928). He mentioned that during December, 1927 when the temperature in the area of Menton in South France fell to -8°C, the scales were not adversely affected except when the less tolerable host died.

In nature a normal reduction of C. rusci, (L.)

---

* Species No. 1 in the collection.

takes place every year, when a number of scales perish with the falling leaves and fruits. Since a much higher proportion of scales live on the leaves and fruits than on the twigs, a larger percentage of scales dies compared to that which overwinters.

E. Parasites

Ceroplastes rusci, (L.) suffers greatly from parasites. In this study four parasitic species and one predator, a Coccinelid were observed feeding on this scale. The larvae of Scutellista cyanea, Motsch. (Family: Pteromalidae: Chalcidoidea) were found feeding on the eggs. The full grown larvae of this Chalcid pupate under the infested scale, and the adult emerges through an exit hole made in the scale cover. Only one parasite was obtained from each parasitized insect. The adult Chalcid appears to be a poor flier.

The larvae of Coccidophaga scitula, Ramb., (Family: Noctuidae) feeds on the eggs of C. rusci, (L.) as well as the tissues of the adult Coccid. The caterpillars of this moth seems to have fed on many host individuals before going into pupation. This is also known from literature. The caterpillar carries more than two scales on its back and pupates under them. Further notes on the biology of these parasites are given in Bodenheimer (1951)*

An unidentified Hymenopteron larva was found

* p. 390-395.

parasitizing second stage nymphs of the fig wax scale. The parasitized nymphs develop a brown tinge waxy cover, and are easily differentiated from the healthy pink individuals. The adults of this parasite are kept in vial No. 1 in the collection. In this case also only one parasite emerges from each attacked scale insect.

Another unidentified Hymenopterous parasite was obtained from adult scale insects and has been kept in vial No. 2 in the collection.

The Coccinelid, Chilocorus bipustulatus, L. was observed feeding on the nymphal stages of C. rusci, (L.)

SUMMARY AND CONCLUSIONS

Ceroplastes rusci, (Linn.) is a serious pest of the fig tree in the Mediterranean region. Minor infestations have been recorded from other plants such as *Pistacia*, *Myrtus*, *Citrus*, and oleander. On the latter hosts, this insect does not attain any level of economic importance.

The present work dealt with the study of the life cycle and behavior of this pest on its major host *Ficus carica*, L., on the edible fig. Infestation was secured by transfering ovipositing females and second stage nymphs on young fig plants planted in one-gallon tins. Direct placement of eggs on the fig leaves failed to produce satisfactory results. When eggs of this scale were incubated at 28°C in Zwölfer type constant humidity chambers, kept at 52.9 % and 75.3 % relative humidities, the hatchability was 75 and 52 percent respectively.

The morphological study of the different instars necessitated the preparation of permanent microscopic mounts. These were made by the standard procedure of boiling the specimens in 10 % potassium hydroxide for twenty minutes, washing, staining in acid fuchsin, dehydrating, and mounting in Canada balsam.

The egg is oval and measures 0.27 mm. in length, and 0.15 mm. in width. En masse the eggs appear pink to red.

The first stage nymph (crawler) is, oval, flat, brown in color, and bears one pair of ocelli and one pair of six-segmented antennae on its head. It measures 0.35 mm. in length and 0.17 mm. in width. On the thorax it bears three pairs of well developed legs. The tarsi are composed of one segment each, and ending with a short stout claw. The body has distinct segmentation, ending with a pair of long caudal setae.

The second stage nymph is easily distinguished by the presence of fifteen marginal, whitish, conical waxy processes, and a dorsal one, giving it its star-shaped form. At this stage the third antennal segment shows considerable growth in length. The two pairs of ventral thoracic spiracles are accompanied by stigmatic furrows which include circular derm pores. The latter are probably responsible for the secretions of the waxy powdery material on the stigmatic clefts in living specimens. The waxy shield is undifferentiated and measures 1.2 - 2 mm. in length, and 0.9 - 1.2 mm. in width. The piercing sucking mouth parts are well developed and do not differ from those of other Coccids. The anal ring is composed of two kidney-shaped lobes attached together by a tendon-like structure.

