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Agricultural Experiment Station.

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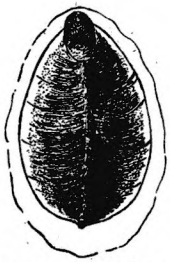
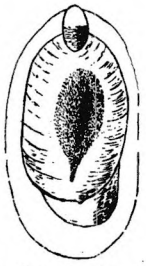


Parlatoria blanchardi (*victrix* form) female scale, greatly enlarged.



Parlatoria blanchardi (pale form) female scale, greatly enlarged.

The Scale Insects of the Date Palm.

By T. D. A. Cockerell.

The Extermination of Date-Palm Scales.

By R. H. Forbes.

Tucson, Arizona, Sept. 23, 1907.

CONTENTS.

The Scale Insects of the Date Palm.

The Extermination of Date-Palm Scales.

ILLUSTRATIONS.

PLATES.

FIGURES.

Fig. 1. Good and bad date-palm horticulture with reference to date-palm scales. The left hand tree is well trimmed up, easy to inspect and treat. The right hand tree is a tangle of foliage, difficult of access and a shelter for pests.

THE SCALE INSECTS OF THE DATE PALM.

By T. D. A. Cockerell.

THE DATE-PALM SCALE.

HISTORICAL.

The Discovery of the Scale.

In July and August, 1890, the U. S. Department of Agriculture received from Africa a considerable number of date palms, fifty-four being from Cairo, and nine from Algiers. These palms were found to be infested by a scale, which was supposed to be identical with the Jujube Scale (*Parlatoria zizyphus* Lucas), a species commonly infesting oranges in the countries bordering the Mediterranean. In reality they were a distinct species, now known as the Date-Palm Scale, but until then unobserved by entomologists, though it has doubtless abounded in Northern Africa for many centuries.

As the palms received at the Department of Agriculture were intended for planting in the Southwest, it was naturally considered important to eradicate the Scale. This proved to be a matter of unusual difficulty, as is shown by the detailed account taken from Insect Life, Vol. 3, p. 442, quoted on pages 193 and 194 following.

The Scale Appears in Arizona.

Some of the date palms referred to above were shipped to Salt River Valley, Arizona, and were planted in the grounds of the Experiment Station Farm. After about four years, Professor Toumey observed that the trees were scaly, and examination showed that the scale was the same as that found on them at Washington. As the scales belonged to an Old World genus and species, not known to infest any plant but the date, it was evident that it had survived on one or more of the palms, notwithstanding the drastic and careful treatment above referred to. Professor Toumey was so kind as to send me some specimens, and finding that the identification as *Parlatoria zizyphus* was erroneous, I described them as *Parlatoria victrix*, the "conquer-

ing *Parlatoria.*" (See Bull. 14, Arizona Experiment Station, June, 1895.)

The Independent Discovery of the Scale in Africa.

Soon after the discovery of the Scale at Washington, Professor Targioni-Tozzetti, of Florence, Italy, received a scale from M. Raphael Blanchard, of Paris, the latter having received it from the Oasis of Ourir, in the Sahara Desert. This scale was infesting the date, covering the young leaves in great abundance. Professor Targioni-Tozzetti, finding it to be undescribed, wrote a lengthy account of it, which was published by the Zoological Society of France in 1892 under the title "*Aonidia blanchardi,* nouvelle espece de cochenille du dattier du Sahara". The material was very good, enabling Targioni-Tozzetti to describe both sexes, and the immature stages.

When describing *Parlatoria victrix* I was in possession of Targioni-Tozzetti's paper, but concluded that his scale could not possibly be the same as mine, for the following reasons:

(1) He described it as an *Aonidia,* whereas the Arizona scale was clearly a *Parlatoria.* As Targioni-Tozzetti himself founded the genus *Parlatoria,* it did not seem likely that he would fail to recognize it.

(2) *Aonidia blanchardi* is described as having the second skin (which forms the greater part of the scale) parchment-color, brown by reflected light, yellow by transmitted, without any black. The Arizona scale, on the contrary, had the second skin black, broadly margined with pale straw color.

(3) There were also certain anatomical differences. It has turned out subsequently, however, that Targioni-Tozzetti's scale was a veritable *Parlatoria,* that the difference in color is due to variation, and that the supposed anatomical differences were due to the immaturity of my material. Thus the scale becomes *Parlatoria blanchardi,* the *blanchardi* proper being a pale form, while the *victrix* is the much more common dark one.

The Discovery of the Scale in Australia.

Mr. W. M. Maskell, in the Transactions of the New Zealand Institute for 1897 (published in July or August, 1898), described a scale which he called *Parlatoria proteus,* variety *palmae.* It was found in the northern district of South Australia, on date

palms imported from Algeria about three years previously, and planted near Lake Harry. This scale was undoubtedly *Parlatoria blanchardi* of the dark *(victrix)* form.

The Recognition of the Typical Parlatoria blanchardi in Algeria.

On January 23, 1899, the distinguished American naturalist Dr. A. S. Packard was traveling in Algeria, and wrote me from Biskra: "I find myself in this oasis of the northern edge of the Sahara, where there are 170,000 date palms. In a beautiful garden I found a date palm, indeed several, affected by Coccids, which I enclose." These proved to be the real *P. blanchardi,* much paler in color than the Arizona insects. In discussing them (Science, March 17, 1899, p. 417) I transferred *Aonidia blanchardi* to *Parlatoria,* but still supposed that *victrix* was a distinct, though closely allied species.

DESCRIPTIVE.

The Adult Scale.

To the naked eye the Scales appear as small dark-grey or black specks, edged with white. Their appearance, enlarged about 2¾ diameters, is so well shown on Plate I that recognition will be easy. Plate II (Figs. 1 & 2) illustrates the details of the female scale greatly magnified. At one end will be seen a small oval object, which is the "first skin"; that is, the skin shed by the young at its first moult. The large shield-shaped object is the "second skin", and the white surrounding part is the scale secreted by the insect in its last stage. In Fig. 1 the second skin is dark (form *victrix),* in Fig. 2 the dark area is greatly reduced, approaching the character of typical *blanchardi.* These variations often occur on the same tree, the light ones usually hidden at the bases of the leaves. If the scale is lifted by means of a pin or the point of a knife, the soft, plump and juicy female, of a rose-pink color, is found underneath. In Fig. 3 this female is shown, greatly enlarged. It will be seen that she is feebly segmented, without legs or any other conspicuous organs, except a structure at the middle of the anterior end, which is the mouth, from which in the living insect protrudes the tube through which the sap of the plant is sucked. The hind end of the body is consolidated into a "pygidial area", so-called, on the edge of which is a fringe of lobes and fine scale-like processes which are very

important in distinguishing species. The posterior end, more magnified, directed upward, is shown in Fig. 4. Figures 3 and 4 are made from material collected by Dr. Packard at Biskra.

