

A BIOLOGICAL STUDY OF THE RED DATE-PALM SCALE, PHOENICOCOCCUS MARLATTI

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INTRODUCTION

The present paper gives the results of a study of the biology of the red date-palm scale made during monthly field inspections in the Coachella Valley, Calif., during the year 1920. This study was conducted with the object of determining the factors in the life history which may be of importance in considering control of this pest. No attempt has been made to determine the details of the life cycle, such as length of instars, variation in length of life cycle, etc., excepting those more important points which bear directly on the general study. Most of the work was conducted at the Government Gardens at Mecca, Calif., as the older trees in these gardens are generally heavily infested with scales, but frequent inspections were made of several of the larger commercial plantings to check up the observations.

DISTRIBUTION

This scale was discovered in 1890 by Dr. C. L. Marlatt at Washington, D. C., on some date palms imported from Algeria, North Africa. In 1899 Mr. T. D. A. Cockerell, while in Washington, studied the material collected by Dr. Marlatt and described the insect as a new genus and species (*Phoenicococcus marlatti* Ckll.). Several years later Mr. Cockerell found small colonies in palms in the gardens at Tempe, Ariz. Since then the infestations have increased, and it has been brought in with practically all of the later introductions of offshoots into California and elsewhere. Distribution of these and other infested offshoots has established the scale in practically every garden of imported palms.

There are over 10,000 imported palms in orchard form in the Coachella Valley now, and practically all are infested.

The quarantine act of 1913² affecting interstate movement of infested palms has restricted the distribution of this insect outside of the States

¹ The writer wishes to acknowledge the assistance of Mr. Bruce Drummond and Mr. A. J. Shamblin, of Indio, Calif., who have given freely of their time and practical field experience. In many ways the present work has been corroborated by the observations and experiences of these men.

² [AN] ACT TO REGULATE THE IMPORTATION OF NURSERY STOCK AND OTHER PLANTS AND PLANT PRODUCTS; TO ENABLE THE SECRETARY OF AGRICULTURE TO ESTABLISH AND MAINTAIN QUARANTINE DISTRICTS FOR PLANT DISEASES AND INSECT PESTS. ... [Approved August 30, 1912, amended March 4, 1913, and March 4, 1917. In U. S. Statutes at Large, v. 37, pt. 1, p. 315-319, 853-854, 1913; v. 39, pt. 1, p. 1165-1166, 1917.]

and counties then known as infested, but distribution within this area has been only partially retarded.

There is little probability of the dissemination of the scale by its own movement, as only during its very young stage does it move at all and it could hardly travel from tree to tree at this time.

The most important means of distribution is through the infested offshoots. These offshoots are invariably rather heavily infested and derive the infestation from the bole of the parent tree. Many severely infested offshoots have been found in the propagation houses, where they are placed for rooting.

Of lesser importance is the accidental carriage of the scale by the men at pollination time; and carriage by birds, insects, and the wind, especially in the spring during the so-called migratory period of this scale insect.

ECONOMIC IMPORTANCE

In severe infestations this scale has the habit of massing on the new succulent fruit stems and leaf bases of the palm in such numbers as greatly to weaken their normal development. In fact when the fruit stems are severely attacked the flow of sap is so greatly arrested that the fruit drops just before reaching maturity. Mr. Drummond states that a heavily infested Tazizaoot palm lost its entire crop for three successive seasons at the Mecca gardens. One date-growing company lost approximately 1,200 pounds of fruit from 75 infested palms in 1917. In the early spring during the migratory period the insects mass not only on the fronds but also on the fruit clusters and occasion serious damage. That they also retard the normal growth of the palm is evident.

DESCRIPTION OF STAGES.

In the body of the mature, wine-colored insect may be seen the developing embryos with their six legs, antennæ, dark eye spots, and coiled mouthparts. The young are born alive and issue from the ventral side of the mother scale into a depression in the body wall.

LARVA

The young female larva is flat and oval in shape, pinkish white in color, 0.24 mm. in length, with body segmentation fairly well defined. The antennæ are 6-segmented, the basal segment being very broad and the terminal segment cylindrical. The abdomen is 7-segmented and bears two pairs of setæ on the caudal end, the inner pair being nearly twice as long as the outer. The mouthparts are fully twice the length of the body, exceedingly fine and whiplike.