The adult female is characterized by the division of the waxy shield by means of distinct furrows into eight marginal rectangular plates, and one octagonal dorsal plate. In the preoviposition period the waxy shield in pink to buff. During oviposition, the dorsal plate loses the distinct furrows, becomes highly raised, and brown in color. The waxy shield of ovipositing females measures 4 mm. in length, 3.5 mm. in width, and 3.0 mm. in height. The legs, eyes, antennae, and other parts are retained during the preoviposition period, but are lost during oviposition.

No males were found during this study.

The eggs hatch underneath the scale of the mother. The incubation period is about 4 - 15 days. The larvae or 'crawler' continue to appear for about 20 days. The crawlers are very active, and capable of disseminating the species. About one week after hatching, the crawlers settle on leaf veins and midribs. In 1 - 3 days they develop to the second stage nymph. The main function of this stage is feeding and growth. After about one month, some nymphs migrate to the twigs. Copious amounts of honey-dew are secreted by the second stage nymphs and young adults. This honey-dew contributes largely to the damage done to the fig tree. It also attracts some ant species and adults of the Mediterranean fruit fly, _Ceratitis capitata_, (Wied.). The function of the adult stage is egg laying. About 1200 eggs are produced per female, with a range of 150 - 1900 eggs. This wide range seems to be influenced by the size of the female, and possibly by the nutritional state of the adult.

In the laboratory three generations were completed. The adults of the three generations appeared in late July, late August, and those of the third generation started appearing in late November. The insect overwinters as second stage nymphs and young adults.

The threshold of development was calculated to be 15.4 degrees Centigrade, and the thermal constant to be 806 days-degrees.

Unfavourable weather conditions, abundance of natural enemies, as well as leaf drop influence greatly the fluctuations in the fig wax scale population from season to season.

The Pteromalid, Scutellista cyanea, Mostch, and the Noctuid moth, Coccidophaga scitula, Ramb.were found to be the most important enemies of this insect.

Finally, parthenogenesis seems to be the mode of reproduction in this Coccid.

LITERATURE CITED

1. Balachowsky, A., and L. Mensil, Les Insectes Nuisibles aux Plantes Cultivées. Vol. 1, pp. 596-600, Paris, 1935.

2. Batinica, J. and M. Colic, An outbreak of the fig Coccid in Herzegovina. Plant. Prot. 22: 18-23, Belgrade, 1954. R.A.E. (A) 43: 393, 1955.

3. Bodenheimer, F.S., Citrus Entomology in the Middle East. pp. 388-395. Hoitshema Brothers, Groningen - Holland, 1951.

4. Bodkin, G.E., The fig wax scale Ceroplastes rusci, (L.) in Palestine. Bull. Ent. Res. 17: 259-263, 1927.

5. Brain, C.K., The Coccidae of South Africa. Bull. Ent. Res. 11: 1-41, 1920.

6. Brethes, J., Insecto ūtiles y dañinas de Rio Grande do sul y de la Plata. Anales Soc. Rural Argentina, Buenos Aires, 7: 281-290, 1920. R.A.E (A) 8: 299, 1920.

7. Busvine, J.R., A critical review of the techniques for testing insecticides. Commonwealth Institute of Entomology. London, 1957.

8. Carmin, J. and D. Scheinkin, The fauna of Palestenian Plants: Ficus sycomorous, L. Bull. Societe Entomologique D'Egypte, 15: 164-187, 1931.

9. Comes, H., La profilaxia en patlogia vegeta. Bol. Agric. technica y Economica, Madrid, 9: 508-514, 1917. R.A.E. (A) 6: 55-56, 1918.

10. Condit, I.J., The Fig. Chronica Botanica Company, p. 181, 1947.

11. Delassus, (-), Les Insectes ennemis de l'Olivier en Algerie, Rev. Agric. Afr. Nord. 22(239 and 240): 135-139, 151-155, Algiers, 1924. R.A.E.(A) 12: 186-187, 1924.