The male scales are much smaller and narrower than those of the female, and lack the "second skin". The male is rarely seen. It is described by Targioni-Tozzetti as a very small insect, with six well-developed legs, and a pair of long ten-jointed antennae, the genital armature projecting as a long tail or spike at the posterior end. It is said to be wholly without wings, which is unusual among male Coccidae.

HABITS AND ENEMIES.

Reproduction.

During the winter the female is dormant, but, in Salt River Valley, at least, eggs begin to be laid about the middle of March. These are minute oval objects, found underneath the scale, at the posterior end. Only a few are produced at a time, and the total number is very small in comparison with many other scale insects. The larvae begin to hatch from the egg, one at a time, about April 1st. These are very minute creatures of a pink color, with legs and antennae. They crawl restlessly about for some time, and then settle down in some place, where they remain the rest of their lives. The male, hatching from the male scales, impregnates the female and dies, his whole life being probably very brief. The number of annual generations is not known.

Migrations.

Since the female insect is only able to move about in its earliest stage, and then only by crawling, it might seem that it would be practically impossible for the scale to migrate from one palm to another. However, the little larvae have the habit of clinging to anything that approaches, and it is believed that they are carried, accidentally as it were, by various winged insects, and also by birds. Birds nesting in the palms are especially likely to be the means of spreading the scale. Ants are also known to be the means of spreading various scale insects. A species of ant, *Pheidole cockerelli* Wheeler *, was found by Mr.

* Described by Dr. Wheeler in a paper about to be published. It was first found, by the present writer, at Prescott, Arizona. I am indebted to Dr. Wheeler for the determination of the specimens.

F. H. Simmons attending the date-palm scale at Tempe. When the trees are growing close together, the larvae are probably often blown from one to another by the wind, though the chances of any individual larva reaching a place of security by this means must be slight.

Enemies.

The natural enemies of scale insects are principally of two kinds; small beetles and their larvae, of the family Coccinellidae, and minute four winged flies of the order Hymenoptera, known as Chalcididae. We are totally ignorant of the enemies of the Date-Palm Scale in Africa, and it appears probable that none of them have ever reached this country. From the point of view of parasites, it may very well be safer to introduce into a country a badly infested tree, without treatment, than to *almost* but *not quite* exterminate the scales. In the former case the natural enemies, or at least some of them, would be very likely to survive; in the latter, their chances would be slim.

Some of the native Arizona insects have begun to prey upon the Date-Palm Scale, though not really enough to keep it in check. Professor Toumey, as far back as 1895, mentions finding a lady-bird beetle *(Coccinella abdominalis)* feeding on the scale at Phoenix. I have seen a different species *(Chilocorus cacti)* at Phoenix, engaged in the same way, and suspect that the two records really refer to one kind of beetle.† This Spring I found a very small purplish Coccinellid larva, apparently a species of *Scymnus*, underneath a scale sent from Tempe. For some years, at different times, I had searched for evidence of the attacks of Chalcididae, which are internal parasites, the adults escaping through a hole made in the scale. In this search I had never been successful until this Spring, when I found a single parasitized scale from Tempe figured on Plate II, Fig. 5. I tried to breed some of the adult parasites from the scales, but without success.

Food Plants.

So far as I have been able to observe, the scale is strictly confined to the date palm. Even the *Washingtonia* palms growing close to the infested date palms at Phoenix are not affected.

† The *Coccinella* looks like the *Chilocorus*, but it is easily distinguished by the cream-colored marginal band of the thorax.

Mr. R. Newstead has recently (Quarterly Journal of Inst. of Commercial Research in Tropics, April, 1906) reported its occurrence on jasmine foliage, which is very unusual, and would be regarded with doubt, were not the authority so good.

MR. C. L. MARLATT ON THE VARIATION OF THE DATE-PALM SCALE.

Mr. C. L. Marlatt of the U. S. Bureau of Entomology, has very kindly gone into the question of the two color-forms of the scale at great length, concluding that there is certainly only a single variable species. As his letter contains much interesting information, I quote the greater part of it with his permission:

"It is true that the material from Arizona indicates pretty generally the darker type of scale; with plenty of examples, however, on almost every lot of material, of light scales; and you do not have to go to the base of leaves to find great variation in the amount of color. The original importation in 1890 was, as you probably know, of nine large trees from Algeria received July 8, and 54 small ones from Cairo received about the end of the same month. I do not know now where all of them were distributed; some in California, however, and others in Arizona. I have here two packages of material which I collected October 7, 1890, from these importations. The scales on these are mostly light colored, but with nearly always a streak of dark, and very often individuals quite as dark as the normal Arizona type. This stock seems in Arizona to have developed the darker type. Specimens of the same lot which went to California seem to have maintained more closely the light color. For example, I have specimens received from Pomona, California, March 8, 1894, which are mostly light or with a rather small dark area, but some of them are fully as dark as the darkest of Arizona. Another lot, from Riverside, California, collected May 6, 1897, range from light to dark. I have two lots of the material collected by Packard at Biskra, Algeria, which range mostly light in color, but many with a slight dark streak or spot, and some as dark as any ever become. Another lot collected by Paul Marchal at the Oasis of Sidi, near Biskra, shows about the same characteristic; namely, rather light scales with the black reduced to a small streak or small spot. Specimens collected by Packard at Assuan, Egypt, are very light, but all showing more or less evidence of the black mark or streak. I have specimens which I collected myself from Cairo and Luxor, Egypt, the latter mostly black but with all graduations, and the former rather approaching the lighter stage, with merely a streak of dark, but occasionally specimens nearly as dark as the Arizona type. The material from Bagdad, collected by Mr. Fairchild, has a rather large dark spot, but not excessive. That from Bussorah, collected here at the Department grounds by Mr. Sasscer

from recently imported material, is absolutely light down at the base of the large leaves where they are almost hermetically sealed. Further up the dark streak and spot appears, approaching if not almost equalling the condition of the Arizona scale." (Letter of January 22, 1907.)

From all this we must conclude that the color-differences are partly due to individual variation, and partly to environmental influences. These latter are of two sorts, climatic, and the amount of light received, the last being due to the position on the plant. Why the Arizona scales are prevailingly dark as compared with those of various other places, we do not know.

THE MARLATT SCALE.

HISTORY.

Many years ago Mr. C. L. Marlatt found a singular scale insect on date palms imported from Algeria, and made some study of it, though he published nothing concerning it. It was observed that the female scales were broad-oval or plum-shaped, wine-red in color, and occurred packed in great numbers in little cavities about 10 or 12mm. long by 4 or 5mm. broad on the midribs of the leaves, communicating with the air by a narrow longitudinal slit.