After remaining under the mother scale for a time the larva crawls out and wanders about in search of a suitable place to feed and then settles for life. The long stylet mouthparts are inserted, and the larva begins

to feed. The body becomes greatly distended with sap and assumes a rounded elliptical shape, rather shiny and yellowish white in color. Fine filaments of "cotton" are given off, first from the lateral glands, and before long the entire body is covered with a cottony mass.

Under this mass the first molt occurs. The cast skin shows a ventral split and the exuvia is thrown off dorsad of the new insect (the mouthparts remaining attached) and is incorporated in the posterior end of the cottony mass.

The larva now appears somewhat long, oval, light yellow in color, without legs, and with antennæ reduced to small tubercles. Feeding continues and additional "cotton" is secreted, but the insect enlarges so rapidly as to split the cottony mass dorsally and expose the insect. The skin becomes very tight before the second molt.

The second molt is now passed, the cast skin splitting on the ventral side but not always completely thrown off, and the rapidly growing insect (now an immature adult) spreads it so as to leave it incorporated on the upper edges of the old "cotton." The new insect is nearly round but somewhat flattened, 1 to 1.25 mm. in length, wine-red in color, and without apparent appendages or segmentation, but the antennæ under high power are still seen as minute tubercles. The cottony mass formed during the immature period forms a nestlike bed for the scale. Embryos are soon formed within the body and develop rapidly. With the development of the mature scale the wine-red is replaced by a light brown, which starts at the margins; and the color changes to a bronze in the old, dead scale. No embryos have been found in the bronze-colored scale. From field observations it was found that in the cooler part of the year the insect passes from larva to a fully matured adult in approximately a month, and doubtless in the warmer months this period is greatly shortened. As to the life of the scale no definite records have been taken, but field observations would indicate that the scale lives from six to nine months. This is determined by the development of the scale on the fruit stems and leaf bases which become infested in May but have no dead scale on them until late in November.

MALE

Thus far the writer has been unable to discern any distinction as to sex in the larva up to the first molt. From the first molt, however, which in the male form is similar to that described above, there comes a larva similar to but smaller than the female second stage; and from this comes the male pupa, which is rather long, yellowish, and with antennæ and legs folded close to the body. At the third molt the adult male issues, usually through the end of the cottony cocoon. It is shaped not unlike a thrips, with distinct body segmentation, somewhat club-shaped antennæ, rather stout legs, and long, narrow, pointed abdomen, but without wings. The

male, 0.4 mm. long, is very active and moves about much more quickly than the female larva. The number of adult males in proportion to adult females is exceedingly small. Throughout the year, in examining over 300 larvæ and cocoons, the writer found as many as 30 male pupæ but only 8 adult males.

NATURE OF INFESTATION.

The main infestation of scales on a mature palm (Pl. 127) is found on the white living tissues of the leaf bases and fiber bands from $1\frac{1}{2}$ to 3 feet down from the crown, or from the fifth to tenth leaf whorl (Pl. 128). Both inner and outer surfaces are usually infested, and the area may be from $\frac{1}{2}$ inch to 5 inches in width. The scales will be massed together, often in more or less definite order and frequently several layers deep. Infestations of lesser severity will continue on the living tissues of the old leaf bases and fiber bands even to the ground, but as the margin of living tissue narrows the quantity of living scales becomes appreciably less. These insects are usually buried to a depth of 4 or 5 inches under the plant tissues; and as the fiber bands and leaf bases are exceedingly tight, the scale is well protected from heat, dry atmosphere, or control measures. Due to the rapid growth of the palm and definite migratory habit of the scale, the crown of the tree for from three to five leaf whorls, depending upon its size and growth, is kept free of scales. This has been proved by cutting open the crowns of several palms and offshoots. During the greater part of the year (July to April) practically all of the scales are found on the leaf and fiber bases and the fruit stems. The small number found out in the leaf pinnæ are usually of little importance.

