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Date Palm Insects in the United States

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CONTENTS

INTRODUCTION

This publication contains information on the appearance and habits of date palm insects, and on methods for reducing the damage caused by them. It is based largely on the results of two separate investigations. The first was begun in 1921 and was carried on intermittently for 15 years by the senior author, who died on August 15,

[1] The generous, long-continued cooperation by date growers and date packing-house officials has made these investigations possible. Assistance of the personnel of the United States Date Garden at Indio, Calif., and of the University of Arizona Experimental Date Garden at Tempe, Ariz., is also acknowledged. Members of the staff at the Citrus Experiment Station, University of California, Riverside, Calif., cooperated in the investigations during 1945–48.

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1936. His notes and preliminary manuscript drafts have been summarized and brought up to date by the third author. Stickney worked chiefly on the parlatoria date scale, the red date scale, the date mite, the datebug, the Apache cicada, and the Indian-meal moth. He also compiled information on the palm rhinoceros beetle, the giant palm borer, and the saw-toothed grain beetle. Most of the literature references were assembled by him.

The other program of research, by the second author, was begun late in 1945, in cooperation with the California Citrus Experiment Station at Riverside. Progress reports of this phase of the date-insect work have been published in the Reports of the Date Growers' Institute (Barnes and Lindgren *11* and *12*, Bliss and Lindgren *14*, Lindgren, Bliss, and Barnes, *42*).[2]

During the interval between the two investigations, changes in the agriculture of the Coachella Valley created a more favorable environment for the development of certain insects. Additional date palms were planted, and those already in production increased in size and shaded the soil surface more. Grapefruit trees, interplanted with date palms, added to the cull-fruit supply, and the production of tomatoes, melons, grapes, and sweet corn provided new food for the insects.

In the fall of 1943 rapid ripening of the date crop and an inadequate supply of labor permitted much ripe fruit to remain too long on the palms, and infestations built up to serious proportions. Ripening was slower and infestations were lighter in 1944, but in 1945 rains in July and August damaged the date crop severely, causing the fruit to sour and mold on the bunches. Losses, chiefly from diseases and infestation by insects of the group known as nitidulids, were estimated to be about $945 per acre throughout the 3,300 acres of bearing gardens, a total loss of over $3,100,000.

About 25 species of insects that affect dates are discussed in the following pages. Growers and packers of dates are likely to encounter most of them at sometime during their operations. These insects vary in importance from time to time, often as a result of seasonal influences. In some cases, for example, when rains damage ripening dates, the sudden increase of certain species is due to the presence of abnormal amounts of waste fruit. At other times, however, the reasons for fluctuations are not apparent.

Although no clear-cut division of date insects can be made on the basis of their feeding habits, they can be grouped loosely into species that attack the palm, those found chiefly on or in the developing fruit, species that feed on dropped dates decaying on the ground, and those that attack stored dates. In the warm regions where dates are produced, the stored-product species, found only indoors in temperate climates, are able to live in date gardens throughout the year.

There are two general types of insect development and both are found among the pests of date palms. In the simple type the newly hatched insect develops to the adult stage through a series of larval molts and size changes without passing through a pupal stage. The outstanding feature of this so-called incomplete metamorphosis is that the final or adult stage resembles the larval stage, in most cases.

[2] Italic numbers in parentheses refer to Literature Cited, p. 54.

Larvae of insects that have this type of growth often are referred to as nymphs. A good example of an insect having incomplete metamorphosis is the grasshopper, for an adult looks much like a young one. With minor exceptions this also describes the life histories of the parlatoria date scale, the red date scale, the datebug, the Apache cicada, and the western leaf-footed bug.

In contrast, the moths, beetles, bees, and flies that attack date palms or date fruit pass through three stages after hatching—larva, pupa, and adult. Their metamorphosis or form change is complete.

The Apache cicada develops in a manner intermediate between the types represented by a grasshopper and a moth. Although its metamorphosis is classed as incomplete, it passes through a pupal stage that differs from the larval stage. However, the pupa is active, not stationary, as is the pupa of a moth or beetle. Likewise, the immature males of the date scale insects gradually depart from a typical nymphal form and assume a pupal condition for a time before the adult emerges.

Mites that attack dates pass through incomplete metamorphosis. They differ in structure from insects in having an undivided body, no antennae, and, except when newly hatched, eight legs instead of six.

MAJOR INSECT PESTS INFESTING DATE PALMS AND DATE FRUITS

Parlatoria Date Scale

The parlatoria date scale (*Parlatoria blanchardi* (Targ.)) was first observed in the United States on offshoots of the date palm (*Phoenix dactilifera* L.) received in Washington, D. C., from Algeria during the summer of 1890. Shortly after its discovery this scale was studied abroad and described as a new species by Targioni Tozzetti in 1892 (*65*). Other accounts of the insect have appeared from time to time in American and foreign literature, but little has been published concerning the details of its biology.

Contributors to the literature on this insect include Cockerell (*24*, *26*), Buxton (*22*), Rao, Rao, and Dutt (*56*), and Balachowsky (*6*), who have supplied general information. The anatomy has been described by Targioni Tozzetti (*65*) and Stickney (*63*). Balachowsky (*4*, *5*) has published an account of the predators that attack the scale. Remedial measures have been discussed by Forbes (*36*) and Boyden (*16*, *17*, *18*, *19*, *20*, *21*).

As reported by Boyden (*21*) the efforts toward eradication, which were begun in 1907, were brought to an apparently successful conclusion 29 years later. The fact that the parlatoria date scale has been eliminated as a handicap to date production in the United States does not remove it as a subject of interest, or even of possible future concern.

NATURE OF INJURY

The parlatoria date scale is capable of spreading over all surfaces of the foliage and fruit of the date palm (fig. 1), and has a tendency to encrust all parts of the tree. Heavy infestations may extend deep

Figure 1.—Parlatoria date scale infesting dates.

down behind the fiber on the white tissue and fiber bands of the leaf bases.

These are inaccessible areas, as seen by the structure of the palm. The stalk of each leaf is expanded into a wide, thin basal portion, which extends entirely around the trunk and clasps it tightly like a

collar (fig. 2). A closely spaced succession of overlapping leaf bases covers the trunk from ground level to the single growing bud at the tip of the plant. Each leaf base is overlapped by portions of seven others.

At the line of the leaf's attachment to the trunk the leaf-base tissue is whitish and of the consistency of moist leather. At varying distances above the line of attachment the white tissue becomes a brown fabric of interlacing fibers. The frayed edges of the fiber bands form a rough brown packing between the leaf stalks. Scale insects favor the succulent white tissue, protected by layers of other white tissue and of fiber. The thickened part of the base where the leafstalk begins is

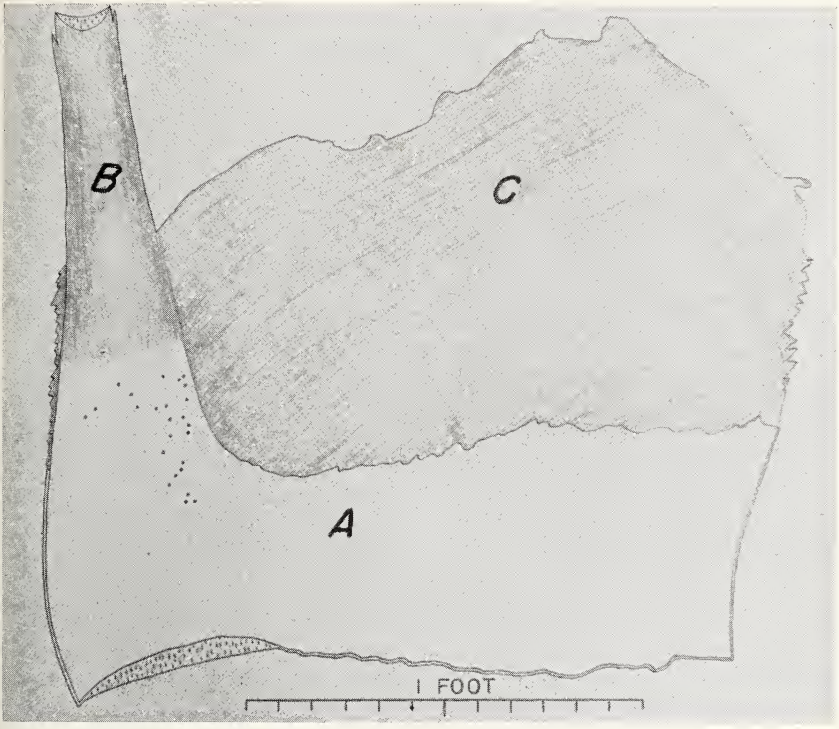

Figure 2.—Date palm leaf base showing: *A,* Band of white tissue with red date scales indicated by dots; *B,* green exposed part of leaf stem; and *C,* brown fiber.

likewise protected, and even when the stub of a cut-off leafstalk appears to be dead, soft living tissue persists on it lower down, beneath the covering of fiber. Probably there is no more well-protected, inaccessible harbor for scale insects than on the leaf bases of date palms.

A discolored area of injured tissue is formed where each individual parlatoria date scale settles and feeds. Thus, the more numerous the individual scales, the greater is the amount of injured tissue present. The foliage, composed predominantly of relatively thin leaflets, or pinnae, is more seriously affected as infestations develop, until eventually the leaves die. In advanced stages of infestation all older leaves are either dead or nearly so, and most of the younger leaves

show a heavy infestation above the fiber. Consequently such palms are unthrifty, but usually do not die, because new uninfested leaves constantly emerge. However, this insect contributes to the death of neglected palms.

DESCRIPTION AND LIFE HISTORY

The eggs and first-stage nymphs are deep pink or bright red; in the later stages both sexes are a rich blood red. Newly hatched nymphs are very small, averaging $\frac{1}{96}$ inch in length. The female and male nymphs molt two and four times, respectively, and pass through three and five nymphal stages before reaching maturity. Adults of both sexes average nearly $\frac{1}{35}$ inch. The females are broadly oval and are somewhat flattened in all stages. In the first stage and early part of the second the scales of both sexes are the same shape, but from then on males become increasingly elongate. Ferris (*34*) has illustrated this insect.

The females of all stages, and the males of the first and second stages, secrete a white, waxy substance, which hardens into a shell-like covering for the body. The covering of the adult female is $\frac{1}{20}$ inch long and $\frac{1}{35}$ inch wide, being rather elongate-oval, owing to its extension beyond the posterior end of the body of the insect. The covering of the second-stage male, under which all subsequent stages develop, is $\frac{1}{25}$ inch long and $\frac{1}{60}$ inch wide, being smaller and proportionately narrower than that of the adult female.

The second molted skin of the female ranges in color from yellow or light brown to nearly black. This skin is embedded in the scale covering, where it is plainly visible. Masses of the scales on palm tissue appear grayish because of the dark coloration of the molted skins against the white background of the waxy coverings.

The newly hatched nymphs have well-developed eyes, legs, and antennae. They crawl about for a while and then settle down, each one inserting into the host tissue a mouth tube which is more than twice as long as the body.

In the second stage the male has vestigial eyes, legs, and antennae, but in the third and fourth stages his legs and antennae become increasingly developed and wing pads may be present. He feeds during the second stage but not thereafter, for there are no functional mouth parts in the last three stages of this sex. When the mature male emerges from beneath the waxy cover, he is equipped with eyes, legs, antennae, and, generally, a well-developed pair of wings, but since he cannot take food, his life span is probably brief.

The female remains for life in the same place. In the later stages she possesses no more than vestigial eyes, legs, and antennae. When 266 females were examined the number of eggs beneath the coverings ranged from 0 to 6, and the number of newly hatched nymphs from 0 to 4. The largest number of eggs and nymphs beneath a single individual was 7.

Observations on the life history of the parlatoria date scale, made in March and April, showed that the egg period ranged from 7 to 11 days during the middle of March, and from 2 to 7 days at the end of March and early in April. It was not learned how long the newly

hatched nymphs remained under the covering of the mother, but within 24 hours after hatching they crawled away and began to settle. During the middle of March nearly all nymphs settled within 3 days, and some had completely covered themselves with shells within 8 days after hatching. Beginning March 15 the nymphs required 27 days to progress from hatching to the first molt, and beginning March 21 they needed 21 days.

At various times in March several lots of newly hatched nymphs were removed from the host plant to see how long they would survive without food. Nymphs kept continuously in the shade and exposed to outdoor air survived a maximum of 5 days, whereas in humid air, in the shade, they lived a maximum of 7 days.

Wherever found on the living tissue of palms, infestations were observed to be in vigorous condition throughout the year. There was some reduction in activity during the winter months; yet in the coldest parts of the year many newly hatched nymphs were observed crawling over and settling on palm foliage.

FOOD PLANTS AND DISTRIBUTION

The parlatoria date scale has been found infesting the date palm, the Canary Island palm (*Phoenix canariensis* Hort. *ex* Chabaud), the doum palm (*Hyphaene thebaica* Mart.), and the native California fan palm (*Washingtonia filifera* (Linden) Wendl.). It has been taken from no other plants in this country, but Newstead (*49*) has reported it on jasmine foliage, Draper (*31*) on yellow jasmine and periwinkle, and Hall (*38*) on a species of *Latania*, a fan palm.