In 1899, when I was in Washington, Mr. Marlatt kindly allowed me to study the insects, and finding them to represent a new genus and species, I called them *Phoenicococcus marlatti*. While I was working on them fresh palms were imported from Algeria, and I found them myself in great quantity on the insides of the sheathing bases of the leaves. The account of the insect was published in the Proceedings of the Academy of Natural Sciences of Philadelphia, 1899, p. 262.

Several years later, when inspecting the small date palms in the orchard at Tempe I found this species alive in very small quantities. Since then it has multiplied on certain palms, so that abundant living material could be sent to me, furnishing the material for the accompanying illustrations.

Nothing further has been learned concerning this scale, unless Mr. R. Newstead's account of *Sphaerococcus draperi*, a supposed new species found in Egypt on date palms and described

in 1906, really refers to it. Mr. James G. Sanders has kindly sent me a copy of this description (from Quart. Journ. Inst. of Commercial Research in the Tropics, April, 1906), with the remark that it would apply well to *Phoenicococcus marlatti.* The description is as follows: "The female of the new species is distinguished chiefly by the minute rudimentary antennae, the entire absence of legs, and the character of the waxlike covering. The larva is also characterized by the antennae, which have the first segment unusually broad. There are also other minute differences." I presume that further particulars will be furnished at a later date.

DESCRIPTION.

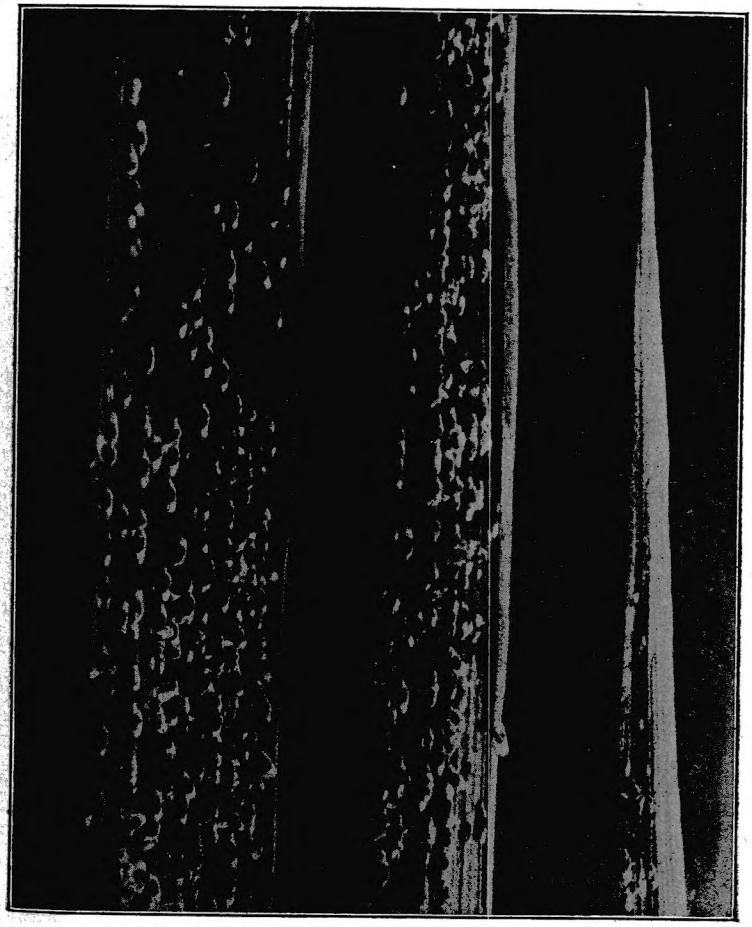
The female insect is from 1 to 1¼mm. long, and secretes a white waxy substance but does not produce any true scale like that of the *Parlatoria.* The appearance of the females, crowded on the inner surface of the base of a leaf, is well shown in Plate III, enlarged about or nearly three diameters. Plate IV shows a single female greatly magnified, and Plate V, Fig. 1 shows the same, cleared with caustic potash and still more magnified. It will be observed that the female has no visible segmentation, and is without legs. The antennae are reduced to small tubercles. The mouth parts can be seen, a little anterior to the middle. The male is not known.

REPRODUCTION.

The embryos are developed to a large size within the body of the females. Plate V, Fig. 2 shows the anterior end of the female, and within her body are plainly seen several embryos, two being especially conspicuous. Their two eyes appear as black spots, the coiled up mouth-parts look like a pair of watch springs, and in one an antenna, fully extended, is readily visible.

Plate V, Fig. 3 shows the larva after hatching, very greatly magnified. There are six legs, and a pair of antennae, the latter very broad at the base. From the hind end arise two pairs of hairs or bristles, the inner ones longer than the outer. These larvae, like those of the *Parlatoria,* wander about for a short time, and then settle down for life.

No natural enemies of this scale have been found.



Date-Palm Scale. *Parlatoria blanchardi* (*victrix* form).
From a photograph by Mr. H. C. Markman.

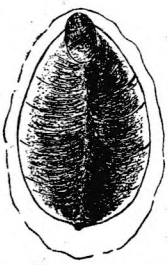


Fig. 1. *Parlatoria blanchardi* (*victrix* form) female scale, greatly enlarged. From a drawing by Mrs. W. P. Cockerell.

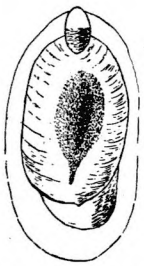


Fig. 2. *Parlatoria blanchardi* (pale form) female scale greatly enlarged. From a drawing by Mrs. W. P. Cockerell.

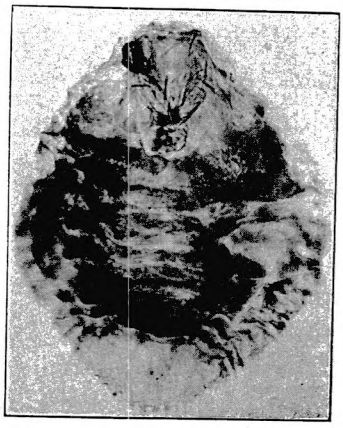


Fig. 3. *Parlatoria blanchardi.* Adult female (removed from scale) much enlarged.