That the fruit stems of the current year are found in the area of the main infestation and are tender and succulent at their base explains in part why they are invariably so heavily infested. A number of fruit stems have been removed which were completely massed with scales $\frac{1}{8}$ inch thick for a distance of from 6 to 18 inches up from the base. Such infestations seriously injure the development of the fruit. Another important factor is that the fruit stem spathes open and the tender young stem is exposed at the same time that the so-called "spring migratory period" of the scale takes place, thus insuring a complete infestation of that tissue. The buds for the blossoms are laid down deep under the leaf bases in July to September. The bud growth continues through the fall and winter and the spathe pushes out in the spring. Flowering occurs in early April, or late April and early May, depending upon the season and plant variation. Young palms often show greater variation. It is during April, May, and part of June that the greatest migratory period of the scale occurs and the exposed fruit stems become infested. The progress of this infestation was definitely traced during April, May, and

June of 1920. By the latter part of June the fruit stems of the current year were well infested.

Of the infestations on the roots only the so-called superficial roots have been observed by the writer to be infested (Pl. 129, 130). These short, fleshy, gnarled roots, forming above ground, at the base of the bole, are usually under decaying leaf bases and frequently, on old palms, carry a relatively light infestation. They are often so concealed as to be entirely protected. Attention was drawn to an infestation below the ground surface on the bole of a young palm planted in a commercial grove, but on examination it proved to be only a case in which an infested offshoot had been set out and planted deeper than normal, thus burying some of the scale infestation. It has been reported that the scale has been found on the main roots of the palms planted in a very heavy soil at Heber, Calif., which cracked open after each irrigation and left the roots more or less exposed, but no roots have been observed to be infested in the usual sandy soils.

Some scales may be found in the pinnae of the leaves for a distance of from 2 to 6 feet out from the trunk at all seasons of the year, but the quantity is usually negligible. They undoubtedly get out there during the migratory periods and by the natural pushing out of the growing leaves, but usually they are almost completely controlled by the heat of summer. In some cases scales will persist under the sand deposited in the pinnae and will reproduce, but in most instances this infestation has been almost negligible after a few hot, dry days. The greatest number are found out on the leaves from the latter part of April until the latter part of June, though they occasionally appear again in September and October during the so-called fall migratory period. The infestations in the leaf pinnae almost always cause brown pittings on the underside of the pinnae, and these markings are often used to determine whether a tree is infested or not when it can not be cut into. By July only a few living insects are found in the leaf pinnae.

Certain varieties of palms show heavier infestations than others. The following generally develop heavy infestations: Horra, Tazizaoot, Rhars, and Rohm Gazal. Palms vary greatly in the tightness of their leaf fiber and bases, but this does not explain the variation in susceptibility to scale attack, as the variety Horra has a relatively tight fiber, but is possibly the most severely attacked.

SEASONAL HISTORY

The insect has been found in all stages of development at all seasons of the year. This would indicate a continual reproduction and overlapping of generations. Though possibly the greater number of active larvae were observed from March to December, even in January the scale was in all stages of development. In January, however, the mortality among

the young larvæ, either from moisture (mildew) or cold, appeared to be higher than at other times. The greatest development of the scale is possibly reached in the spring (April to June). This is the so-called spring migratory period when the young leave the old areas of infestation and migrate up on the bole and out on the new growth of offshoots to new areas. From the old center of infestation in the area of last year's fruit stems the new center of infestation is moved to the area of the fruit stems of the current year. This is accomplished by actual migration of the young larvæ to the new leaf and fiber tissues above and to the leaf pinnae. That by June many of these larvæ are killed in the exposed places is evident. From about the middle of April palms with heavy infestations show quantities of cottony masses out on the fronds and new fruit stems and on the new growth of their offshoots. By July this has practically all disappeared.

Mr. Shamblin has often observed a fall migration similar to the spring migration. It is much less severe and the "cotton" of the exposed insects is usually found out on the fronds of the offshoots and parent tree during September and October and disappears almost entirely by the latter part of November. The occurrence of this migration depends entirely upon weather conditions, a cool fall usually bringing on a migration. No fall migration was noted in any gardens during 1919. That this appearance of the insect is usually of relatively small proportion (less than half of the spring generation) and often is completely controlled by weather conditions makes it of much less importance than the spring occurrence.