All infestations in the United States have been traceable directly to imported date offshoots. So far as is known, this scale became established in the United States only in the Coachella and Imperial Valleys of California, in the Yuma and Salt River Valley Districts of Arizona, and near Laredo, Tex.

According to Quayle (*55*) this insect occurs in Algeria, Australia, Egypt, Italian Somaliland, and India.

DISSEMINATION

Aside from the transportation of portions of infested palms, such as offshoots, male blooms, and leaves used for religious purposes, the most common means of disseminating the parlatoria date scale appears to be the natural spread of crawlers. The development of colonies of scales beneath birds' nests and around cicada egg punctures points to the probable role of birds and insects as carriers of the nymphs. Wind is believed to be an important factor in effecting short movements of the crawlers. Man's activities in date plantings, including pollinating, pruning, thinning, and picking, no doubt result in nymphs being carried on clothing and tools.

CONTROL

So far as is known, no natural enemies of the parlatoria date scale were introduced with it into this country. According to Essig (*32*), Glick (*37*), and Tourney (*66*), ladybird beetles have been observed preying upon the scale; however, their activities were insufficient

to prevent the increase of the insect. A ladybird beetle, *Chilocorus cacti* L., has been observed by the senior author feeding on the scale in the Imperial Valley.

Boyden (*21*) has reported in detail the efforts, brought to a conclusion on June 30, 1936, that resulted in eliminating the scale as a factor in American date production. Briefly stated, the methods included quarantine, inspection, removal of unwanted palms, pruning to reduce infested parts of trees followed by searing the remaining surfaces with a gasoline torch, and reinspections. According to Buxton (*22*) the survival of palms burned in the great fire at San Francisco in 1906 suggested the flaming method.

Red Date Scale

Infestations of the red date scale (*Phoenicococcus marlatti* Cockerell) probably have been observed by Old World date growers for centuries. Apparently, however, little specific information on the insect was collected until it was introduced into the United States on offshoots from North Africa in 1890. These were the same offshoots on which the parlatoria date scale was discovered (Boyden *21*). C. L. Marlatt made some study of the red date scale at that time, and Cockerell (*24*), using material from the same source, described the insect as a new genus and species in 1900. Since then, accounts of the scale have appeared from time to time in American and foreign literature, including publications by Borden (*15*), Ferris (*35*), Morrison (*47*), and Stickney (*62*).

NATURE OF INJURY

Now that the parlatoria date scale apparently has been eradicated, the red date scale is the only scale insect attacking date palms in the commercial date-growing regions of the United States. This scale often completely covers large areas of the white tissue, throughout the year. Its abundance on the protected white tissue of leaf bases, on fiber bands, and on fruit stalks caused it at first to be regarded as a serious pest. In time, however, some growers concluded that the vigor and yield, even of heavily infested palms, were not noticeably affected by the insect. A Federal quarantine that had been instituted against the scale was eventually removed.

The red date scale does not maintain itself on the green foliage, nor does it penetrate to any extent the basal parts of the closely packed younger leaves. On palm roots it is intolerant of direct contact with the soil, and most of the tightly packed basal parts of the roots are not infested. The insect congregates in large numbers on the thick palm tissue; therefore, most of the sap channels are not affected by it.

Definite injury from the red date scale has been noted in some imported offshoots planted in propagating sheds formerly used as date palm nurseries. These offshoots were small and unthrifty; they had shown little or no growth over a long period; and, with increasing age, their leaf bases had loosened, so that masses of the insects were able to settle there. Because of heavy infestation the leaf bases were slender and practically girdled, and the tissue had a brownish, bruised appearance. Where there was a pronounced drooping of the leaves,

the discolored tissue sometimes extended through their bases. The abnormal condition of the offshoots probably was due in part to causes other than the scale attack, but the scale undoubtedly intensified the damage.

On well-grown palms old masses of the scale cause browning, but young colonies cause little or no discoloration of the tissue. Browned areas (fig. 3) may extend ⅛ inch deep into infested surfaces.

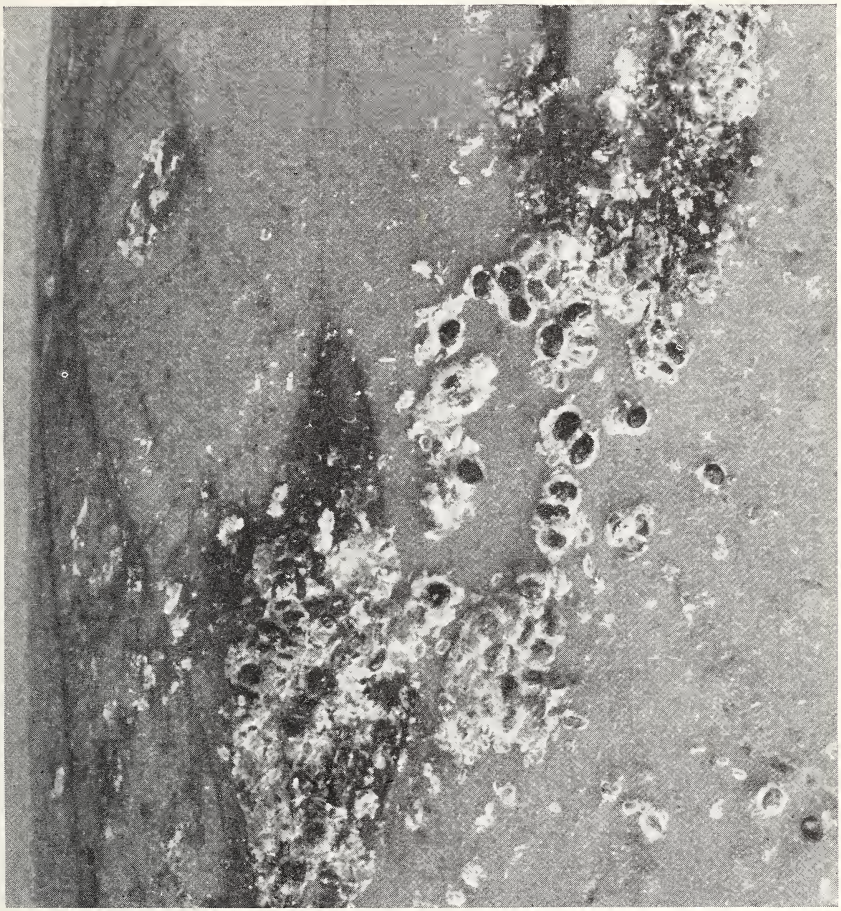

Figure 3.—Part of a date palm leafstalk showing groups of red date scales and areas of browned tissue.

On the whole, the degree of damage still may be an open question. It is possible that the scale contributes to drying of fruit on the palms, to premature dying of older leaves that bear the heaviest infestations on their bases, and to general unthriftiness of some palms.

DESCRIPTION AND LIFE HISTORY

The female of the red date scale develops through three stages and the male through five. All stages are wingless, this condition in

the male being an exception to the rule among scale insects. Only in the first stage of both sexes and in the adult male stage are eyes, antennae, and well-developed legs present, and only in these stages are the scales able to crawl. The first and second stages of both sexes and the adult females possess an external mouth tube. Albino forms sometimes occur in these stages.

Wax is produced by the first two stages of both sexes and by the adult females. Wax forms in curly, shining, white strands that make a fluffy, cottony mass about the body, being densest in the second-stage male, but sufficiently abundant in all stages to cover the body completely. On specimens that have settled behind the fiber, the waxy covering may become more or less matted down and cream-colored. When leaf bases and fiber bands are removed to expose infested tissue, the wax is often pulled away and the bodies of the insects are revealed (fig. 3).

Red date scale eggs are $\frac{1}{90}$ inch long, oval, smooth, and pinkish with a pearly lustre. The fragile egg shells are often found in masses beneath the mother scales.

First-stage nymphs, which are alike in both sexes, are elongate-oval, and have black eyes and two long, hairlike appendages at the rear end. When newly hatched they are flattened, pale pink, and $\frac{1}{80}$ inch long. Shortly after hatching the pink pigment, which gives the insect its name, increases in intensity.

Individuals of the two later female stages and of the second-stage male become sucking bags, the antennae and legs being reduced to mere knobs. In these stages the body color becomes a deeper pink than in the first stage. When egg laying begins, the body of the adult female becomes dark red, and after reproduction ceases, her drying body becomes hard and leathery.

The body of the male in the third, fourth (pupal), and adult stages is deep pink. The antennae and legs are short, stout, conical projections in the third-stage male, and longer and less conical in the fourth stage. The adult male has black eyes and a spinelike projection at the rear end.

Throughout the year the red date scale is present in all stages of development on the white tissue behind the fiber. In the late spring and through the summer, newly hatched nymphs are there in large numbers, which gradually lessen during the fall and early winter. The population is at a minimum in January, but increases progressively late in winter and early in spring.

On other portions of date palms the population is largest late in spring and early in summer. At that time the issuing leaves commonly become infested, and the rapid development of the new leaves exposes many scales. As the summer advances, the heat in such exposed locations is unfavorable to their survival, and fewer migrants come up and settle outside the protection of the fiber. Summer populations outside the fiber are low, but increase for a short period late in fall.

Development of the red date scale was recorded in an insectary for nearly a year. White tissue and green foliage were used as hosts. There was a minimum of four generations. Development was greatly retarded during the colder part of the year, increased during the

spring, and was at a maximum during late spring and summer. The lengths of the various stages and of the life cycle of the female are given in table 1.

TABLE 1.—*Life cycle records of female red date scales*

Date nymphs settled	Approximate period as—			Date nymphal production of next generation began	Length of life cycle
	First-stage nymphs	Second-stage females	Adult female to beginning of nymphal production		
1922	*Days*	*Days*	*Days*	*1923*	*Days*
Nov. 18	82	27	56	May 2	165
1923					
May 2	15	15	31	July 2	61
July 5	12	12	37	Sept. 4	61
Sept. 1	11	17	38	Nov. 6	66

Other life cycles, which began on December 14, January 23, and April 4, covered 152, 107, and 55 days. The last was the shortest period recorded, and it occurred during the spring migration when activity on the palms was high.

The male and female insects pass through the first molt and reach the adult stage in about the same time. The male, however, develops through its second, third, and fourth stages while the female is in the second stage.

The red date scale produces both eggs and living young. Some eggs hatch within the body of the mother, some begin to hatch immediately after they are laid, and others hatch in an hour or more after deposition.

The following data were obtained from 74 females living behind the fiber of date palms, from early May until the end of July. These females produced an average of 67 eggs, ranging up to 5 a day. Seven of the females laid an average of 108 eggs. The length of the egg-producing period was from 33 to 85 days. During the same period, records from two lots of females reared on leaves came within the ranges previously mentioned.

On various occasions females that had been kept isolated from males did not develop eggs, an indication that reproduction without fertilization is lacking in this species.

From 28 lots of the red date scale bred from the middle of February until the end of July, counts of the individuals of each sex produced were 33 females and 31 males in February and March, 102 females and 78 males in April and May, and 33 females and 24 males in June and July.

The maximum length of life of a fertilized female living on a small palm in an insectary was a little over 8 months, from November 22 to July 26. Crawlers were being produced by this individual up to the end of the period. Several virgin females lived 7 to 8 months during about the same period, and one lived almost 9 months.

The longevity of adult males was not exactly determined. During the summer two lots of males were observed. One was kept under outdoor-air conditions and the other was held in air saturated with moisture. All of both lots were dead after 48 hours.

HABITS

The hatching process requires 9 to 35 minutes. After breaking away from the eggshell, the nymphs remain beneath the body of the mother from 2 or 3 hours to perhaps 1 day. When observations were made on the distance nymphs crawl, it was found that one nymph moved 7 feet over a smooth surface in about 2 hours at temperatures ranging from 72° F. at the beginning to 66° at the end of the period.

Newly hatched nymphs seek protected places in which to settle down. Upon finding a suitable location, a nymph gradually works its mouth tube nearly to its full length into the host tissue. On a palm leaf pinna the operation has been observed to take from 1 to more than 3 hours, during the middle of April. Most of the nymphs establish themselves within 24 hours after leaving the mother scale.

FOOD PLANTS AND DISTRIBUTION

The red date scale occurs chiefly on plants of the palm genus *Phoenix*, but grows also on *Calamus*, *Daemonorops*, and *Pandanus* (Lepesme *41*). In southern California the location and history of infested trees of *Phoenix canariensis* and *P. reclinata* Jacq. indicated that the insect had spread to them from infested date palms nearby.

In the United States the red date scale is generally distributed in the Coachella, Imperial, and Salt River Valleys, and in the Yuma district in Arizona. It has been found locally at various points along the Colorado River from Needles, Calif., to Yuma, Ariz.; near Whittier and El Cajon, Calif.; in the vicinity of Aztec, Ariz.; and in and near Laredo, Tex.

CHARACTER OF INFESTATION

Leaf bases and fiber bands afford excellent protection to red date scales, which mass on any accessible white tissue behind the fiber (fig. 3). Regardless of whether a tree belongs to a so-called thin, semitight, or tight-fibered variety, there are always seven fiber bands overlying each leaf base in the region where the heaviest infestations of red date scales are found.