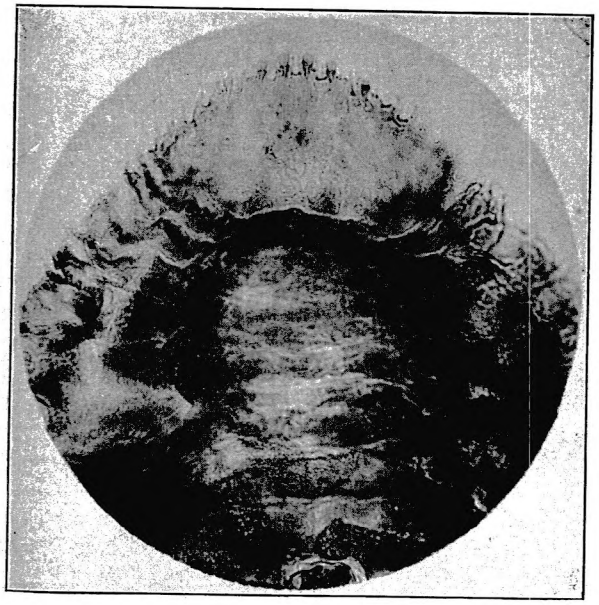
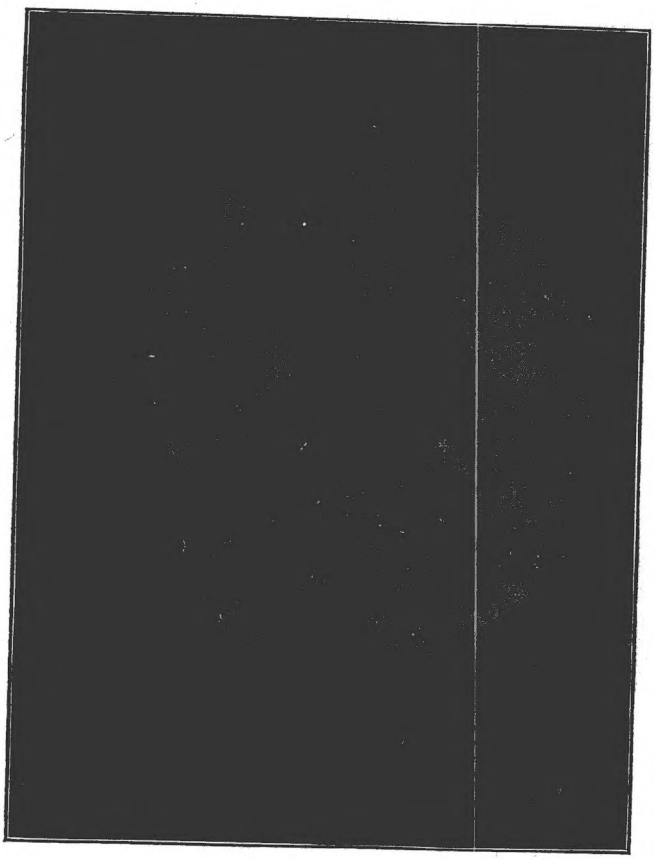


Fig. 4. *Parlatoria blanchardi.* Caudal end of adult female showing lobes, etc.

Fig. 5. *Parlatoria blanchardi* female scale parasitized. a, hole of exit of parasite.

PLATE III.

Marlatt Scale. *Phoenicococcus marlatti.* Females in situ on base of leaf.
From a photograph by Mr. H. C. Markman.



Marlatt Scale. *Phoenicococcus marlatti.* Female, greatly magnified. From a photograph by Mr. H. C. Markman.

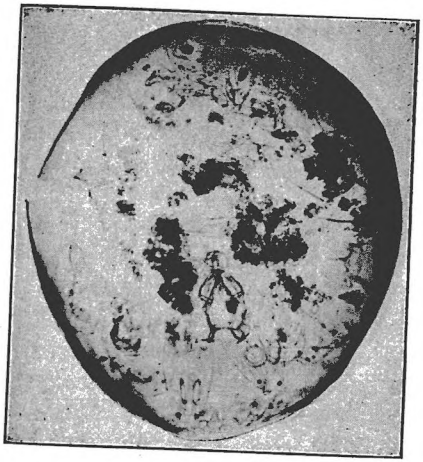


Fig. 1. Marlatt Scale. *Phoenicococcus marlatti.* Female, greatly magnified.

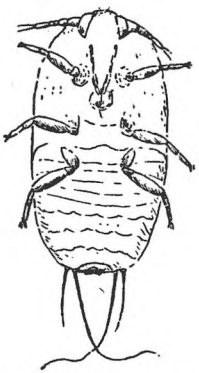


Fig. 3. *Phoenicococcus marlatti.* Larva, much magnified.

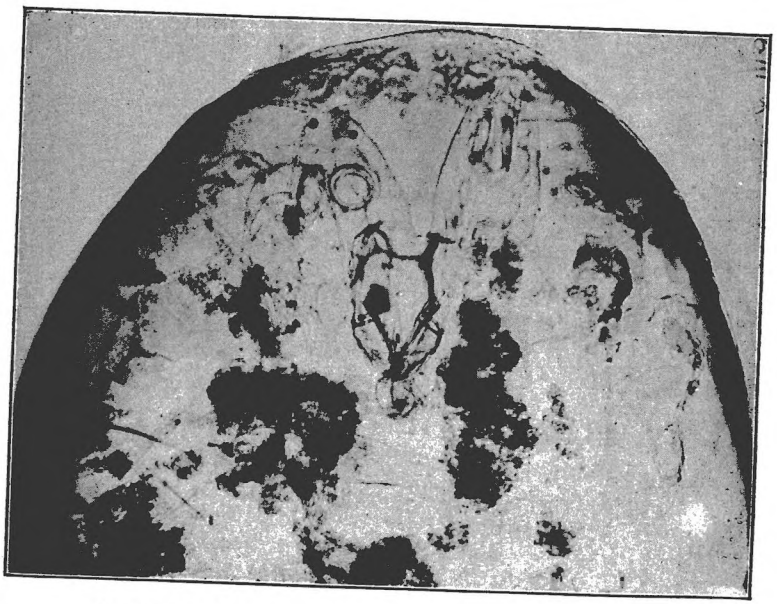


Fig. 2. *Phoenicococcus marlatti.* Anterior end of adult female.

THE EXTERMINATION OF DATE-PALM SCALES.

By R. H. Forbes.

Of the two species of scale insects which have thus far been found upon imported date palms in this country, and which have been described on preceding pages by Professor Cockerell, the most to be dreaded is *Parlatoria blanchardi*. This scale spreads rapidly over the leaves of the palms, sometimes in sufficient numbers to sap and make yellow the foliage of the trees; and also reaches the fruit clusters, rendering the product unmarketable. The second species, *Phoenicococcus marlatti*, not well protected by its own poorly developed scale-coat, remains closer to the bole of the tree, concealed for the most part in the narrow spaces between imbricated leaf stubs.