12. De Stefani, T., The insects found on fig trees suffering from withering in the province of Palermo, Annals R. staz. speriment, Agrum, Fruttice, Acireales, 4 (1-5), 1916-1918. R.A.E.(A) 7: 413, 1919.

13. Habib, A., The morphology and biometry of Eulecanium corni, Bouche group, and its relation to host plants. Bull. Societe Entomologique D'Egypte, 41: 381-410, 1957.

14. Hagan, H.R., The fig-insect situation in the Smyrna fig district. J. Econ. Ent., 22: 900-909, 1929.

15. Hall, W.J., Observations on the Coccidae of Egypt. Minist. Agric. Egypt Tech. and Sci. Service Bulletin 22, pp. 17-18, Cairo, 1922.

16. Masi, L., A new species of Cerapterocerus, Westw. from Italy. Entomologist's Mthly. Mag., London, 3rd Ser. No. 28, p.80, Ap. 1917. R.A.E.(A) 5: 236, 1917.

17. Newstead, R., Observations on African scale insects. Bull. Ent. Res. 2: 85-104, 1911.

18. Picard, P., Les insectes du figuier. Progres Agric. Vitic., Montpellier lxii (36): 279-286, 1914. R.A.E.(A) 3: 10-11, 1915.

19. Poutiers, P., La resistance des insectes au froid. Progres Agric. Vitic., Montpellier, lxxxix (5): 120-121, 1928. R.A.E.(A) 16: 287-288, 1928.

20. Silvestri, F., Contribuzion alla conoscenza degli insetti dannosi e dei loro simbionti. Boll. Lab. Zool. Gen. Agrar. R. Scuola, Sup. Agric. Portici, 13: 70-126, 1919. R.A.E.(A) 8: 122-123, 1920.

21. ______., Il Ceroplaste (O cocciniglia) del fico, Circ. R. Lab. Ent. Agrar. Portici (4), 1927. R.A.E.(A) 17: 633, 1929.

22. Trabut, (-), Le Figuier: Ennemis et maladies du figuier. Bull. Agric. Algerie - Tunisie - Maroc. 29: 117-124, Algiers, 1923. R.A.E.(A) 11: 463, 1923.

23. Zaotti, (-)., La Coccinigila O pidocchio del fico (The fig scale). Riv. Agric. 26(44): 549, 1920. R.A.E.(A) 9: 7-8, 1921.

A P P E N D I X

EXPLANATION OF ABBREVIATIONS

Abbreviation		Explanation
AP	-	Anal plate
AR	-	Anal ring
CS	-	Caudal setae
DAA	-	Dorsal anterior arm of tentorium
DP	-	Derm pore
DTA	-	Dorsal transverse arm of tentorium
Ey	-	Eye
L	-	Lever
Lb	-	Labium
LS	-	Labial setae
Md	-	Mandible
Mx	-	Maxilla
PA	-	Posterior arm of tentorium
Ph	-	Pharynx
SC	-	Sheathing cone
SF	-	Spiracular furrow
Sp	-	Spiracle
SS	-	Stigmatic spines
St	-	Stylets
TS	-	Tendon-like structure
VAA	-	Ventral anterior arm of tentorium