The greatest scale populations on good-sized trees occur about midway up the trunk. On a 16-year-old Halawi date palm with terminal leaves rising 9 feet from the ground, the heaviest infestations extended from 5 feet above the ground (where the bases of the oldest living fronds were located) to within 2½ feet of the terminal leaves (in the vicinity of the fruit stalks of the preceding season). Thus, the area

of greatest abundance was in a band about 1½ feet wide around the tree. Owing to the tightness of the fiber, this band of scales reached only to within 1½ inches of the attachment of the leaf to the trunk of the tree, and its upper margin was about 2 inches below the top of the fiber.

Above the area of greatest infestation on such a tree the white tissue increases in proportion and in tightness and the scale population decreases in numbers and in the extent of its penetration downward. Below the zone where infestation is heaviest, leaf bases and bands become increasingly loose and the white tissue decreases in amount. This condition permits an easier entry for the insect, but provides less and less tissue for feeding. Although the population decreases, the scale penetrates lower down on the tissue until near the ground it reaches the point where the leaf bases and bands connect with the trunk of the tree and may even extend over onto the white tissue of the trunk. Usually the leaf bases and bands nearest the ground are so decayed that they provide few or no suitable areas on which the insect may feed.

New fruit stalks become heavily infested within 2 or 3 months, more quickly than the leaf bases and bands in the immediate vicinity. The scales mass on fruit stalks as they do on leaf bases, and frequently completely cover the tissue within the infested area.

Only a small percentage of the scales on a palm are ever found outside the fiber, and of this percentage the largest numbers occur on the youngest leaves, where they are most abundant on the inner surfaces of the midribs, along the edges of the unexpanded pinnae, and between the closely overlapping surfaces of the pinnae. In the Coachella Valley, the scales are common on these parts during the spring and early summer only, but toward the California coast they frequently are found there in large numbers throughout the year.

Red date scale migrants also settle outside the fiber in the depressions at the bases of new fruit threads, in the flower cups of new inflorescences, and beneath small scaly secretions of leaf bases. These places offer poor protection, especially during the warmer time of the year, and the insects seldom survive in them longer than through the first stage. They settle readily in cracks, breaks, or cuts in exposed palm tissue; between closely grouped pinnae of very slowly growing, deformed leaves commonly issuing from the trunks of palms; and in the cuplike bases of pinnae. The protection in these last locations is usually sufficient to permit most of the insects to complete their life cycles at all times except during the hottest part of the summer. However, near the California coast, as in El Cajon Valley, a large percentage of live scales in all stages has been observed in August at the bases of pinnae and on the basal surfaces of fruits. In drier regions no infested fruits have been seen at any time.

Since the scales tend to produce a brown discoloration on the parts attacked, one usually can detect an infested tree by glancing at the bases of the pinnae. As many as 136 scales in all stages have been taken from one pinna cup.

Both aerial and underground roots are attacked. The scales settle between closely grouped roots near the palm trunk. Scale mortality is heavy on aerial roots, because they tend to die back and because their position subjects the insects to too much exposure.

Although the red date scale does not occur on surfaces in direct contact with soil, the insect may be found a foot or more beneath the soil surface, between closely bunched roots. The base of palms planted deeply in a light soil may be as much as 3 feet below the surface, and many live scales have been observed on the basal parts of the roots of such palms several years after planting. On the other hand, scale infestations on the basal parts of the roots of palms planted as deeply in adobe soil have been observed to die within 2 years.

Figure 4.—Method of demonstrating red date scale infestation. *A,* Date palm trunk with fiber intact; *B,* flexible hinged blade inserted to clasp the fiber and serve as a guide for cutting (one leaf-base stub has been sawed off); *C,* fiber cut through and pulled apart to expose the fluffy, white wax produced by recent infestation; *D,* cut through fiber repaired with tree-wound cement, and sawed-off leaf base stub replaced by use of finish nails.

The senior author was unable to make a sufficiently extensive survey to determine possible differences in the susceptibility of varieties of date palms to the red date scale, because inspection involved cutting into and permanently disfiguring the trunk.[3]

[3] An inspection method that avoids disfiguring the palms has since been developed by one of the authors (Simmons). This method consists in sawing off a leafstalk stub, and making a clean vertical cut through the fiber behind it, in front of the leaf base to be examined. The fiber is then pulled apart to reveal the leaf base. After inspection the fiber is sealed back in place with tree-wound cement. The sawed-off stub is replaced by driving finish nails part way into the sawed surface of the portion attached to the palm and driving the severed part onto the protruding nails. The operation is illustrated in figure 4.

DISSEMINATION

The red date scale spreads by the same means as those outlined for the parlatoria date scale. Spread of the red date scale is slow. As an example, in a planting set out in standard form, about 27 feet apart, there were originally 3 infested trees in one corner of the block. After 14 years no scales were found on any trees beyond the seventh row from the 3 palms. In a group of 27 trees planted about 60 feet from 4 old infested ones, only 4 trees were found to be infested 6 years later. During 24 years all of a group of 133 trees growing near a nucleus of 11 infested trees became infested. The nearest originally clean palm was 190 feet from the source of spread.

The secretive habits of the insect and its sensitivity to exposure probably account for its unusually slow dispersion.

NATURAL ENEMIES

No internal parasites and but few predators of the red date scale are known. *Cybocephalus californicus Horn*, a small, black beetle of the family Nitidulidae, has been observed feeding on the insect on the terminal leaves above the fiber. A mite belonging to the family Eupodidae occurs commonly on the upper parts of leaf bases, where it feeds on masses of the red date scale. All stages of this mite, including the egg, are brilliant orange. A scattering of undetermined orange-colored fly maggots is not uncommon in the midst of scale colonies on the upper parts of leaf bases behind the fiber, but they have not been observed actually feeding on the scale. Borden (*15*) found similar maggots in the midst of scale masses, and he observed a beetle of the genus *Laemophloeus* (probably *truncatus* Casey) feeding on the scale.

REMEDIAL MEASURES

Several treatments for control of the red date scale have been tried, but for one reason or another have not been recommended. A type of kerosene emulsion was sprayed on the trunks, but was unsatisfactory because it failed to reach the scales in the tight areas behind the fiber. Offshoots were immersed in a similar emulsion, both in vacuum and at atmospheric pressure. In other tests, fish-oil soap and 40-percent nicotine sulfate were added to the emulsion and offshoots were immersed in it under vacuum. Although it was possible to kill all the scales with some of the treatments, the recovery of the plants was retarded. Offshoots were fumigated in vacuum with hydrocyanic acid gas, but treatments that did not cause tissue injury failed to effect a satisfactory kill.

Good results were obtained by exposing offshoots to moist heat and to hot water. These treatments killed all living scales and permitted satisfactory recovery of the offshoots. It was found that subjecting offshoots to 120° F. in an insulated room for 65 hours, without attempting to regulate the humidity, was the best method of control.

Date Mite

The date mite feeds on the foliage and fruits of date palms and on grasses. This mite was originally described in 1914 by Banks (*8*) as

Tetranychus simplex from date palms at El Centro, Calif. In 1922 Ewing (*33*) described a mite found infesting date fruits in the Coachella Valley and named it *Paratetranychus heteronychus.* McGregor (*44*) has shown that these species are identical, and that the scientific name should be *Paratetranychus simplex* (Banks). Apparently this is the only mite attacking date palms in the Coachella and Imperial Valleys. Economic aspects of the date mite have been discussed by Stickney (*61*) and Essig (*32*).

The study of the date mite was first begun during the summer of 1921. At that time the superintendent of the United States Date Garden at Indio had been observing this mite infesting dates in the Coachella Valley for 10 years or more. It is not clear whether this pest was introduced. McGregor concluded that it is distinct from the Old World date mite, which he described as *Paratetranychus afrasiaticus.*

NATURE OF INJURY

The date mite rasps the surface of the host tissue, destroying the original pigment. The rasped surface becomes grayish white or pale yellow, and heavily infested date fruits turn brown. A heavy deposit of fine webbing (fig. 5) is spun over much of the area fed upon. The mites work extensively beneath the webbing, but as colonies develop some of the mites expose themselves beyond the margins of the webbing.

DESCRIPTION AND LIFE HISTORY

In all nymphal stages the date mite is robust in form, pale yellow or yellowish white; sometimes yellow, pale orange, or greenish. Along the sides of the body are irregular spots of the same color as the body, but of a deeper shade. Sometimes these spots are indistinct or absent. The anterior margin of the body and the forward appendages are paler than the body proper. The eyes are bright red. The adults, especially the females, show stronger coloration than do the nymphs.

The body of the adult female (fig. 6) is ovate and about $\frac{1}{85}$ inch long. Adult males are bluntly subtriangular and smaller, being $\frac{1}{100}$ inch long. Immature mites resemble adult females, except that newly hatched ones, called larvae, have six legs instead of eight. These larvae are only $\frac{1}{200}$ inch long. After molting they become 8-legged nymphs. The egg is pearly white, almost transparent when deposited, spherical, and $\frac{1}{200}$ inch in diameter.

The date mite is present in all stages of development throughout the year. During the winter its activity is much reduced, and its numbers decrease as the cold season advances. With the advent of warm weather it begins to increase in activity and in numbers, and maintains a high rate of activity throughout the warmer part of the year. On date fruits the population peak is reached during the latter part of July or early in August. Although the mites disappear from ripening dates, they are able to maintain themselves in full force on green fruits of late varieties or on dates developing off season.

Infestation usually appears on dates about the first of June, when the fruit is the size of buckshot. Depending upon the earliness of the

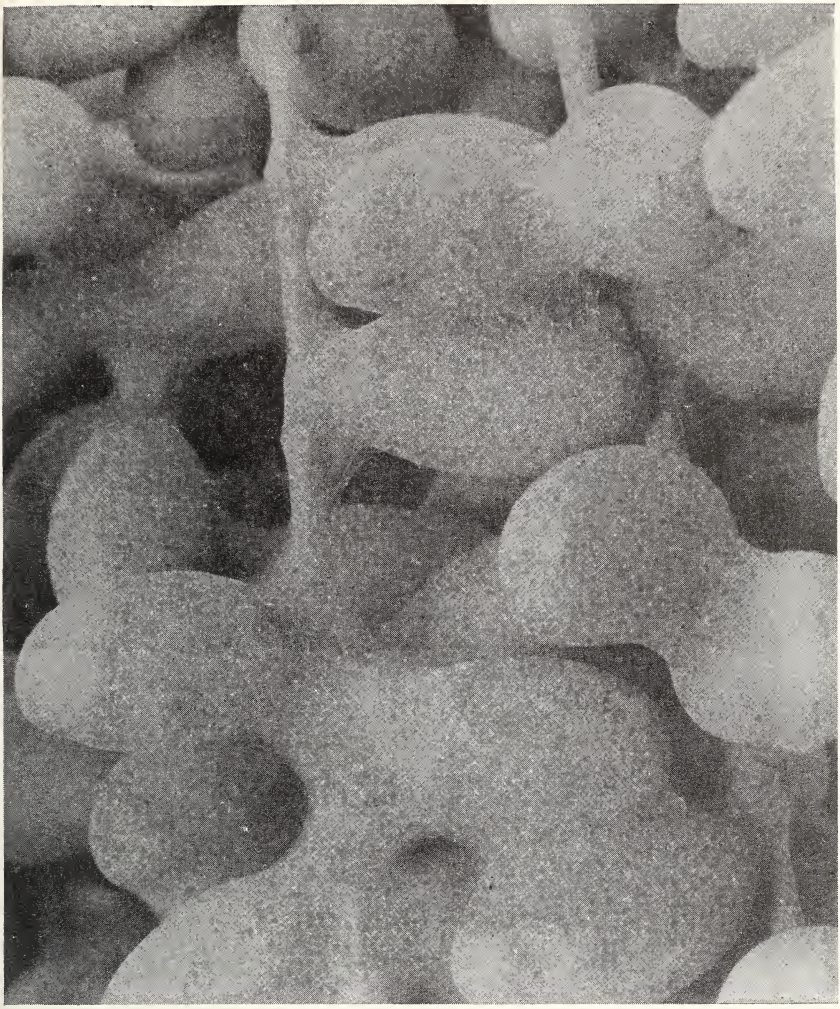

Figure 5.—Dates infested with the date mite, and covered by the silk webbing spun during heavy infestations.

season, infestations begin from mid-April to as late as the first of July. When the mites attack the fruit, small colonies are irregularly distributed in individual bunches scattered over the palms.

During the winter the mites are found on the foliage of the date palm, frequently on partially expanded pinnae. In the pinnae they are well protected and produce little webbing. Some of the mites pass the winter on small date seedlings and on grasses.