Various methods of treatment have been employed by different experimenters during the last seventeen years, more especially with reference to *P. blanchardi*.

WASHES.

Kerosene Emulsion.

During the summer of 1890, at Washington, Messrs. Marlatt and Townsend of the U. S. Department of Agriculture, subjected with others, an importation of 54 date offshoots from Cairo, Egypt, to a most thorough course of treatment with kerosene emulsion. Inasmuch as a portion of this lot was sent to points in Arizona and is the first source of *P. blanchardi* in that Territory, the following detailed account, quoted freely from Insect Life, Vol. III, pp. 442-443, will be of interest:

"This lot of trees was sprayed about the first of August with kerosene and soap emulsion diluted about fifteen times. August 16 the plants were still in many places covered with live scales and were again sprayed with kerosene emulsion diluted ten times. August 18 and 19 examination showed a considerable percentage of seemingly healthy scales. The trees were uninjured. Two of the younger trees were then sprayed with the kerosene emulsion diluted only five times. These trees were, August 22, somewhat yellowed and injured and the

scales were all apparently dead. Later, September 2, the plants had partly regained their normal color and no living scales were found. On September 5 all the trees were carefully examined, and about 5 percent of living scales were found, showing that many of the scales at first apparently unaffected by the earlier washings had eventually succumbed.

"It was hoped that the remaining living scales had been affected and would die, but examination, September 18, showed about the same percentage of healthy scales and also a few young. The trees were then thoroughly washed with a stiff brush to remove the loosely adhering dead scales and were again sprayed October 4, with a newly made and excellent kerosene and soap emulsion diluted eight times. Continuous rains fell on the 6th and 7th, and on October 8 very few living and apparently healthy scales were found. October 9 the application of the emulsion in the same proportion was repeated, the rain having vitiated the preceding application. This spraying we believe effected the final and complete extermination of the scales, but as the trees stood these applications without injury, to put the matter of extermination beyond doubt, and as a final precaution they were again all sprayed, and were shipped October 10."

Nevertheless, two years later, of the nine palms from this thoroughly treated lot which were growing on the Station Farm near Phoenix, Arizona, Professor J. W. Toumey found two to be badly infested. Kerosene emulsion was again applied using one part of emulsion to five of water, the treatment being then repeated with emulsion diluted with only one part of water. Even after this treatment from 3 to 5 percent of the scales were found alive. The palms were again sprayed but in 1895 were found restocked with scale. *

It appears, therefore, that eight applications during five years, of very strong kerosene emulsion failed to eradicate *P. blanchardi*, although the endurance by the palms of concentrated kerosene emulsions was sufficiently demonstrated.

Whale Oil Soap.

After the failure of kerosene emulsion, almost yearly applications of whale oil soap solution (1½ pounds to 1 gallon of water) in no instance resulted in completely eradicating the scale, up to the year 1898. †

* Arizona Sta. Bull. 14, page 48.
† Arizona Sta. Bull. 29, page 147.

Distillate Spray.

In 1903, the scale having begun to spread from the much treated imported palms on the Station Farm to neighboring places, Professor A. J. McClatchie applied the distillate spray, used in California for scales and other insect pests, to some badly infested palms on the Andrews farm, nearby. Although the resistant foliage of the trees was noticeably blanched by the treatment, the scales *(P. blanchardi)* were as numerous as ever the following year.

Resin Wash.

This wash, Coquillet's formula, was tried by Messrs. Townsend and Marlatt, in 1890, upon imported scaly offshoots and found "practically without value." †

FUMIGATION.

Beginning about 1897, the imported date palms on the Station Farm have been repeatedly fumigated by Toumey, McClatchie and the writer, with hydrocyanic acid gas, with the uniform result that the scale was checked but not exterminated, although the charges of gas have usually been sufficiently strong to injure the foliage of the trees. From 1900 until the present time all imported suckers planted at the Tempe Cooperative Date Orchard, at Yuma and elsewhere in Arizona, have been fumigated in this manner, usually using oiled tents and extra strong charges of gas. For several years it was thought that this treatment was efficacious, but recent outbreaks of *P. blanchardi* and *P. marlatti* in the Tempe Cooperative Date Orchard, for reasons to be pointed out below, indicate the failure of the method to *exterminate* these scales. Fumigation, however, under some circumstances may be a useful means of destroying exposed scales, thereby checking their spread; and for this reason is worthy of detailed description in its connection with the date palm.

Effect of Hydrocyanic Acid Gas upon P. blanchardi in Various Stages of Development.

Old palm-leaf stubs full of sap, infested with *P. blanchardi* in various stages of development, were subjected to fumigations of

† Insect Life, Vol. III, page 442.

various strengths, April 20, 1907, and the effects observed ten days later. The cut surfaces were snugly wrapped in oiled paper to retard loss of gas by solution in moisture, the doses of cyanide for generating gas were accurately weighed, and the exposure of the material was made in a measured glass belljar, the gas after generation being thoroughly distributed by means of a small fan manipulated through the tubulure of the jar.

April 20. Fumigations, 1 hr., shade.			April 30. Condition of Insects.		
Strength of Gas used.	Temp.	Old Scale.	Young.		Eggs.
.1% by volume	20 deg. C.	Blackened	Dead and dry		Plump and pink
.3% "	"	"	"	"	"
.5% "	"	"		"	"
.7% "	"	"		"	"
.0 "	"	Pink, alive	Active	"	"

In another experiment a scaly leaf stub was fumigated in a belljar 2½ hours with .1 percent gas. Eight days later young active scales were found under the scale coat of an adult dead insect, having probably developed from the eggs after fumigation. Upon this point Professor Cockerell says:

"I should say that there is no doubt that young *P. blanchardi* hatched *since* the fumigation. The duration of the active stage in this particular species does not seem to be known, but it cannot be more than a few days. You can assume, apparently, that the fumigation killed the adults, but did not kill the eggs. The larva is developed in the egg shell *within* the body of the female, and probably hatches in warm weather, almost as soon as the eggs are laid. Hence it might well be that very mature eggs, not yet laid, would be protected from the gas by the body of the mother, and would produce some young, though not extruded. Some allied species are ovoviviparous, the larva hatching in the body of the mother normally."

It appears, therefore, from the above observations that, while as little as .1 percent gas is fatal to the insects at all times after hatching, eggs containing even well developed larvae apparently withstood as high as .7 percent gas. Inasmuch as the maximum calculated strength employed in our field fumigations is .6 percent for one to several hours, this immunity of the eggs at least partly explains the failure of hydrocyanic acid gas to exterminate *P. blanchardi* during the years it has been tried at the Station Farm, and elsewhere in the Territory.