Fig. 1. - A. Ventral view of first stage nymph

B. Larval antenna

C. Eggs

D. Dorsal view of adult female in the preoviposition period

E. Adult female in the preoviposition period after removal of wax

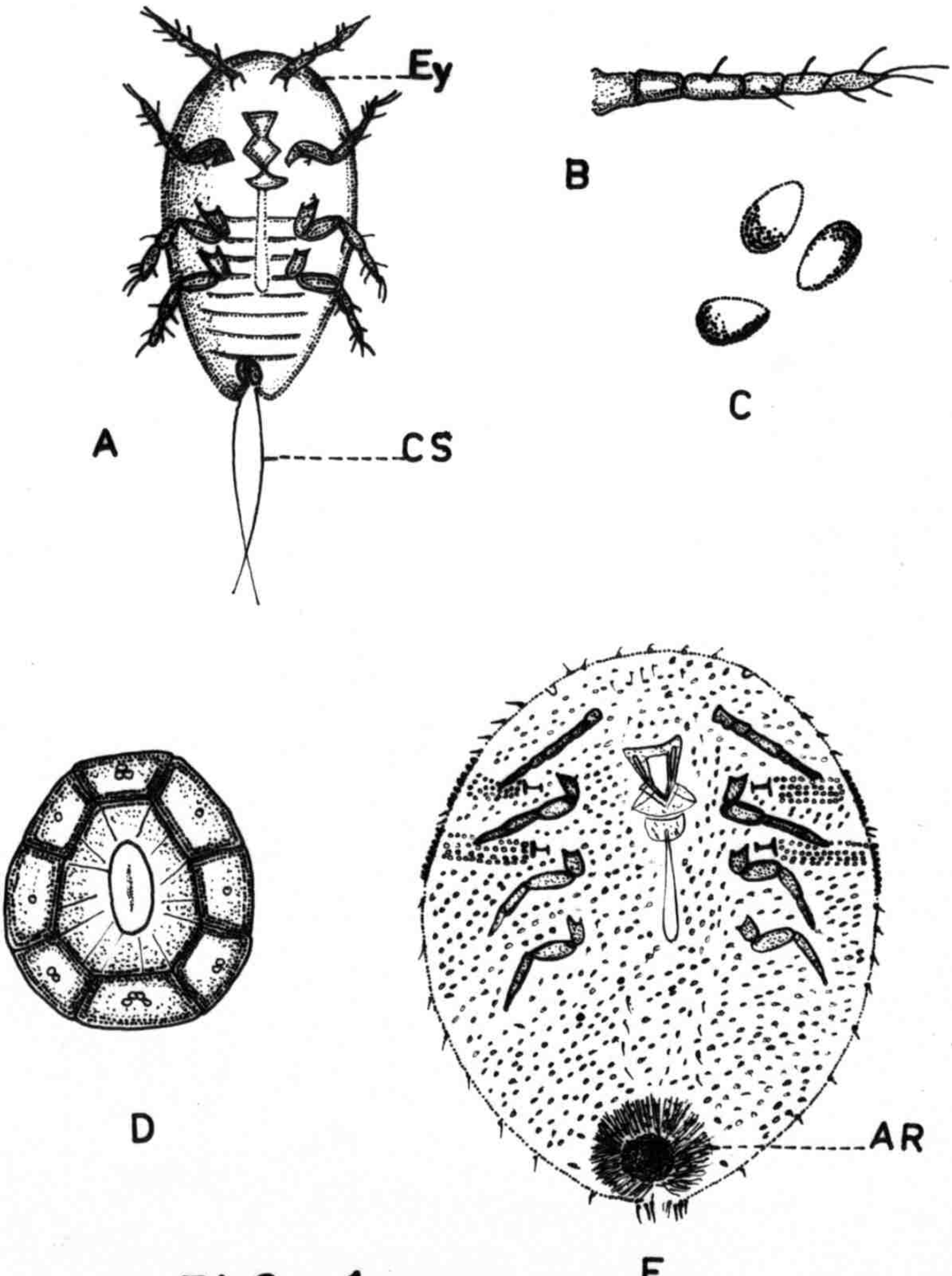

FIG. 1

Fig. 2. - A. Top view of second stage nymph

B. Young second stage nymph after removal of wax