The development of *Paratetranychus simplex* was studied for the most part by enclosing, in transparent covers of glass or celluloid, dates growing on commercial palms. The glass covers consisted of cylinders placed over fruit threads and closed at both ends with absorbent cotton or silk cloth. The celluloid covers were cone-shaped,

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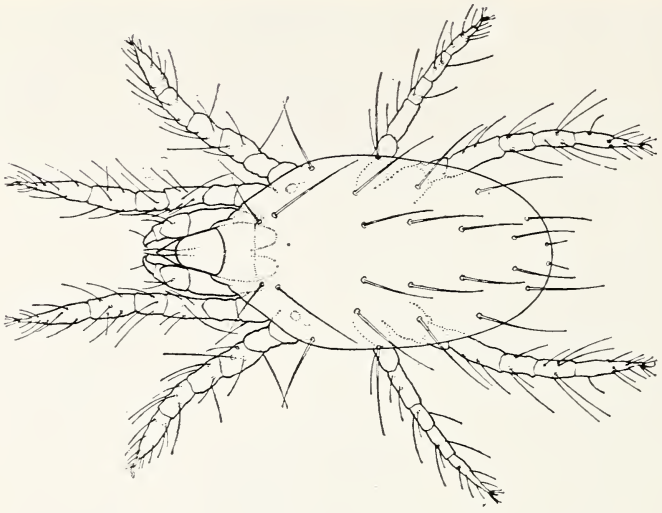

Figure 6.—Date mite, adult female. From McGregor (*44*).

with the apex fastened around fruit threads and the large end left open. Information about development of the mites on foliage was obtained by placing glass cylinders over parts of small potted date palms in an insectary. The data obtained in this experiment are shown in table 2.

TABLE 2.—*Length of egg period and life cycle of the date mite*

Date of egg deposition		Egg period	Life cycle
Initial	Following generation		
		(*Days*)	(*Days*)
June 23 to Sept. 5	July 3 to Sept. 15	3 or 4	9 or 10
Sept 15	Sept. 26	4	11
Oct. 8 [1]		6	
Oct. 14	Nov. 3	7	20
Oct. 21		10	
Oct. 31 [1]		12	
Nov. 2 [1]	Jan. 19	13	78
Nov. 11		15	
Dec. 28		27	
Jan. 16	Mar. 5	25	48
Jan. 19 [1]		23	
Feb. 8		21	
Mar. 8		11	
Mar. 14		9	
Apr. 6	Apr. 23		17
Apr. 18 to May 4	May 1 to 17	6	13
May 11 to 25	May 23 to June 6	4 or 5	11 or 12

[1] Data from date mites bred on foliage. Other records are from mites bred on growing dates.

The records presented in table 2 indicate that life cycles are repeated most frequently when the mite is doing its worst damage, from the latter half of June until the middle of September. The maximum number of generations is about as follows: June 23 to September 15, 8 or 9; September 15 to 26, 1; October 14 to March 5, 3; April 6 to 23, 1; April 23 to June 23, 5. There are about 20 generations a year.

One hundred seventy-three female mites, bred on dates under celluloid cones between the latter part of April and the middle of June, laid 2,388 eggs, and averaged 14 eggs each. Egg production lasted from 2 or 3 days to 15 or 16 days. The number of eggs laid daily per female was irregular, ranging up to 3.

Females died soon after egg production ceased. During the period from late April to mid-June the length of life varied from 2 to 4 weeks. About one-half of the life span preceded egg production; the other half was spent in producing eggs. The males lived several days longer than the females.

Of 253 individuals reared during April, May, and June, 64 percent were females. Of another group of 385 mites, reared between August 12 and September 19, 52 percent were females.

HABITS

The eggs of the date mite are scattered beneath and in the webbing, or sometimes apart from the webbing in exposed locations. They adhere to the surface on which they rest and are not easily detached.

Newly hatched larvae are active and begin feeding immediately. Preceding each molt the nymphs pass through a quiescent period in protected places.

Both nymphs and adults are easily disturbed, and when temperatures are high they crawl away rapidly. Disturbance often causes them to float off into the air attached to a thread of silk. They are able to cling to bare host tissue through a rather strong wind.

This mite is tolerant of sunshine. Observations made on two consecutive windless days, when the relative humidity was about 11 percent, showed that mites resting on dates exposed to the sun moved into the shade as soon as the air temperature in the sun reached 115° F. At 114° they showed less inclination to move away, and at 113° they did not attempt to escape direct sunlight. Other records showed that when the air temperature was 115°, the surface temperature of dates in the sun was a degree or so higher and in the shade 4 or 5 degrees lower.

Groups of 15 mites in various stages of development died after the following exposures in dry air: 147 minutes at 116° F., 49 minutes at 122°, 29 minutes at 129°, and 9 minutes at 136°. The mites were without food. Relative humidity was 15 to 17 percent. When exposed to similar temperatures in air saturated with moisture the mites were somewhat less resistant.

When deprived of food the mites do not live long, even in the shade. For example, in August, 87 percent of 160 adults of both sexes, kept in the shade, succumbed within 24 hours when the mean maximum and minimum temperatures were 108° and 83° F.; all died within 46 hours. In December, however, when the mean maximum and mini-

mum temperatures were 68° and 45°, 56 percent of 25 mites in both immature and adult stages, confined in a shaded location, died during the first 6 days, and none were alive after 11 days.

Date mites are able to build up large populations only on the date fruit, where concentrations are much greater than on grasses. Although the mites readily attack dates from the time of their earliest formation until they begin to change color as the ripening process sets in, they will not infest mature fruits.

Colonies of the date mite usually begin to form between two date fruits or between the base of a date and the thread to which it is attached. As the colonies grow, the infested areas spread, and are likely to cover the entire fruit surface. Whole bunches of fruit may become enshrouded with webbing.

Dates that are only lightly infested, as is the case when the mites are destroyed by early treatment, ripen normally, and although the injured surfaces remain discolored, the damage does not extend beneath the skin of the fruit. Such dates are edible, but they cannot be rated as first-class fruit. As infestation increases, the fruit skin becomes roughened and hard, and injury extends to the tissue beneath the surface. A small colony may increase so rapidly that serious damage results within 2 or 3 weeks.

Mite-damaged surfaces are likely to crack after a rain or if exposed too much to the sun. Heavy deposits of dust collect in the webbing. Severely infested dates do not develop properly, owing not only to the direct damage caused by the feeding of the mites, but probably also to the abnormal conditions induced by the sheets of dusty webbing.

FOOD PLANTS AND DISTRIBUTION

The date mite assumes added significance because the fruit of the important Deglet Noor variety is very susceptible to the attack of this mite. On the other hand, some varieties are nearly free from damage.

The date mite has also been identified as infesting the following grasses. (Most of the records are from Indio, Calif.):

Intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.).
Giant reed (*Arundo donax* L.).
Sixweeks grama (*Bouteloua barbata* Lag.).
Field sandbur (*Cenchrus pauciflorus* Benth.).
Feather fingergrass (*Chloris virgata* Swartz.).
Bermuda grass (*Cynodon dactylon* (L.) Pers.).
Hairy crabgrass (*Digitaria sanguinalis* (L.) Scop.).
Jungle-rice (*Echinochloa colonum* (L.) Link.).
Stinkgrass (*Eragrostis cilianensis* (All.) Link.).
Ryegrass (*Lolium* sp.).
Green bristlegrass (*Setaria viridis* (L.) Beauv.).
Sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray).

The mites infest both sides of the grass blades at the base and often cause them to turn pale and to dry out. The plants, however, do not die, since small areas are attacked and the root stocks are not reached.

Additional records of date mite occurrence, made by McGregor and received from him in correspondence, are as follows: field corn at

Phoenix, Ariz.; Canary Island palm at Indio, Imperial, and El Cajon, Calif.; unnamed grasses at Bangs and Richland, Texas; and sugarcane in Florida.

The date mite is generally distributed in the four chief date-growing regions. Heavy infestations develop on date fruits in the Coachella, Imperial, and Yuma Valleys, but no severe infestations have been observed in the Salt River Valley.

Another mite, similar in structure to the date mite, has been found on grasses but not on date palms, even though the infested grasses may be near the palms. McGregor (*44*) named this species *Paratetranychus stickneyi* and called it the grass mite.

Particular attention has been given to the distribution of the date mite on Bermuda grass, the most common grass in the Southwest. This mite has been identified on this grass at well-separated points in the Coachella, Imperial, and Salt River Valleys. It also has been found on this host in such diverse localities in California as Lakeside and Vista (both near the southern coast), Warner Springs (at an elevation of more than 3,000 feet in the San Jacinto Mountains), Blythe; in the Colorado River lowlands east of Blythe; Los Banos, in the San Joaquin Valley; Corning, in the Sacramento Valley; and in the Arizona desert at the isolated points of Salome, Wenden (about 50 miles west of Wickenburg), and Bella Loma (about 27 miles east of Gila Bend). Other Arizona locations are Tempe and Tucson. These records indicate widespread occurrence of the date mite in the Southwest.

NATURAL ENEMIES

Adults and nymphs of the six-spotted thrips (*Scolothrips sexmaculatus* (Pergande)) feed on the date mite. This common insect, probably the most important predator of the mite, is a small, light-brown thrips with three darker brown spots on each forewing. A minute, black ladybird beetle of the genus *Stethorus* and a bright-orange mite belonging to the family Eupodidae have been noted feeding on the date mite. These enemies are not effective in preventing damaging build-up of mite populations.

REMEDIAL MEASURES

Tests with sprays of colloidal sulfur, lime-sulfur, and oil emulsions, and with sulfur-nicotine and sulfur dusts showed that the dusts were easier to apply than the sprays and were fully as effective. Dusts were more readily removed from the fruit than were the residues from the sprays containing sulfur.

Dates that were in good condition and somewhat protected by foliage did not show burning from sulfur dust. Brown discoloration sometimes resulted, however, when the dust was applied to unthrifty or mite-scarred fruit that was exposed to direct sunshine during unusually hot weather.

Good results were obtained by treating date bunches with a light coating of fine sulfur, with thorough coverage, as soon as colonies of date mites appeared. Time of application varied from the first of May to the middle of June. Both adults and immature stages suc-

cumbed readily to sulfur dust. The eggs appeared to be unaffected, but larvae hatching from dusted eggs were killed.

Bliss and Lindgren (*14*) found that applications of a sulfur dust containing 3.41 percent of ferric dimethyl dithiocarbamate, put on primarily for disease control, caused infestations of the date mite to disappear.

Datebug

The datebug (*Asarcopus palmarum* Horv.) (fig. 7), was described as a new genus and species in 1921 by Horvath (*40*). American literature includes brief mention of it by Essig (*32*), Nixon (*51*), and Stickney (*61*). It is undoubtedly an introduced species, but the time of its establishment in date plantings in the Southwest is not known. The datebug was first noticed in 1922, and since that year it has been

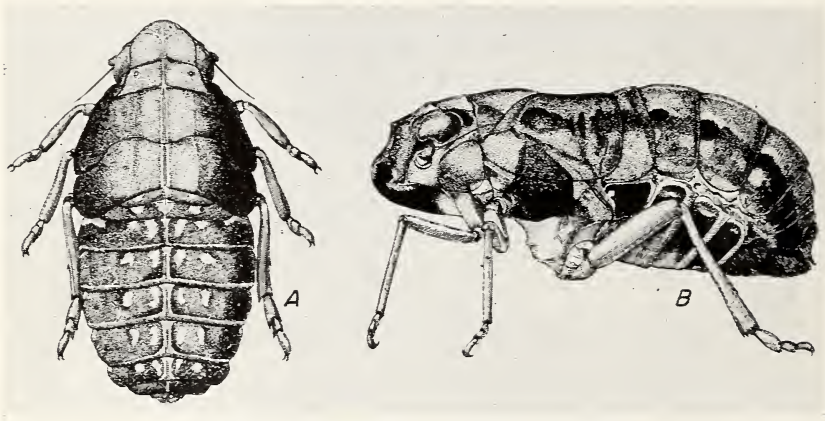

Figure 7.—Datebugs: *A*, Nymph; *B*, adult.

occasionally reported as causing serious damage to date palms. The insect is a member of the family Fulgoridae, the lanternflies, which includes few members that have any economic importance. Some of the closer insect relatives of the lanternflies are the cicadas, treehoppers, spittlebugs, and leafhoppers.

Nature of Injury

The datebug concentrates on the white tissue behind the fiber, between unexpanded parts of terminal leaves, and within the spathes on the white tissue of the current season's fruit stalks (fig. 8). In these places it is protected and is not readily observed. Few datebugs are found elsewhere on date palms. Those that infest the white tissue behind the fiber do not penetrate so deeply as do the scale insects.

Where the datebug feeds, the host tissue turns brown and the affected parts take on a bruised appearance. The injured places are typically quite variable in size and outline. They seldom cover an extensive area of host tissue, chiefly because the insect moves around freely and usually does not occur in large masses. However, as many as 330 datebugs in all stages have been collected from the basal parts of the

Figure 8.—Datebugs on new growth of date palm.

terminal leaves of an offshoot weighing only 2 pounds. Healthy palms are so little affected by datebug infestation that damage is seldom obvious, largely owing to the rapid production of new terminal leaves and to the compactness of the parts where the datebug prefers to congregate. Small, weak palms may be so injured that the

terminal leaves droop because of heavy infestation on their slender, loosely growing bases.