Resistance of Date-Palm Foliage to Gas.

The hard thick foliage of the date palm withstands a much greater strength of hydrocyanic acid gas than do the deciduous

and citrus trees with which it is most used. In California two-tenths percent gas by volume for citrus trees is considered strong, care being taken not to fumigate in bright sunlight, when ill effects of gas upon foliage are greatest.

Our experiments to determine the critical strength of gas for date-palm foliage do not entirely agree among themselves because of variations in material and experimental conditions from time to time. The most satisfactory series of results, however, is shown below. Small potted palms were employed, pots and soil being closely covered with oiled paper to retard loss of gas by contact with them. Fumigation was made in tight bell jars and boxes, the charges of cyanide being exactly calculated for the space used.

	Experimental Conditions, Apr. 17.			Results, Apr. 30.
Percent gas by vol.	Illumination.	Temperature.	Time.	
.1	Shadow	20 deg. C.	1 hr.	No damage
.2	"	" " "	"	" "
.3	"	" " "	"	" "
.4	"	23 " "	"	" "
.5	"	23 " "	"	" "
.5	"	20 " "	22 hr.	Badly burned
.5	Sunlight	to 40 deg.	1 hr.	" "
.6	Shadow	18 deg. C.	"	Slightly burned
.7	"	25 " "	"	No damage
.8	"	25 " "	"	Slightly burned
.9	"	27 " "	"	" "
1.0	"	27 " "	"	Badly burned

In this series the limit of tolerance seems to be reached in shadow and with 1 hour's exposure, at from .6 to .8 percent gas, the damage being confined to older foliage; being also much increased in sunlight (with elevation of temperature), and with prolonged exposure.

In another series carried out in shaded belljars, with cut leaves exposed at ordinary temperatures, old leaves were injured by .4 percent gas and stronger, while young leaves, probably because of their compact condition, showed less injury with even 1 and 2 percent fumigations.

These observations agree fairly well with field experience, in which about six-tenths calculated percent by volume of gas in diffused light for one hour or more, has been adopted as the limit near which the damage to foliage becomes occasionally noticeable.

From these experiments and observations it appears quite likely that a strength of gas which will destroy at least the older foliage of a palm under ordinary conditions, will not kill the eggs of *P. blanchardi,* indicating that so far as the last traces of scale are concerned the treatment is more severe to the tree than to its parasite.

FURTHER OBSERVATIONS ON OCCURRENCE OF SCALE.

All methods having failed to exterminate the scale at the Station Farm the insect began to spread to adjoining places where palms were growing, carried probably by birds in some instances and by trees and suckers transplanted from the infested locality in others. Even in the Tempe Cooperative date orchard, thought until 1905 to be free from scale, no less than 106 out of a total of some 522 growing trees have been found infested since that time. Other imported lots of palms established at Yuma and in the Salton Basin region are also known to have developed scale in spite of precautionary fumigations.

The danger from this pest was therefore evidently rapidly increasing, and confronted by the necessity for better methods of control, the writer, assisted by Mr. A. J. Shamblin, began work on the subject in April, 1905.

An inspection of the old infested trees at the Station Farm revealed the fact that the strong and closely imbricated stubs of old leaves clear to the bases of the trees were still full of sap next the boles, though to all outward appearances quite dead. These juicy stubs, not less than twelve years old at the bases of the palms, were found infested with numerous living specimens of *Parlatoria blanchardi,* apparently secure against washes or fumigation in the confined spaces between leaf bases into which they were wedged. *Phoenicococcus marlatti* was also found on trees in the Tempe Cooperative Date Orchard, for the most part in these confined spaces and not ranging out upon leaves and fruit like *Parlatoria.*

Confined in this manner upon living leaf stubs these scales may evidently persist for years, until opportunity arises for their escape. Such opportunity may be presented when a sucker forces its way out between leaf bases, and several of the infested trees at Tempe gave evidence of having been unlocked in this

manner. These trees were thought to be free from scale, having been most thoroughly fumigated seven years ago, and repeated inspections failing to show scale until 1905 and 1906, when badly infested suckers were found from which scale was spreading at points of contact with other parts of the trees. Rats, also, circulating through the trees in search of fruit have been supposed to carry young scales from leaf stubs outward to less confined parts of trees.

RESISTANCE OF PALMS TO FIRE.

The method of treatment finally adopted was suggested by the Mexican practice of cleaning palms by burning the great bundles of pendant dead leaves which accumulate beneath their crowns when they remain untrimmed for a number of years. Although the fire kindled for this purpose is intensely hot, the only damage is to the outer green leaves scorched by the up-draft of the flames, which do not reach the vulnerable bud above and within these green leaves. By reason of the endogenous and very succulent character of the trunk of the palm, external damage by fire is limited and ineffectual. Phoenix-like a new crown of leaves arises from the blackened summit of the tree, which soon stands fully restored.

Remarkable instances of the resistance of palms to heat have been afforded by the San Francisco fire. Many fine trees in the burned district were subjected to temperatures at which fire is stated to have been carried by superheated air alone, the trunks being externally charred and the leaf crown destroyed. Nevertheless these trees unexpectedly developed new foliage, which presents an odd contrast to surrounding scenes of ruin.

In St. Pierre also, shortly after the destruction of that city by the eruption of Mont Pelee, Professor F. E. Lloyd observed banana plants, which had been buried in hot ashes and externally burned, pushing out fresh green leaves after characteristic endogenous resistance to fire.

THE FLAME TREATMENT OF PALMS FOR SCALE.

In view of the known resistance of palms to fire and of the peculiar habits of the two species of date-palm scales thus far observed, it was thought that the latter could be exterminated

without serious injury to the trees, by means of the gasoline blast-torch.

Preparatory to treating the old infested trees at the Station Farm, in July, 1905, the scaly leaf bases were cut short and the tops of the palms cropped closely, nothing remaining but bare trunks surmounted by tufts of green stubs. The naked boles were then drenched or sprayed with gasoline and fired, the work

Fig. 2. Palms in the burned district in San Francisco, on Sutter and Bush streets, respectively. "Very much alive" and the only survivors of the catastrophe in that locality. Photos by W. O. Hayes, May, 1907, 13 months after the great fire.

being completed by means of a gasoline blast-torch of the kind used to scorch the spines off cactus for cattle, similar burners having also been tried elsewhere, with results on the whole unsatisfactory, upon scale and other insects infesting certain crop plants and trees.* Traces of scale were still found, September 12, on two of the forty-eight trees treated.

In October the old leaf stubs were cut still more closely and crowns and trunks again gone over with the torch. In March,

* See Ill. Exp. Sta. Bull. 89.