In Tempe, Ariz., there is much less scale development than in the Coachella Valley, possibly due to a moister climate. This in a way corroborates the observations on the mortality of the young scales during January, 1920. Mildew seems to form quickly in the scale mass when it becomes too moist. The preferred feeding place of the scale (the soft living tissues of the leaf bases and fiber strands) is found to be cool and slightly moist even on the hottest day. This possibly explains the mortality among the exposed scales under the hot, dry condition of summer.

CONDITION OF FRUIT STEMS AT DIFFERENT SEASONS

A study of the progress of the infestation on the leaf bases and fruit stems cut from heavily infested palms at different seasons of the year proved most interesting. It shows clearly how fruit stems of the current year become infested from the spring migration and also shows the development of the scale.

There are usually from 5 to 7 leaf bases between the tip of the crown and the fruit stems of the current year and five leaf bases between the fruit stems of each succeeding year. The leaf bases are arranged in a

spiral on the bole of the palm. The fruit stems come out from behind the leaf bases in a definite area around the bole each year.

August, 1919. Fruit stems of current year (1919) heavily infested with immature and mature (wine-red) stages. Leaf bases above (first two) show rapid decrease (almost clean) in amount of scale of similar development. Leaf bases (third, fourth, fifth) below fruit stem with increasing amounts of old brown and bronze-colored scales, but still some living immature and mature forms.

Fruit stems of 1918 dead and brown but covered at base with old dead scales. Leaf bases below with small margins of scales in all stages of development but decreasing in quantity.

November, 1919. Condition similar to that noted above but with increased amount of scale mass and more reaching brown stage.

April, 1920. (Migratory period beginning.)

Fruit stems of current year (1920) with only few (migratory forms) on outside of bases of spathe.

First leaf base above clean.

First leaf base below clean.

Second leaf base below with only a few very young scales in fiber.

Third leaf base below with young (migrating) forms settling.

Fourth leaf base below with young and a few mature (wine-colored) forms.

Fifth leaf base below heavily infested with wine-colored forms and with a few brown ones.

Fruit stem of 1919 heavily infested in all stages, mostly brown and bronze.

June 2, 1920. (Migratory period about over.)

Fruit stems of current year (1920) lightly infested from 6 to 18 inches from base with immature scales.

First leaf base above clean.

First leaf base below lightly infested with immature forms.

Second leaf base below lightly infested with immature and wine-colored forms.

Third leaf base below with medium infestation; some brown scales but mostly wine-colored and immature forms.

Fourth leaf base below heavily infested with brown and wine-colored forms, some immature at lower margin.

Fifth leaf base below heavily infested, all brown, mostly dead.

Fruit stems of 1919 heavily infested, all brown, dead.

NATURAL ENEMIES

Apparently there are few natural enemies of the red date-palm scale. Of greatest importance is the little beetle identified by Mr. E. A. Schwarz as *Laemophloeus (Cryptolestes) truncatus* Casey (?) found working throughout the year on the heavier infestations in the Mecca gardens. Occasionally definite galleries of destroyed scales were noted where these beetles were working. This beetle was also found feeding on the scales out on the fruit clusters in a commercial garden during the latter part of April.

In January, 1920, a number of orange-pink dipterous larvæ, possibly those of some species of Itonididae, were found under a leaf base in the midst of a mass of scale insects.

SUMMARY OF BIOLOGY

Following are the important points in the biological study in relation to control:

1. The most important means of distribution is through imported palms and offshoots from infested trees. These offshoots are invariably severely infested and carry the infestation through propagation to new plantings.

2. The main infestation on a mature palm is limited to the area extending $1\frac{1}{2}$ to 3 feet below the crown, the crown tissues being free of scales. Lighter infestations continue on down the bole even to the ground.

3. From July to April practically all of the scales are concealed beneath the leaf and fiber bases and on the fruit stems of the current year.

4. The so-called spring migratory period of the scale is from April to June, and it is at this period that the new tissues and fruit stems become infested from the infested area of last year's fruit stems.