The datebug secretes a clear, sticky, sweet substance in the form of droplets which frequently run together, producing a smeared appearance. On leaf bases these exudations, which collect much dust and dirt, are exposed by the growth of the leaves.

DESCRIPTION

The oval, flattened datebug nymphs, which hatch from pearly white eggs, are 1/33 inch long by 1/50 inch wide. Mature female nymphs are 1/8 inch long by 1/15 inch wide. In all stages nymphs are at first pale yellow or light brown, each succeeding stage deepening in color. Those of the last nymphal stage are dark brown. The lines between the body segments of nymphs of all instars are pinkish or reddish, the color being most pronounced on the back and on the sides of the abdomen.

The adult female of the datebug is elongate-oval, 1/7 inch long by 1/17 inch wide, of various shades of brown with a broad, light-brown band extending the length of the back, and darker brown markings along the sides of the band and on the under surface of the body. There is a dorsal hump on the abdomen. The adult male is elongate-oval, slightly smaller than the female, the brown of the body being broken into light and dark areas on all surfaces. There are white markings on the back, on the sides of the body, and on the under surface of the abdomen.

All stages of both sexes of the datebug have red eyes. Long hind legs equip them for jumping. They are without wings, but the adults of both sexes possess short pale-brown wing pads. Both sexes pass through five stages before becoming adult.

LIFE HISTORY AND HABITS

The datebug is active in all stages throughout the year. Eggs are deposited during the coldest as well as the hottest months. Although activity is appreciably reduced in winter, the population does not decline during that season.

The datebugs are rather phlegmatic. The females can be gently touched without exciting them, but such treatment causes adult males to crawl away rapidly. Individuals of all stages jump when stimulated by jarring.

Infestations of this species usually are attended by various kinds of ants, which apparently are attracted to the honeydew produced by the datebugs.

Most of the datebug population is composed of nymphal stages. This is true even though adult females, during their most active period, live for a month or more after egg deposition begins. Adult males live about as long as the females.

In the colder part of the year the insect is seldom seen away from the protection afforded by the basal parts of the terminal leaves and fruit stalks. In the warmer season some individuals, chiefly adults, scatter out on the foliage. There the females deposit their eggs, singly and distributed widely, even near the tips of long leaves 6 or 7

feet away from the place where the insects congregate. Eggs are deposited usually on the inner surface of the pinnae. Nymphs seldom are seen very far out on the foliage, and, on hatching, they promptly seek the protection of the basal parts, which, however, harbor but few eggs.

To illustrate a typical occurrence of the datebug on foliage, 13, 45, and 48 eggs, and 1, 4, and 5 adult females were found scattered over the inner surface of the pinnae on 3 leaves of a small palm on April 18. Some of the eggs had already hatched, and the others were in various stages of incubation, but no nymphs or adult males were present. No eggs were found on the outer surfaces of the pinnae, nor in the area occupied by the principal datebug infestation.

Records obtained from individuals kept on small seedling palms in an insectary showed the egg period to be about 14 days, beginning on May 26; 9 days at various times in July; 37 days, beginning on October 29; and 79 days, beginning on November 15. During the same season the lengths of the periods from egg deposition to emergence of adults, beginning on the dates given, were as follows: May 26, 60 days; July 30, 35 days; and November 1, 133 days.

The maximum number of eggs produced by a single female was not definitely determined, but the average number per individual for one lot of 10 females observed over an egg-producing period of 30 days, beginning on July 11, was 124. Another group of 4 females observed over an egg-producing period of 80 days, beginning on October 29, laid an average of 121 eggs. The average number of eggs produced daily per individual during the summer ranged from less than 1 to 10 and during the fall and winter from less than 1 to 4.

FOOD PLANTS AND DISTRIBUTION

The date palm, a closely related species, *Phoenix roebelini* O'Brien, and hybrid palms produced by crossing the date palm and the Canary Island palm, are hosts of the datebug. Forty-four varieties of the date palm, including all the more common ones, have been found to be infested. The California fan palm is a host but not a favored one.

The datebug is well distributed on date palms throughout the Coachella Valley and is present in the Imperial Valley. It is common in the Yuma District, Ariz., and is reported from the Salt River Valley district, including the Gila River Valley. In 1934 the datebug was apparently absent in the Palo Verde Valley, Calif. It has been found near Laredo, Tex. Lepesme (*41*) stated that it occurs in the environs of Cairo, Egypt.

CONTROL

Tests of various dusts and sprays have been made against the datebug during June and July, when high temperatures promote maximum activity of the insect and the highest efficiency of insecticides containing nicotine or sulfur. The dusts were calcium cyanide, black gas sulfur, flowers of sulfur, two nicotine dusts (one containing 2 percent and the other 3.5 percent of nicotine), and a nicotine-sulfur dust containing 3.5 percent of nicotine. The sprays were 40-percent nicotine sulfate in strengths of 1 to 500, 1 to 800, and 1 to 1,000; a plain soap solution at the rate of 4 pounds of soap to 100 gallons of water, and

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a 1.5-percent stable oil emulsion. To each of the nicotine sprays soap was added at the rate of 4 pounds to 100 gallons of water. Both light and heavy applications were tried.

Caution.—Many of the chemicals used for insect control are poisonous to man or irritating to the respiratory tract. Poisonous materials should be stored and handled with care. They should be kept in tightly closed, plainly labeled containers in places where they cannot contaminate food or be mistaken for flour or other food materials or medicines, and where children, pets, or livestock will not have access to them. Persons handling or applying insecticides should use proper precautions to prevent breathing or ingesting the spray or dust. Where there is undue exposure to dusts or sprays, a full-face respirator should be worn. Kerosene and sulfur are inflammable and in certain mixtures with air are explosive. All necessary precautions against fires and explosions should be taken. Dusting machinery used for applying sulfur should be grounded to carry off static electricity.

Of the dusts used, only a heavy application of the nicotine-sulfur combination was lastingly effective in ridding the palms of all datebugs and attending ants. The palms remained free of these insects for at least 12 weeks and control was satisfactory for an entire season. Even a light application, however, greatly reduced the datebug and ant populations. Black gas sulfur and flowers of sulfur were comparatively slow acting, but in time heavy applications of these materials considerably reduced the insects' numbers. Nicotine dust at both strengths and calcium cyanide dust were effective and rapid in their action against datebugs and ants, but their effectiveness did not last long. Ants returned to well-dusted surfaces within 18 hours.

A thorough application of 40-percent nicotine sulfate, 1 part to 500 parts of water, was the most effective spray. All datebugs and ants were eliminated 40 hours after treatment. Nicotine sulfate at a 1 to 800 dilution was effective as an immediate control, and at 1 to 1,000 reduced somewhat the datebug and ant populations up to 40 hours. The oil emulsion and the soap solution gave partial kills. An inspection 12 weeks after treatment showed that infestations of datebugs and ants were about as heavy on all sprayed palms as on the untreated checks.

The palms treated with dusts and sprays were in an infested block, and were exposed continuously to reinfestation. Best results were obtained by opening up the basal parts of the leaves where the datebugs were concentrated in order to direct the flow of the insecticide to the hiding places of the insects. It was not necessary to treat the whole tree, since only a small proportion of the population was out in the open.

Bees, Hornets, and Wasps

Although no study has been made of the kinds of bees, hornets, and wasps that feed on ripe dates, it is known that species of this group sometimes do a good deal of damage. Honeybees, in particular, may be harmful, especially to varieties of soft dates. Hornets and social wasps feed on fresh fruits, and it is probable that several species get food from dates.

In the fall of 1935 losses from these insects in a date garden near Phoenix led to the experimental use of shade-cloth extensions on paper rain covers as possible protection against them. Fifteen hundred special covers were made (fig. 9).

The shade cloth on the covers was of the type used to cover fields of wrapper tobacco, asters, and chrysanthemums. Because the population of bees, hornets, and wasps in the date garden where the experi-

Figure 9.—Paper rain covers with shade-cloth extensions. When in use the covers and extensions were closed by means of spring clothespins.

mental covers were tried was much lower during the harvest of 1936 than it had been the previous year, no test of protection against these insects was obtained. Neither were there enough western leaf-footed bugs, discussed on page 5, to make possible a conclusion on the effectiveness of the cloth extensions for excluding these insects. It was reported by the owner, however, that the fig beetle, described in the section that follows, was able to force its way through the cloth.

The grower mentioned that there was no trouble from the humidity being too high inside these covers, and he added that movement of the cloth in the breeze kept birds away.

The covers shown in figure 9 are not recommended, but they illustrate an experimental model which may suggest improvements in design and materials. Similar covers were tried at Indio in 1934. A general-purpose cover should shed rain, exclude nitidulid beetles and larger insects, be easily opened and closed for picking the crop, and have enough ventilation to prevent the humidity from being too high in the bunches.

Fig Beetle

The fig beetle (*Cotinis texana* Casey), a member of the large family Scarabaeidae, or June beetles, is a pest of dates in the Salt River Valley. Essig (*32*) stated that it is a Central American and Mexican species, the range of which extends into Texas, New Mexico, and Arizona. According to Quayle (*55*) fig beetles were found at Riverside and San Bernardino, Calif. H. H. Keifer, of the California Department of Agriculture, in correspondence, added Tustin (in Orange County) and Loma Linda (in San Bernardino County) to the distribution of the species in California.

The most detailed account of the fig beetle is that given by Nichol (*50*). He described the eggs as being pearly white and called attention to the fact that they increase in size, through absorption of water from the soil cell in which each is separately enclosed, until they are about double their original size. There are three larval stages. Larvae move about by creeping on their backs with the help of rows of bristles, their legs pointing upward.

The yellow pupae are enclosed in earthen cells an inch or more in length, the soil particles being bound together by a mucilaginous fluid secreted by the insect.

Adult fig beetles are robust, velvety green on their backs and shiny green on the head, with a band of yellow around the wing covers. The smallest males are about ⅝ inch long and the largest females about 1⅝ inches.

Most of the fig beetles in Arizona develop in corrals and haystack bottoms. The females lay their eggs from 2½ to 5 inches below the surface layer of organic litter. From 50 to 211 eggs have been laid by 1 female, and egg laying may extend over periods of 4 to 41 days, from early August to late October. Emergence of adults begins about the middle of the following July and continues through October. There is 1 generation a year.

Before casting their first skin the larvae are found just below the surface layer of organic litter, upon which they feed. After the first molt the grubs make permanent tunnels 4 to 12 inches deep. They feed under the litter and return to their burrows after each feeding period. In the last larval stage, after the second molt, the burrows may be 32 inches deep, but most of them are 12 to 24 inches deep. At the lower end of the burrow is a chamber where the grub rests between feedings.

With the first soaking showers of the midsummer rainy season the adults emerge from the pupal cases, which are 2 to 5 inches below

the surface. When the adults first take wing they fly at once to a fruit tree. Fermenting fruit is preferred, and ripe fruit is next in attractiveness. Injured fruits are often attacked, and uninjured fruits are not fed upon until after the beetle has punctured the skin by using the horn on the fore part of its head. Most of the feeding is done from 10 in the morning until sundown.

Figs, peaches, and grapes are favorites, although serious damage may be done to dates. Pears, apples, cracked melons, cactus fruits, damaged late sweet corn, various pollens, and plant gums are fed upon. Much fruit is spoiled by the beetles' excrement.

Larvae may be controlled by cleaning up corrals, manure piles, and haystack bottoms in February, March, and April. Flooding infested areas for 48 hours kills the eggs and young grubs. Satisfactory control measures against the adults have not been reported.

Nitidulid Beetles

Small beetles of the family Nitidulidae, a name based on a Latin word meaning "shiny," have increased greatly in date plantings in recent years, as the quantity of waste fruits available during the season has increased. Members of this group of beetles and their larvae feed on soft fruits that are ripe, partly dried, or in early stages of decay, and on some waste vegetables that contain enough sugar to support fermentation. Fruits and vegetables that are dry or in which rotting is far advanced are not attractive to these beetles or to their larvae.

The most important of the nitidulids in date gardens are the pineapple beetle (*Urophorus humeralis* (F.)), the dried-fruit beetle (*Carpophilus hemipterus* (L.)), the corn sap beetle (*Carpophilus dimidiatus* (F.)), and the yellowish nitidulid (*Haptoncus luteolus* (Er.)).

This group of small beetles, also commonly called sour bugs, are the most destructive insects with which date growers have to contend. Although the "sour" part of this common name is appropriate, "sour beetles" would be a better name since they are not true bugs.

In the warmer parts of the country, much waste ripe fruit falls to the ground, often on damp soil, where it usually squashes or cracks open. The surface that touches the soil becomes soft and very favorable for nitidulid beetles. The adults feed and the larvae develop in a moist, dark environment of yeasty and often moldy pulp. The larvae, feeding for 2 weeks or more, usually go into the soil beneath their host food to transform into the pupal stage. At Fresno nitidulid larvae and pupae have been found as deep as 2 feet in dry soil in a fig orchard.