1906, traces of scale were still found on upper leaf stubs of four of the nine large trees, and the pruning knife and torch were again applied. Another inspection in September, 1906, revealed a doubtful trace of scale on the largest and originally most infested tree, which was then shaved smooth to the bole and once more fired. A final inspection of these nine old imported trees in August, 1907, by Mr. Shamblin indicates that they are now *free from scale.*

Through all this ordeal by knife and fire the palms have prospered surprisingly, all of them but one, the crown of which was fatally injured before the work began, developing new tops, blossoming, and the females producing limited crops of fruit.

In September, 1905, a cursory inspection of the nearby seedling orchard of some five hundred trees, which had become infested from the old imported trees above mentioned, revealed 15 scaly palms scattered throughout the block. The whole orchard was then fumigated under oiled box tents with .3 percent gas for one hour, portions of the foliage being occasionally burned by the gas. In March, 1906, 79 of these trees were found on which scale was living, multiplying and migrating, vigorously, showing the ineffectiveness of fumigation, due in part, without doubt, to leakage of gas from the tents employed. A gas-tight sheet-iron tank, however, has also been used without satisfactory results, upon certain of the infested trees at Tempe.

All infested trees were then cropped closely, and the gasoline torch applied. All remaining trees were then again fumigated. In September, 1906, two scaly trees, one of them previously burned for scale, were found and scorched and in August, 1907, five trees lightly infested with scale (two of them previously treated) were found and scorched.

The burned trees in this orchard, with one exception, have not suffered by treatment, being now indistinguishable from those not so treated. Coincidently with the work carried on at the Station Farm, all other scaly trees in Salt River Valley which could be found were twice visited (September, 1905 and September, 1906) and, with the consent of their owners, pruned and burned. The inspection was repeated in July and August, 1907,

with the result that the 33 infested trees discovered and treated in 1905 and 1906 were reduced to seven.

At the Tempe date orchard, August to December, 1906, 94 palms were found infested with *Parlatoria blanchardi* but on account of the lateness of the season it was thought prudent to prune and burn none but the stronger trees, the weaker ones being fumigated only, for the time being. In May and June 1907, a second inspection disclosed 12 additional infested trees,

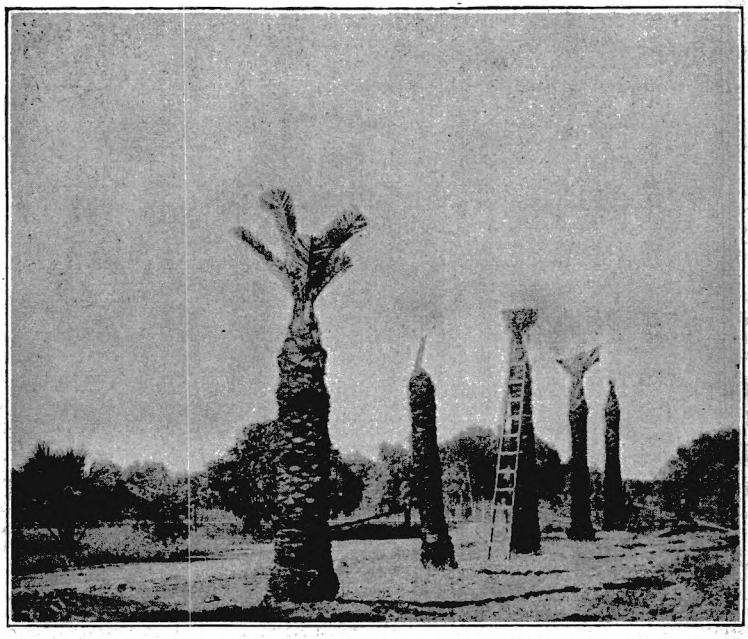


Fig. 3. Old date palms at Station Farm, Sept. 12, 1905, showing tops pushing out 50 days after trimming and firing the trees for scale.

the pruning and burning of all scaly trees being at that time completed.

This serious outbreak of scale was found in many cases centering around suckers which had evidently brought the insects away with them from between old leaf stubs. In other cases the rats *(Sigmodon hispidus eremicus)*, with which the orchard was infested from August to October, had apparently carried scale with them from tree to tree. The traffic throughout the

orchard incident to the fruit crop of 1906 doubtless had the same result.

In order to minimize the spread of the scale and put the orchard in the best possible condition for inspection and treatment all of the older trees, not previously so treated, were

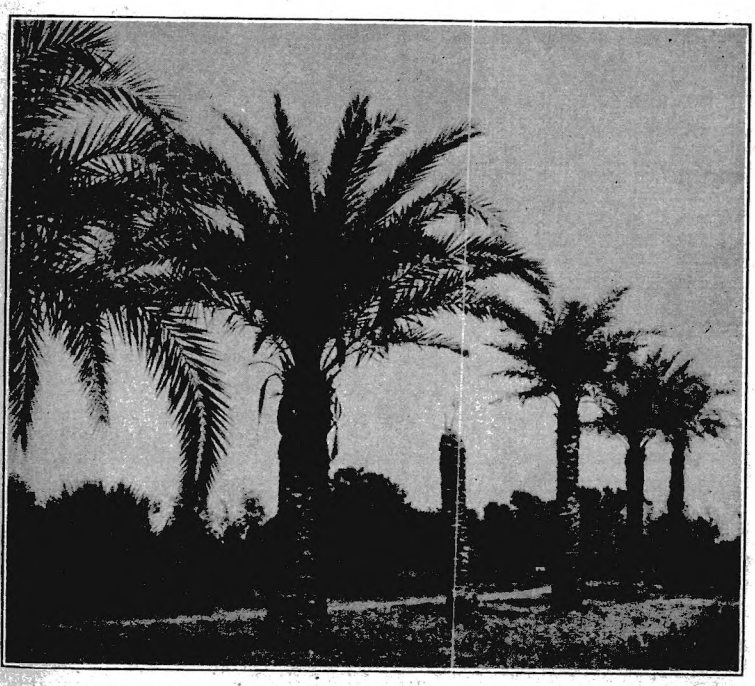


Fig. 4. The same trees Oct. 2, 1906, showing one year's development of tops. One palm was dead before treatment.

thoroughly pruned of their old leaf stubs and superfluous foliage, presenting a very different and much more accessible appearance after this operation.

ENDURANCE BY THE TREES OF THE TREATMENT.

Considering the severity of the method, the percentage of trees destroyed during our two years application of it is exceedingly small. Only one young seedling tree out of about 100 cut back and burned on the Station Farm has perished. There is, in fact, no appreciable difference at the present time between these trees and their untreated fellows.