5. The majority of the exposed generations of the migratory periods out on the leaves are killed by the dry, hot weather following the migration, though some may persist in certain protected pinnæ and reproduce a limited number of scales.

6. The scale is found in all stages of development at all seasons of the year on the soft tissues of the leaf base and fiber band tissues. This indicates a continuous overlapping of generations. The duration of each generation is apparently from six to nine months.

CONTROL METHODS

Though the exposed red date-palm scale is readily killed by most contact insecticides its protected position under the leaf bases and tight fiber bands makes control by spray or fumigant most difficult. It is necessary to use a spray which will penetrate deeply between the fiber bands and leaf bases and to repeat the applications consistently in order to reach the maximum number of scales. As shown in the biological studies, it is important to check the migrations of the scale, thus preventing the new tissues and fruit stems from becoming infested.

The formula and spray calendar recommended by Mr. Drummond and Mr. Shamblin are as follows:

| | |
|---|-----------|
| Liquor cresolis compositus, U. S. P. | 1 part |
| Distillate or kerosene. | 4 parts. |
| Water. | 50 parts. |

If kerosene is used in making the stock solution, only the very best grade should be used, as oils of low specific gravity tend to retard good emulsion, in many cases injuring the offshoot or growing palm.

The spray is best applied by a power sprayer with a good agitator and under 200 to 225 pounds pressure, two leads of 30-foot spray hose being used. Six-foot to 12-foot spray rods with driving-spray nozzles set at

an angle of 45°, should be used. It is advisable to work from an elevated platform in spraying tall palms, rather than to use too long a rod.

Before attempting to spray, the palms should be properly pruned, surplus leaves being removed from the parent plant and the short method of pruning being used on the offshoots. Where possible, especially in the spring months, as many of the offshoots as are ready should be removed from the parent plant prior to spraying. On old palms the decayed leaf bases and infested superficial roots should be removed. If the dirt has been worked up around the base of the palm during cultivation this should be removed before spraying.

Too much importance can not be given to making a thorough application of the spray. Starting about a foot below the crown of the palm the solution should be so thoroughly applied as to soak all the fiber and completely fill the spaces between the leaf bases from this point to the ground. A slow, careful application made from at least two sides of the trunk is to be preferred to a hasty, incomplete spraying. The spraying of the old leaves to control the infestation in the leaf pinnæ may be limited to severely infested trees and especially immediately following the migratory periods. An average 10-year-old tree with a 6-foot trunk, properly pruned, will take from 15 to 20 gallons of spray.

The proper time to spray is determined and limited by the time the fruit crop is off, the migratory period of the scale, the blooming period, and the time the fruit begins to make sugar. On imported palms (barring seedlings) the fruit is generally all harvested by November 15, the blooming period is from the latter part of March on until May, the spring migration of the scale is from April to June, and the fruit begins to make sugar about August. This permits four sprayings per year, as follows:

| | |
|-------------------------------|-------------------|
| First spray period | Jan. 1 to Feb. 15 |
| Second spray period | Feb. 15 to Apr. 1 |
| Third spray period | May 15 to June 30 |
| Fourth spray period | July 1 to Aug. 15 |

On seedling palms the spray periods will of necessity be governed by the factors mentioned above and will also vary with different varieties. In most cases the spray periods will be of shorter duration, but even then not less than four sprayings should be given.

The treatment of infested offshoots as now practiced consists of thoroughly and completely dipping the cut offshoots in a bath of the foregoing solution. They should be submerged for 15 minutes, taken out and drained for 24 hours, and then submerged a second time for 15 minutes, making 30 minutes altogether in the solution. This solution at a strength of 1 to 50 will not injure the offshoot if left in it 24 hours. Offshoots should also be carefully inspected and sprayed during propagation planting.

PLATE 127

Showing nature of growth of leaves, fruit stems, and offshoots of date palm.

(668)





PLATE 128

Typical infestation of *Phoenicococcus marlatti* at base of leaf stem of date palm.

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PLATE 129

Superficial roots on old palm generally infested with *Phoenicococcus marlatti*.





PLATE 130

Close-up of superficial roots, showing infestation of *Phoenicococcus marlati*.