The supply of food for nitidulid beetles is varied when tree fruits and certain vegetables are ripening. Almost anything that contains enough sugar to support yeast fermentation will do. Figs on the trees are very attractive, as are also soft ones on the ground. Mushy citrus fruits, rotting apples, broken watermelons, decaying sweet corn, and similar materials serve as food and breeding places for many of the beetles. The beetles feed frequently on decomposing tomatoes, but do not breed in them to any extent.

The four species of nitidulids most commonly found in infested dates are illustrated in order of their size in figure 10. The individual species will be discussed briefly.

PINEAPPLE BEETLE

The pineapple beetle is the largest nitidulid commonly found in dates in the Coachella Valley. Schmidt (*57*) named it the pineapple beetle because of its dominance among the six species of nitidulids in pineapple fields in the Hawaiian Islands. There the high sugar content of the stumps and leaves that remain after harvest (15 to 20 tons per acre) favors fermentation and produces food attractive to the beetles. There is no loss from attacks on pineapple fruits. However, the beetles are a nuisance in the canneries. Schmidt stated that the pineapple beetle has been found in India, Africa, Mauritius, Madagascar, the East Indies, and China.

The pineapple beetle (fig. 10, *A*) is a shiny black insect nearly $^{3}/_{16}$ inch long with a faint brown area at the base of each wing cover. As with many other nitidulids, the wing covers do not cover the abdomen.

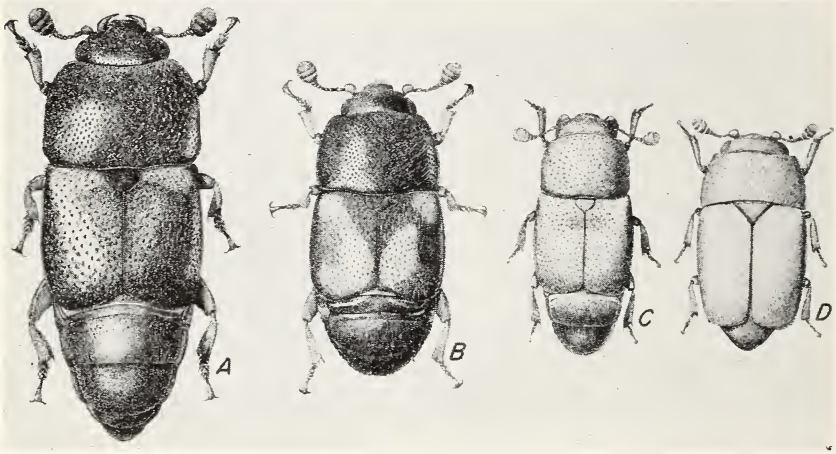

Figure 10.—Nitidulid beetles commonly found in infested dates: *A,* Pineapple beetle; *B,* dried-fruit beetle; *C,* corn sap beetle; and *D,* yellowish nitidulid.

Females, which Schmidt (*57*) kept in glass dishes containing squares of pineapple stump, laid eggs beneath the food. Twenty-five females averaged 882 eggs; the most prolific individual produced 1,466 eggs and averaged almost 15 a day for 100 days. These females lived from 23 to 113 days, the average longevity being 89 days. Egg-laying extended over an average period of 76 days.

Although this beetle occurs in dates, in 1946 it was much more abundant in waste grapefruit in the region around Indio.

Pemberton and Williams (*52*) reported that after developing in pineapple stumps the pineapple beetles fly to sugarcane fields, where their enormous numbers make them a nuisance to the laborers. In the fields the beetles develop on souring cane trash and congregate underground on the cut ends of planted seed pieces, promoting fermentation and interfering with germination.

On Guam this species is found in sugarcane, rotten breadfruit, and decaying cucumbers, according to Swezey (*64*).

DRIED-FRUIT BEETLE

The dried-fruit beetle, long known by this somewhat inappropriate name, was by far the most abundant nitidulid in date gardens when the first observations were made in 1921. In recent years, however, it has been of less importance than the corn sap beetle in dates in the Coachella Valley. Large losses have been caused by this beetle in central California, where it not only infests ripening figs but carries into them the yeasts and bacteria that cause souring.

Dried-fruit beetle adults (fig. 10, *B*) are about 1/8 inch long, black, with two amber-brown spots on each wing cover, one near the tip, and a smaller spot at the outer margin of the base.

The larvae (fig. 11, *A*), 1/16 inch long when newly hatched, attain a length of 1/4 inch. They are white or yellowish, and the head and the rear end of the body are amber brown. They are sparsely hairy. At the tail end there are two prominent spinelike projections, with two smaller ones in front of them. These larvae are similar to other nitidulid larvae found in dates. The pupae (fig. 11, *B*), also typical of the group, are 1/8 inch long, white or pale yellow, and somewhat spiny.

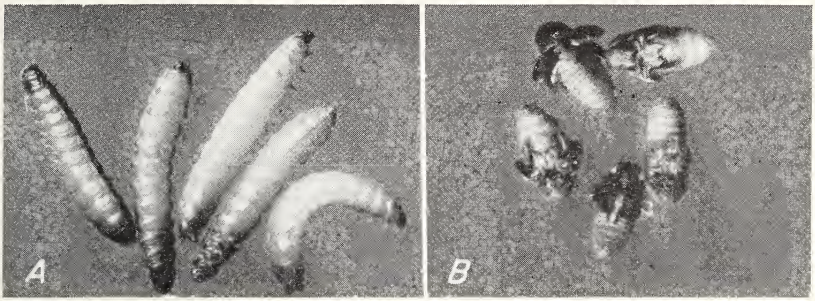

Figure 11.—Dried-fruit beetle: *A*, Larvae; *B*, pupae.

Like the pineapple beetle, the dried-fruit beetle has a short developmental period and a long adult life. The females of both species are very prolific. Records by Simmons, Reed, and McGregor (*60*) showed that mated females lived an average of 103 days and mated males 146 days. Two individuals survived for about 1 year. Deposition of the small white eggs, scattered over the surface of the food, began about 3 days after the adults emerged. The average number of eggs laid was 1,071 and the greatest number was 2,134, produced in 79 days. Eighty-nine percent of the eggs hatched.

The dried-fruit beetle is an insect of wide distribution in warm parts of the world. It probably is the most easily recognized of the common nitidulids because of its distinctive markings.

CORN SAP BEETLE

The corn sap beetle is third in size of the four nitidulids that most commonly affect dates in southern California. It is currently the most abundant nitidulid in dates, and is common in cull grapefruit.

The adults (fig. 10, *C*) are without spots and their color ranges from brownish-yellow through various shades of brown to black tinged with red. Like other nitidulids their variation in size depends upon whether the conditions under which the larvae developed were favorable. The adults of this species are from 1/16 to 1/8 inch in length, but on an average are smaller than the dried-fruit beetle.

Although this species is regarded as a cosmopolitan pest, little was known about its life history until Balzer (*7*) investigated it as an enemy of rice in the South. There it breeds commonly in rice bran and rice polish and to a lesser extent in brown, milled, and rough rice. In the warm moist climate of the Gulf Coast region, rice bran and polish soon become rancid and attractive to the corn sap beetle.

Cracked rough rice on a layer of damp sand was used by Balzer for obtaining biological data. Adults lived an average of 63 days in summer, whereas overwintered beetles lived as long as 200 days. Only 1 day elapsed between emergence and the beginning of egg laying. From 175 to 225 eggs were laid, and some lots of eggs hatched within 24 hours.

A few oviposition records, of a pattern typical of nitidulids, were obtained at Fresno in 1929 by W. D. Reed, of the Bureau of Entomology and Plant Quarantine. Fermented dried peaches were provided as food for the pairs of beetles. Two records are shown in table 3.

YELLOWISH NITIDULID

"Yellowish nitidulid" is the common name proposed for *Haptoncus luteolus* (Er.). The beetle is shorter and broader than the corn sap beetle, and its rectangular wing covers, extending nearly to the tip of the abdomen, give it a blunt appearance (fig. 10, *D*). In length the beetle measures 3/32 inch.

The yellowish nitidulid is common in figs, various waste fruits, and grape pomace in the San Joaquin Valley, Calif. Large numbers have been captured in fig orchards in traps baited with fermenting dried peaches, both in the Coachella and the San Joaquin Valleys. Swezey (*64*) listed the following host foods of the species on Guam: rotten pandanus (screwpine) fruit, rotten breadfruit, and rotten sugarcane.

LIFE STAGES AND FLIGHT HABITS

The lengths of the life stages of the four closely related nitidulids are shown in table 4. Moist dates were used as food. The eggs, larvae, and pupae were developed at fairly constant temperatures in an incubator.

Information about the flight habits of various dried-fruit insects, obtained by Barnes and Kaloostian (*10*), showed the dried-fruit beetle to be a daytime flier. In 1938, at Fresno, captures of this species in a rotary net driven by an electric motor and operated 24 hours a day averaged 59 specimens a day in April, 1,795 in May, and 1,933 in June. Daily flight did not start until full daylight nor until the temperature rose to 63° F. The flight reached a maximum at about 11:30 a. m. and ceased with the coming of darkness. The records, made in a raisin storage yard, included 166,000 dried-fruit beetles.

TABLE 3.—*Deposition of eggs by 2 corn sap beetles, Fresno, Calif., 1929*

Date	Eggs laid by female		Date	Eggs laid by female	
	No. 1	No. 2		No. 1	No. 2
Aug. 7	2		Sept. 7	7	5
Aug. 8	0		Sept. 8	7	4
Aug. 9	0		Sept. 9	6	2
Aug. 10	0		Sept. 10	10	8
Aug. 11	1		Sept. 11	6	4
Aug. 12	0	1	Sept. 12	7	4
Aug. 13	4	1	Sept. 13	6	11
Aug. 14	5	1	Sept. 14	8	15
Aug. 15	2	3	Sept. 15		4
Aug. 16	4	0	Sept. 16		13
Aug. 17	2	4	Sept. 17		10
Aug. 18	1	3	Sept. 18		7
Aug. 19	5	0	Sept. 19		17
Aug. 20	9	4	Sept. 20		0
Aug. 21	7	8	Sept. 21		2
Aug. 22	4	7	Sept. 22		5
Aug. 23	5	10	Sept. 23		7
Aug. 24	1	4	Sept. 24		3
Aug. 25	4	5	Sept. 25		2
Aug. 26	5	0	Sept. 26		2
Aug. 27	3	11	Sept. 27		5
Aug. 28	7	1	Sept. 28		5
Aug. 29	4	15	Sept. 29		5
Aug. 30	9	8	Sept. 30		3
Aug. 31	8	5	Oct. 1		1
Sept. 1	5	7	Oct. 2		2
Sept. 2	0	11	Oct. 3		0
Sept. 3	4	9	Oct. 4		2
Sept. 4	11	4	Oct. 5		1
Sept. 5	10	6			
Sept. 6	1	1	Total	180	278

TABLE 4.—*Length of various life stages of date nitidulids*

Nitidulid	Individuals	Average period			Total
		Incubation	Larval	Pupal	
	Number	*Days*	*Days*	*Days*	*Days*
AT 90° F.					
Pineapple beetle	24	1. 8	13. 0	5. 6	20. 4
Dried-fruit beetle	7	1. 0	12. 4	5. 8	19. 2
Corn sap beetle	10	1. 8	14. 3	5. 6	21. 7
Yellowish nitidulid	11	1. 6	12. 6	2. 4	16. 6
AT 80° F.					
Pineapple beetle	17	2. 2	13. 8	8. 0	24. 0
Corn sap beetle	24	2. 0	17. 8	7. 5	27. 3
Yellowish nitidulid	21	1. 3	12. 2	3. 3	16. 8

On September 30, 1946, a rotary net was operated in a date garden in the Coachella Valley. The pattern of flight of the dried-fruit beetle agreed with that discovered in 1938. Corn sap beetles, however, were found to have different flight habits. They were on the wing all day, but only a few were taken before 1 p. m.; the main flight was after 2 p. m. In contrast to both species, the yellowish nitidulid flew very little during the middle of the day, but was in the air in large numbers early in the morning and late in the afternoon. Pineapple beetles were too scarce to indicate definitely their flight habits, but the few captured were taken between 9:45 a. m. and 2:15 p. m., suggesting light and heat reactions like those of the dried-fruit beetle.

Runs of the revolving net were again made on September 22 and 23, 1948, in the same location. Although nitidulids were present in much smaller numbers than they had been in 1946, the flight records were essentially the same.

In 1935 experiments were made to determine the distances that dried-fruit beetles fly.[4] In open country east of Fresno, apart from the main areas of fig production but containing some grapes, figs, peaches, and oranges, 103,600 stained beetles were released. Traps baited with fermenting dried peaches were put out in four directions from the release point and were moved farther out at intervals. It was shown that beetles traveled more than 1,800 feet in less than 24 hours. Two specimens were recovered 2 and 2.4 miles from the starting point after 4 days, and 2 were taken 2.5 miles away after 6 days. These records show that, in common with many other insects, dried-fruit beetles are strong fliers and may travel several miles to reach attractive food materials. Presumably they travel less when host fruits are more abundant.