As described above, the pruning and repeated scorchings to which the large old palms on the Station Farm were subjected has resulted in the loss of none; but one large tree which was treated for a neighbor was killed.

At Tempe 13 of the 106 trees pruned and burned during the past year have perished, not due to the burning only, but also to other causes—heavy cropping, rats at the roots, removal of suckers and excessively alkaline soil.

Probably the most striking instance of endurance of treatment is that of a scaly sucker which, in 1905, Mr. Shamblin pruned down to the quick, then scorched thoroughly with the blast-torch and planted. It is now growing. In brief, it is safe to say that under favorable cultural conditions, the loss of date palms by the pruning and burning treatment is negligible. But when conditions, such as an excessively alkaline soil, are unfavorable, or when the trees are under strain from cutting of suckers, the attacks of rodents, or heavy cropping, the torch may occasionally be the final cause of the death of a palm.

This work has been done at all seasons, from May to December, with no appreciable difference in the results to treated trees. The endurance by the palms of this savage regimen is due to the thick, sappy trunk and the endogenous character of the date palm. Unlike ordinary orchard trees these palms have no sensitive outer cambium layer whose injury would be fatal. The rough, dry and fibrous exterior of the palm, indeed, assists the torch by contributing fuel to the fire, which is prevented from penetrating too far by the sap-soaked tissues beneath. The most sensitive point is the growing bud at the top of the palm; but this, fortunately, on account of its constant and rapid evolution from within during the growing season, is the least infested portion of a scaly tree.

DATA ON COST.

The method of flaming infested palms being thus far largely experimental, has not yet been systematized with reference to economy in use.

In one instance Mr. Shamblin pruned and burned 48 palms, large and small, in 90 hours, 10 gallons of gasoline being required. Small trees, entirely within reach from the ground, were pruned

and scorched and waste burned in from half to three quarters of an hour; but tall old trees required several hours for treatment. With a set of box tents and the same amount of labor small trees can undoubtedly be fumigated more cheaply than they can be cleaned and burned. Fumigation, however, becomes

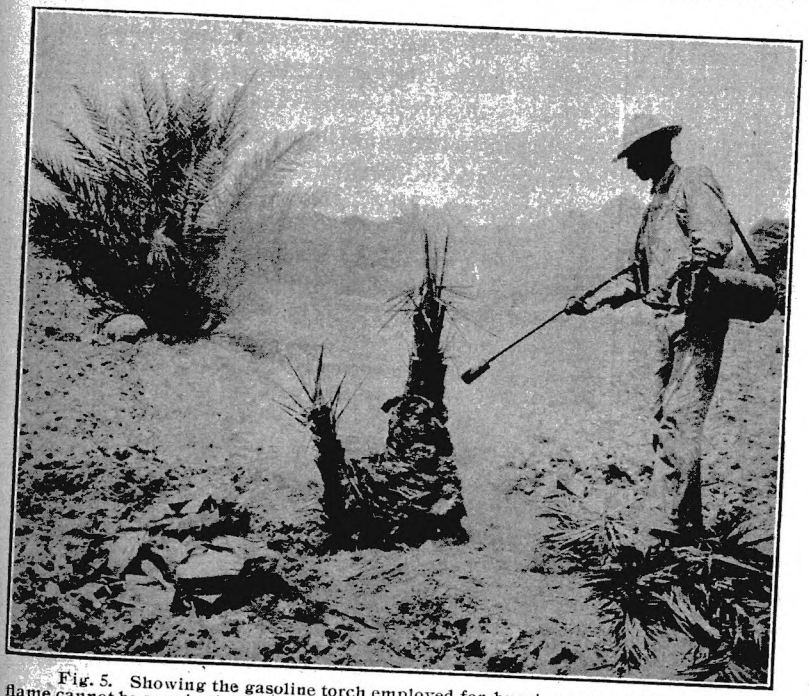


Fig. 5. Showing the gasoline torch employed for burning palms for scale. The flame cannot be seen in the bright sunlight.

increasingly difficult and costly as the palms become taller, which is true to a much less extent of the burning method.

HORTICULTURAL SUGGESTIONS.

With a view to the control of scale in a palm orchard it is important to keep the trees free from old leaves and from the tangle of secondary foliage which accompanies the offshoots. The old leaf bases in particular should be close-cut, as experience has shown them to be the most dangerous lurking places of the scales. An orchard thus properly pruned can be more easily and thoroughly inspected, the offshoots can be more readily

detached, and pollination, sacking and gathering of the fruit more readily accomplished. (See Fig. 1, frontispiece)

ARIZONA INSPECTION LAW.

In March, 1907, the efficiency of the torch method for extermination of date-palm scales being fairly well assured, certain provisions were inserted in the Experiment Station appropriation bill, passed by the Twenty-Fourth Territorial Legislature, the object of which is to empower the proper authorities to suppress outbreaks of date-palm scale insects wherever found in the Territory and to prevent the introduction of infested palms from other regions. The proviso mentioned occurs as a part of Par. 2, Sec. II, Chapter 30, of the Laws of 1907, and is as follows:

"Provided, first, that the University of Arizona Agricultural Experiment Station, through its regularly appointed officers, shall have authority to inspect date palms growing within the Territory of Arizona, or any shipment of date-palm offshoots or suckers brought into the Territory from other states or countries, at any point or station designated by such officers whether such shipments are provided with a certificate of inspection or not, especially with reference to the presence on such palms or in such shipments, of insect pests dangerous to the welfare of the date growing industry; *and provided*, second, that in the event of the discovery upon such date palms or in such shipments, of dangerous insect pests, more particularly the scale insects, *Parlatoria blanchardi* and *Phoenicococcus marlatti*, the Experiment Station, through its aforesaid officers, is hereby empowered at its own expense, to suitably treat or at discretion, destroy such infested trees or shipments."

No difficulty has thus far been encountered in the application of this law, for the reason that at all times, both before and after its passage, owners of infested palms have been most willing to submit their trees to treatment.

EPITOME.

Parlatoria blanchardi, when once established, spreads rapidly, damages the foliage of the date palm and renders the fruit unmarketable, being therefore a serious menace to the industrial future of the tree under our climatic and cultural conditions. Fortunately, however, the limited size of the broods, insect enemies, the probably wingless condition of the male, and the fact that this scale so far as now known has no other food plants in this region, all tend to limit the numbers and range of the insect.

Phoenicococcus marlatti, because of its closer confinement to the bole of the palm, is comparatively harmless and to be regarded with less apprehension.

With the radical and thorough method of treatment by burning at command, described in preceding pages, at the same time fatal to scale insects and not seriously injurious to the palms, and with a suitable law for the application of the method, there is no reason, except lack of vigilance, why the scale insects [illegible] in Arizona.