C. Antenna of second stage nymph

D. Tentorium and mouth parts

E. Old second stage nymph after removal of wax

F. Metathoracic leg of second stage nymph

G. Spiracle; much enlarged

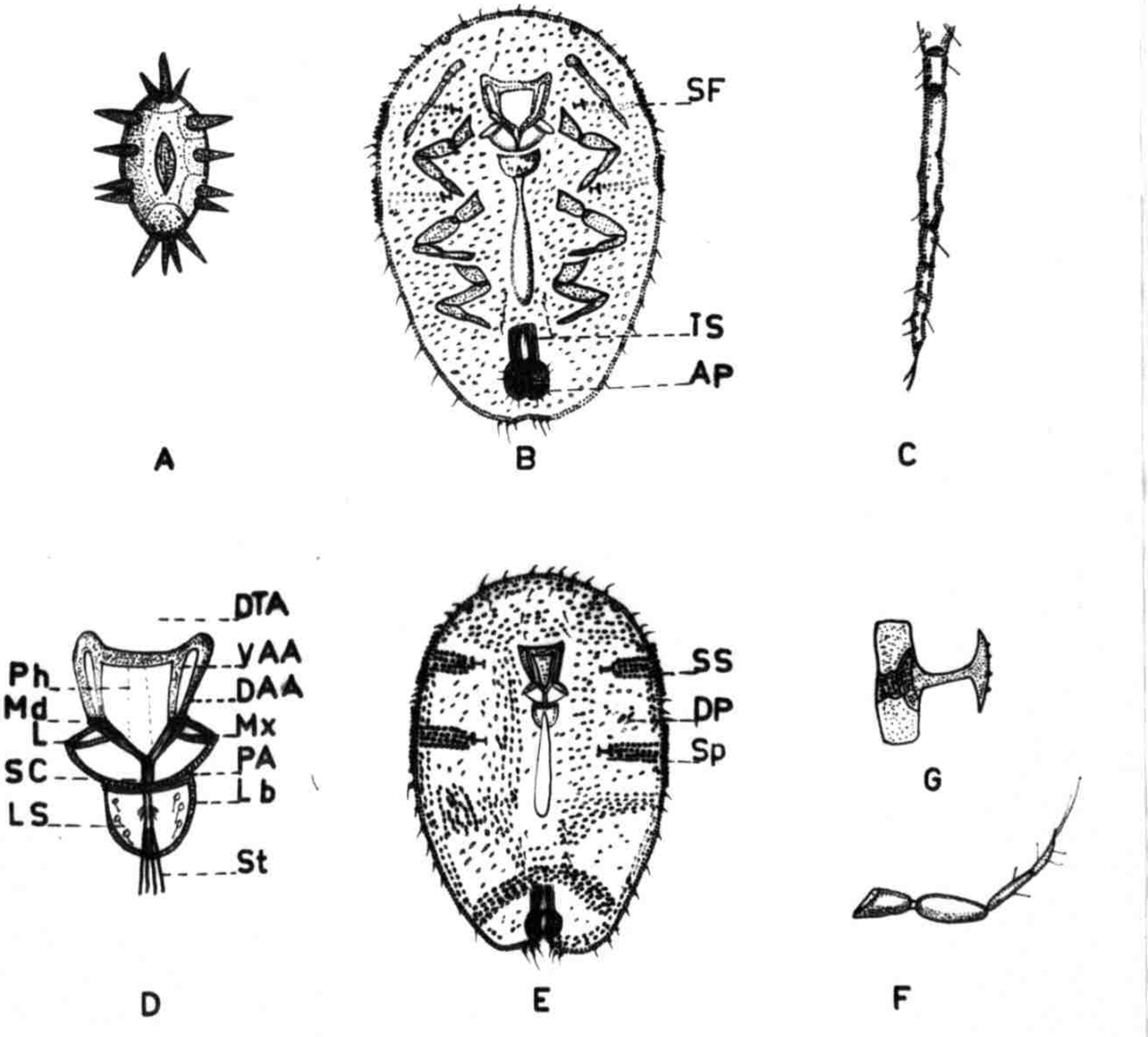

FIG.2

Fig. 3. - Graph showing the relationship between the number of eggs laid by a female and its size.