POPULATIONS IN DATES AND SOIL

During 1946 and 1947 nitidulid beetles were collected from several varieties of dates, from the floors of rooms in which dates had been fumigated, and from sweet corn damaged by corn earworms, waste grapefruit, and waste figs. There were marked differences in the composition of the infestations. For the most part the species were the four discussed. A few specimens of *Carpophilus obsoletus* Er. and *C. decipiens* Horn were found in dates. Table 5 gives typical collection records of nitidulids.[5]

The corn sap beetle was the dominant species in the Coachella Valley in 1946 and 1947 (table 5). The pineapple beetle was abundant only in the waste grapefruit.

These collections of nitidulids demonstrate the potential importance of cull material, when the large populations found are considered in relation to the capacity of the beetles for rapid increase. One purpose of these census studies was to emphasize the urgent need for as much farm sanitation as can be managed under the pressure of high costs of production.

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[4] Barnes, Dwight F., Kaloostian, George H., and Fisher, Charles K. [Unpublished report.] 1935.

[5] Lorin Roy Gillogly, of Sacramento, Calif., a specialist in the Nitidulidae, separated the species in many of the collections.

TABLE 5.—*Number of nitidulids collected from dates and other sources in the Coachella Valley*

Source and location	Time	Number of pieces of fruit	Pineapple beetles	Dried-fruit beetles	Corn sap beetles	Yellowish nitidulids
Deglet Noor dates:						
Old-crop, from ground	May 1946	100	0	0	500	0
	April 1947	80	37	284	1, 286	218
New-crop, unripe:						
From ground	July 1946	338	7	35	215	4
	July, Aug. 1947	550	135	296	1, 555	662
Beetles shaken from bunches	July 1946	[1] 74	2	1	1, 141	2
	July, Aug. 1947	[1] 29	0	4	37	1
Medjhool dates, unripe, from ground	June 1947	36	0	5	134	7
Khadrawy dates, unripe, from ground	June 1947	12	2	3	25	28
Maktoom dates, from ground	June 1947	12	2	11	180	12
Seedling soft dates, unripe, shaken from bunch	July 1947	[1] 1	35	131	235	878
Beetles swept from floor where—						
Deglet Noor dates had been fumigated	Oct. 1947	----------	0	68	2, 493	3
Soft dates had been fumigated	Sept., Nov. 1947	----------	49	1, 740	664	27
Beetles removed from decaying grapefruit	May, July 1946	18	4, 074	40	493	1, 184
Beetles removed from worm-damaged sweet corn	July 1946	20	52	312	457	2
Beetles found in waste Brown Turkey figs	July 1946	25	19	143	48	3

[1] Bunches shaken to dislodge beetles.

In addition to the nitidulids in waste fruit lying on the ground, there is beneath it a subterranean population of the same species, chiefly full-grown larvae and pupae. This fact points up the need for removing infested culls before larvae develop to full size and bury themselves in damp soil for pupation. Soil populations are, as a rule, in direct proportion to the amount of waste dates under the palms.

Examinations of soil at Indio with a washing device consisting of a series of screens have shown that over 90 percent of the nitidulids are in the top 8 inches. The distribution of 469 individuals at two locations was as follows:

Depth (inches):	*Number*
0 to 4	125
4 to 8	325
8 to 12	17
12 to 16	2

There were 124 larvae, 234 pupae, and 111 adults. Most of the adults had recently transformed from the pupal stage.

When soil samples were taken at 1-foot intervals beginning 1 foot from the trunk of a palm, it was found that 75 percent of the nitidulids were within 3 feet of the trunk. The distribution was as follows: 1 foot out, 1; 2 feet, 13; 3 feet, 16; 4 feet, 3; 5 feet, 6; 6 feet, 0; 7 feet, 1; 8 feet, 0.

The soil-sampling data indicate that efforts to kill larvae, pupae, and adults in the soil during and after harvest should be effective to a depth of 1 foot and within a radius of 6 feet from the palm trunks. This applies, of course, to gardens where the dropped dates have not been scattered by tillage.

CONTROL IN DATE GARDENS

Experiments on the control of nitidulid beetles were carried on as a cooperative project with the Citrus Experiment Station, University of California (*11, 12, 42*). Since the beetle infestation in the Coachella Valley was closely associated with date spoilage by molds and yeasts caused by rain and high humidity, the work was tied in with the experiments on disease control that were being carried on by Bliss (*13*), Bliss and Lindgren (*14*), and Lindgren, Bliss, and Barnes (*42*).

Four types of control measures were studied: Sanitation, protection of bunches, flood irrigation, and fumigation.

Sanitation.—Clean-up of waste host materials is a basic operation in keeping down increase of nitidulids. The importance of sanitation is emphasized by the fact that infestation in date gardens may be continuous throughout the year. Ripening of the crop extends through 3 or 4 months. In 1946, Barnes and Lindgren (*12*) found that nitidulids survived in old-crop waste dates until the insects began to infest immature new-crop dates as early as June 30.

Any progress that can be made in neighborhood or district clean-up will benefit date growers. Elimination from the home place of such beetle breeders as rotten citrus fruits and cracked pomegranates is advisable. Pomegranates hang on the trees all winter, giving harbor to many beetles. In Arizona, pomegranates provide food and shelter for western leaf-footed bugs.

The abundance of a variety of foods at a season when growers are busy and find it hard to clean up thoroughly all waste fruits is the chief reason why nitidulid beetles often increase to enormous numbers. The expense of getting rid of such waste fruit is also a factor, for a new supply of fruit keeps dropping from the trees and most of it has no value to offset partially the cost of picking it up.

To complicate control measures still further, many beetles often develop on nearby farms, but cause the operator of that property no concern. As examples, broken watermelons in a field or culls in a harvested peach orchard may not present any threat whatever to the owner. Consequently, he is not inclined to spend money to clean up the waste fruit. Such areas harbor beetles and, checkerboarded through a district where dates or figs are grown, present an infestation hazard that has never been successfully met. A grower, too, may help to create his own infestation risk, by growing melons, or interplanting fig trees with pomegranate trees or date palms with grapefruit trees.

Cultivating-under waste fruits does little to remedy the situation, because larvae continue to develop in host food buried to shallow depths. The adults are able to escape from the soil after pupation. Trapping the beetles with baits has never been successful, because the great bulk of attractive food upon which the insects are feeding presents overwhelming competition with the baits in traps.

Use of Insecticides.—Treatment of cull fruits after they have been collected has not been satisfactorily worked out. Lindgren, Bliss, and Barnes (*42*) found that benzene hexachloride dissolved in kerosene is effective in killing most of the nitidulids in and around waste dates on the ground. Further tests are needed to determine whether it would be safe to use benzene hexachloride year after year, perhaps twice each season, to treat dropped fruit under date palms. This pungent, persistent chemical sometimes contaminates products on which it is sprayed or which are growing in soil treated with it.

Long intervals between pickings contribute to nitidulid infestations by providing the beetles with a large supply of ripe dates on the bunches. Furthermore, many ripe fruits shatter off when picking is delayed.

Protection of Bunches.—Both mechanical and chemical protection of dates on the bunches offer promise as means of reducing losses by infestation. Although not perfected, mechanical protection by means of bunch covers (fig. 9) offers good possibilities.

Bliss (*13*) found that spoilage by fungi was greatly reduced by dusting bunches of Deglet Noor dates with sulfur, sulfur containing 10 percent of Yellow Cuprocide, and sulfur containing 5 percent of Fermate (ferric dimethyl dithiocarbamate or ferbam). The two last materials reduced fungus spoilage in 1945 from 53 percent to 11 percent, and nitidulid infestation in the treated dates was relatively light.

Bliss and Lindgren (*14*) in 1946 dusted the Deglet Noor, Khadrawy, Saidy, and Medjhool varieties of dates with sulfur containing 5 percent of Fermate, a mixture originated by Bliss and named by him "Thiomate." Fungus spoilage and nitidulid infestation were reduced in all 10 test plots.

Lindgren, Bliss, and Barnes (*42*) in 1947 reported information on further tests with fungicidal dusts, most of which contained sulfur. Thiomate again gave encouraging results for control of fungi and nitidulids. Insertion of wire rings to separate the fruit strands of Deglet Noor bunches before dusting with the sulfur-Fermate mixture resulted in the best control of infection by fungi. See caution statement, p. 26.

Flood Irrigation.—Prolonged flooding in basins (fig. 12) kills most of the nitidulids in the treated area. Barnes and Lindgren (*12*) found that no pupae and few larvae survived in soil that had been flooded for 6 days, whereas in untreated soil infestation had increased by 85 percent. Another test, laid out early in 1948, showed reductions

Figure 12.—Flooded date palm grove. Photograph by Clyde Simmons.

that were, in general, in direct proportion to the duration of flooding. Few larvae and pupae remained alive after 8 days under water.

Nixon (*51*) emphasized the importance of adequate penetration of irrigation water, 9 to 12 acre-feet of which are needed per year in the Coachella Valley for date palms in full production. Flood irrigation for nitidulid control, therefore, should not seriously upset irrigation programs, which normally are heavy. However, light porous soils cannot be kept flooded without excessive costs for water.

Fumigation.—Because fumigation is useful against a number of other date insects as well as the nitidulids, this phase of control will be treated near the end of this circular.

Raisin Moth

The raisin moth (*Ephestia figulilella* Greg.) first became an important pest of raisins in California in 1928. Its biology and control have been discussed in detail by Donohoe, Simmons, and Barnes (*29*, *30*). Since 1928 large losses have been caused by larvae of this species in figs, and the fondness of the larvae for dried peaches, apricots, raisins, and pears has led to substantial expenditures for fumigation. Other foods are ripe grapes, waste plums, fallen mulberries, cottonseed cake, cacao beans, and cashew kernels.

The raisin moth adult (fig. 13) is a small gray moth with a few obscure darker bands and spots on the forewings, which have a spread of 5/8 inch. The pupa is a typical moth chrysalis, brown in color and enclosed in a tough silken cocoon which is spun under bark or in the topsoil and, in storages, under boards and boxes or between folds of

Figure 13.—Raisin moth, female.

paper. Raisin moth larvae closely resemble those of the Indian-meal moth (fig. 14), but instead of being uniformly white the body is streaked with six rows of lavender dots. In length the full-grown larva measures about 5/8 inch.

Although the lives of the adults are brief in warm weather, averaging only 11 days for males and 16 days for females, their reproduction is prolific. An average of 351 eggs has been recorded, the maximum being 692 eggs.

At 83° F. eggs hatch in 3 to 6 days, larvae develop in about 32 days, the prepupal period is 1 day, pupae develop in about 9 days, and the egg-to-adult period is about 43 days. Winter is passed in the larval stage, generally as well-grown larvae. Pupation takes place in the spring. In the San Joaquin Valley adults begin to appear in April.

Barnes and Kaloostian (*10*) reported that flight of the raisin moths begins on warm nights about a half hour after sunset and continues until sunrise. Most of the aerial activity of the females, and their egg laying, are concentrated in the first few hours of darkness.

This insect is a member of the family Phycitidae, which includes the Indian-meal moth, the Mediterranean flour moth, and the navel orangeworm. Infestations of the raisin moth have been found in storages in many parts of the world. In California and Arizona, and probably in Egypt and Australia, it is chiefly a field insect that maintains itself out-of-doors throughout the year. When infested materials are moved from farms to storages, the larvae continue to develop and the adults emerge, but new reproduction in stored dried fruits is greatly restricted.

The raisin moth has been found in dates in the Coachella, Imperial, and Salt River Valleys, and in the Yuma, Ariz., region. Lindgren, Bliss, and Barnes (*42*) found that Deglet Noor dates examined in the experiments of 1947 contained $\frac{1}{20}$ as many fruits infested with the raisin moth and the Indian-meal moth combined, as with nitidulid beetles. The Medjhool variety was the most heavily attacked, and 8 percent of the fruits contained infestation by both moths.

Various measures have been developed for control of raisin moth infestations in the dried fruits produced in the San Joaquin Valley, but when dates become infested prompt fumigation probably is the best procedure. Experience with shade-cloth protection of dried peaches and other dried fruits gives assurance that date bunch covers closed with open-weave fabric would exclude most of the raisin moths.

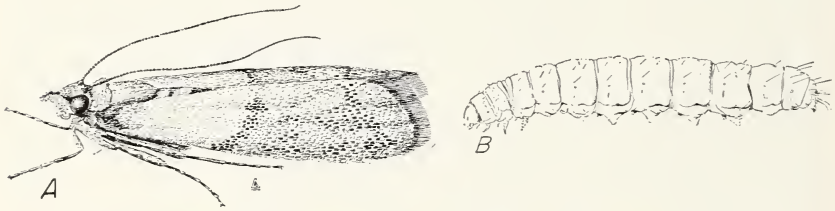

Figure 14.—Indian-meal moth: *A*, Adult; *B*, larva.

Delays in picking provide the best conditions for infestation of dates on the bunch by this species, and by the Indian-meal moth.

Morrill (*46*) reported that *Microbracon hebetor* (Say) often is seen attacking the larvae.

Indian-Meal Moth

The Indian-meal moth (*Plodia interpunctella* (Hbn.)) is worldwide in its distribution. Its larvae feed on many substances, including all kinds of dried fruits, nut meats, candy, grain, and milled cereal products. The adult (fig. 14, *A*) is an attractively marked moth of variable size, most specimens being about $\frac{3}{8}$ inch long. The outer half of the forewing is reddish brown with darker markings and the inner part is gray. There is a coppery band between the two contrasting areas.