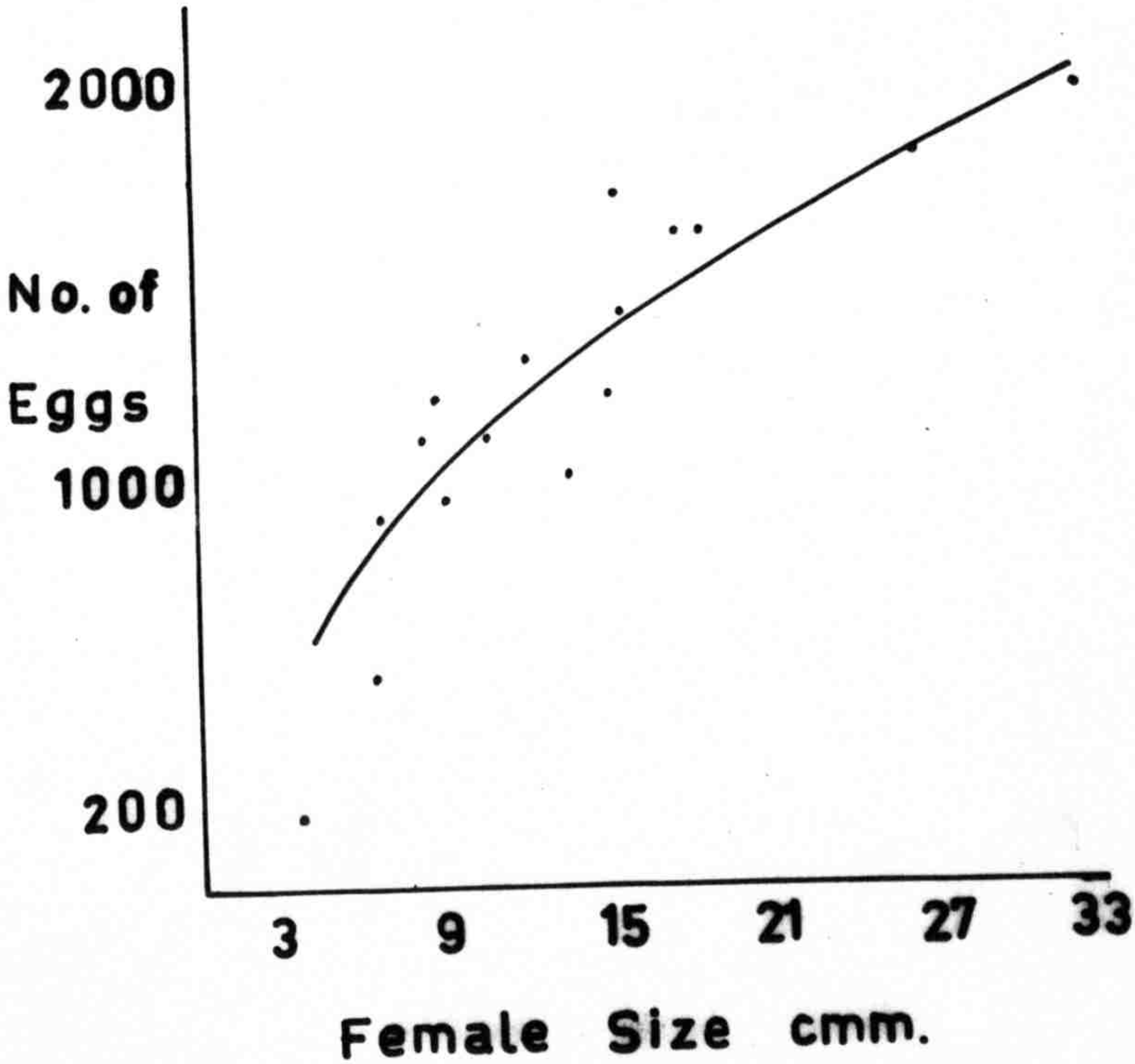

FIG. 3

Fig. 4. - Upper: Adult scales on leaf veins.

Lower: Adult scales on fig fruits.

Fig. 5. - Second stage nymphs settled on leaf veins.