During the day the adults remain quiet in dark places, but some may be seen resting on walls and ceilings of storage rooms. Barnes and Kaloostian (*10*) reported that their nocturnal flight habits resemble closely those of the raisin moth. Indian-meal moth adults feed only on liquids and do no damage to dates.

In the San Joaquin and Coachella Valleys the species is to some extent a field insect, but even in these warm regions it is primarily a pest in storage buildings. In this respect it differs from the raisin moth, which thrives in the field but does poorly in storage.

In an open insectary at Indio, Indian-meal moth adults of both sexes lived 2 to 5 days in the summer, up to 7 days in May and October, and as long as 10 days late in November. One to two days after emergence, deposition of the very small white eggs began. They adhered weakly to the outside of dates, singly or in groups, chiefly in depressions and along creases in the skin. The eggs produced by 7 females during the latter half of May averaged 170. There was much irregularity in the count of eggs deposited day by day.

During the summer the eggs hatched in 2 to 4 days, from September to the middle of October in 3 to 5 days, and late in October in about 7 days. Eggs deposited on November 23 hatched in 17 days; those laid November 30 hatched 22 days later; early in April the incubation period was 5 days.

Newly hatched larvae are dull white, but older individuals (figs. 14*B*, 15) often become yellow, sometimes pink, and less often assume a greenish tinge. When newly hatched, the larvae are $\frac{1}{25}$ inch long, becoming about $\frac{1}{2}$ inch when mature.

After leaving the egg shell, the larvae enter any break in the surface of a date, but if there are none they are able to gnaw through intact skin. The hole at the calyx end is most often the place of entrance. All types of ripe dates are attacked; also dates attached to the bunches, whether soft and just ripening or dry and well matured; dropped dates of all kinds, except those actually wet; and stored dates. General infestations of fruit on palms are uncommon, and the drier, more mature, dates in the bunches are preferred. The larvae also nibble on hard date seeds, which are frequently scarified and even shallowly bored into.

Threads of silk are spun by the caterpillars as they crawl about. In heavy infestations sheets of silk and webbed-up masses of excreta are produced. A common habit is to cover with a web the entrance hole at the calyx end of dates.

On reaching maturity the larvae usually leave the dates and pupate elsewhere, spinning cocoons between or beneath dates or in cracks or corners of boxes (fig. 15). The pupae are light brown at first, then turn darker. They are $\frac{3}{8}$ inch long.

In the insectary at Indio, the insect passed the winter in the larval stage and began to change to the pupal form in March. Throughout the winter larvae not yet mature fed to some extent and increased in size slowly. Those that hatched November 3 pupated early in March and emerged as adults the first week in April. Thus, the larval period was slightly longer than 4 months and the pupal period about 25 days. The life cycle was a little over 5 months. During the hot season, from the middle of May until the end of September, the life cycle ranged from 36 to 70 days and generations overlapped.

Hamlin, Reed, and Phillips (*39*) reported that, at Fresno, Calif., larvae of the Indian-meal moth reared on raisins required 21 to 74 days to reach maturity and that pupation required 4 to 9 days, in June, July, and August.

A small, yellow and black, wasplike parasite, *Microbracon hebetor* (Say), often is seen in large numbers attacking larvae of the Indian-meal moth. According to Morrill (*46*) the economic importance of this common external parasite as a control has not been determined.

Morrill's investigation of the life history of *Microbracon hebetor*, carried on at Fresno, resulted in the production of 14 generations in a year. As many as 358 eggs were laid by an individual, but the average was 90. From 1 to 11, usually 5, eggs were deposited beneath or beside larvae of the host that had been paralyzed by stinging. Small, white, silk cocoons were constructed by the parasite larvae near the remains of the host. In hot weather the eggs hatched in 1 day, the larvae fed for 4 days, pupation extended through 4 days, and the egg-to-adult period was 10 days. Females lived for about 33 days in the spring, and males for 10 days.

Figure 15.—Full-grown larvae of the Indian-meal moth in cocoons made between two date-drying trays.

Control of the Indian-meal moth in dates is chiefly a packing-house problem. Prompt fumigation of receipts is of course advisable. Inspection of a plant with a flashlight early in the evening will reveal flying adults if infestation in stored dates has become established. Search of the premises may turn up infested old-crop fruit that has been overlooked in routine cleaning operations.

Packaged dates are likely to become infested if exposed to egg-laying females, unless the packages are tightly sealed. Tests have shown that newly hatched larvae of the Indian-meal moth are able to reach food through a crevice only 0.12 millimeter (0.0047 inch) wide.

Saw-Toothed Grain Beetle

Larvae and adults of the saw-toothed grain beetle (*Oryzaephilus surinamensis* (L.)) feed on almost all kinds of stored-food products

of vegetable origin—cereals, copra, dried fruits, nut meats, and candy—and may also be found in tobacco, drugs, and dried meats. They prefer dry substances. Fresh and stored dates fairly high in water content are not ordinarily attacked, and even dates low in moisture seldom are molested until an appreciable storage period has elapsed.

The species is typically a packing-house insect. It is uncommon in recently harvested fruits delivered at the packing house. However, this grain beetle eventually infests dates under the palms whether they ripened dry and remained sweet or ripened in a moist condition, soured, and then dried out. Dates do not become too hard for attack by this insect in either the adult or the larval stage. Sometimes the adults have been found on decaying palm fiber and leaf bases.

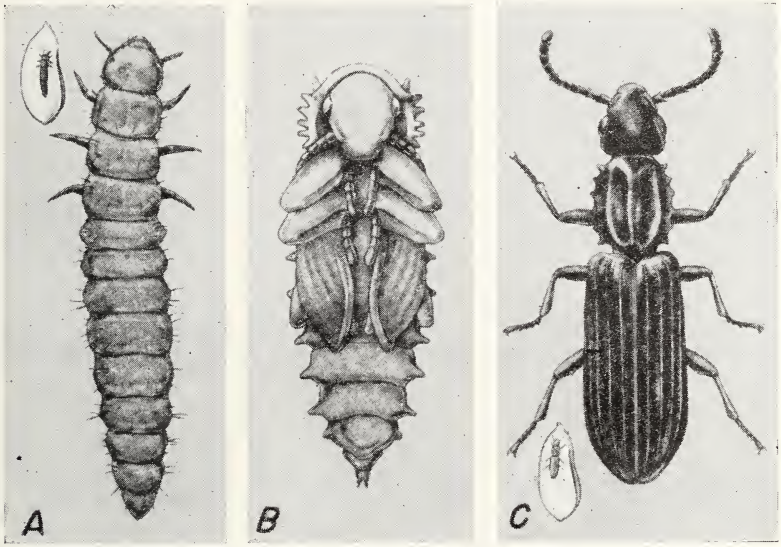

Figure 16.—Saw-toothed grain beetle: *A*, Larva; *B*, pupa; *C*, adult.

The adult (fig. 16, *C*) is less than $\frac{1}{8}$ inch long, chocolate brown, narrow, and much flattened, with six toothlike projections along each margin of the body in front of the wings. This beetle is a rapid crawler and, although it has well-developed wings, flight has never been observed. Like larvae of the Indian-meal moth, newly hatched larvae of the saw-toothed grain beetle can enter crevices that are exceedingly narrow. Even the crack around the cover of press-top tin cans of dates has been penetrated by them.

The eggs are elongate-oval, white, $\frac{1}{25}$ inch long, and have been seen scattered about within the cavity of dates. The larvae (fig. 16, *A*) are yellowish white and when full grown are slightly less than $\frac{1}{8}$ inch long. Pupae (fig. 16, *B*) are white or yellowish white and are found within dates infested by the adults and larvae of the insect. A cocoon or cell usually is made for protection of the pupa, the cell being made of fine particles of food cemented together by secretion from the mouth of the larva. Some pupae have no cocoon protection.

Back and Cotton (*3*) recorded that in their observations on the saw-toothed grain beetle the number of eggs laid per female ranged from 45 to 285. The lengths of the various periods in its life cycle were as follows: Preoviposition period, 5 to 207 days; egg period, 3 to 5 days in midsummer and 8 to 17 days in spring and fall; larval period, about 2 weeks in midsummer (the shortest was 12 days), and 4 to 7 weeks in the spring; pupal period, 6 to 9 days in midsummer and 19 to 21 days in midwinter. The life cycle from egg to egg ranged from 27 to 315 days.

Saw-toothed grain beetles are long-lived. Several specimens kept under observation by Back and Cotton lived for more than 2 years and one survived for over 3 years.

Both the adults and larvae remain active throughout the year in stored dates and in dropped dates out-of-doors. Accumulations of dates left undisturbed for any length of time are likely to become heavily infested. Feeding on dates results in roughened, tunneled, and contaminated fruit.

A common external parasite of the larvae and pupae of the saw-toothed grain beetle is *Cephalonomia tarsalis* (Ashm.). The yellowish silk cocoons of this minute, black wasplike insect frequently are seen where the hosts are plentiful. A life history study by Powell (*53*) revealed that fertilized females first paralyze the host by stinging and then deposit 2 eggs on the victim's body—a female egg and a male egg. Total egg production averages about 85, and hatching takes place within 24 hours. The larvae feed for 4 days, then spin a cocoon for pupation. Winter is passed in the pupal stage. The female parasites live for an average of 35 days, and the males live only 6 days. Powell concluded that the parasite does not accomplish an important degree of control of the beetle.

Merchant Grain Beetle

An insect similar in appearance to the saw-toothed grain beetle is the merchant grain beetle (*Oryzaephilus mercator* (Fauv.)), which also occurs in waste dates in the Coachella Valley. The relative abundance of the two species of grain beetles has not been investigated. These two small beetles are readily killed by fumigation.

MINOR PESTS INFESTING DATE PALMS

Apache Cicada

The Apache cicada (*Diceroprocta apache* (*Davis*)) is common in the desert regions of the Southwest. It is discussed by Quayle (*55*, p. 95) as a minor pest of date palms, and of grapefruit and other citrus trees. Observations made by the senior author on a cicada of similar habits in the Coachella Valley are given in the following paragraphs.[6]

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[6] The senior author discussed the cicada which he found in date gardens under another name, now considered to have been a mistaken identification. The specimens have been lost, but the weight of evidence is in favor of the conclusion that they were *Diceroprocta apache;* therefore the senior author's records are provisionally referred to what may be called the Apache cicada.

The female of this cicada injures fruit trees when she punctures the tender parts of the tree with her egg tube and lays her eggs in the puncture. On date palms the punctures are made on the midribs and pinnae of the leaves and, less commonly, on the fruit threads. The punctures occur in rows ranging from a fraction of an inch to 12 inches in length, but most rows are 2 to 6 inches long. There are about 7 egg punctures per inch, slanting into the tissue. A typical row, made by one female, was 4 inches long, consisted of 28 punctures, and contained 158 eggs. There were 4 to 8 eggs in each puncture. At this rate about 470 eggs would be found in a 12-inch row.

Only a few of the egg punctures on a palm are made on the pinnae. There the eggs are pushed entirely through, becoming exposed on the opposite side of the thin pinnae. On the midribs the punctures usually are made on the outer surfaces, more often toward the tip of the leaves. Egg punctures are most numerous on the older leaves, an indication that punctures are accumulated from year to year. On living fruit threads the punctures are made in any location, but generally are found between the dates and the base of the threads.

Although punctures made near the slender tips of the midribs sometimes cause the surrounding parts to die, injury to a leaf is always insignificant. Punctures on fruit threads, however, may obstruct the flow of sap, and the effects on the fruits may be harmful. Palms on the edge of the desert, near large mesquite thickets, are likely to have more puncture rows on their leaves than trees within cultivated areas.

The most severe attack observed on fruit threads occurred on 2 palms in the midst of a date-growing center. Of the 279 threads on these trees, 28 percent were punctured and 7 percent were damaged enough to affect the dates. During the same season 5 percent of 3,161 fruit threads on 24 trees taken at random in 6 well-separated gardens were punctured by the cicada, but the fruits on only 1 percent of the threads were affected. Damage varied from complete drying up of dates to slight reduction in size.

Immature stages of the insect inhabit the soil but do no damage to the roots of date palms. During 10 years many hundreds of offshoots and small palms were handled, but nymphs of the cicada seldom were found around the root bases.

DESCRIPTION

The eggs of the cicada are elongate, $\frac{1}{12}$ inch long by $\frac{1}{75}$ inch in diameter. They are smooth, shiny, milky in color, and translucent at both eids.

The nymphs are brown, thick-set, and have strongly developed front legs fitted for burrowing in the ground. The adults of both sexes are alike in shape, size, and coloration. The body is stout, broad across the anterior end, and ranges in length, including the folded-back wings, from $1\frac{3}{8}$ to $1\frac{5}{8}$ inches. The general color is brown, from light to dark brown on the back, with lighter shades of brown on the underparts and legs. There is a prominent light-brown band across the back at the base of the wings, which are transparent and have brown veins.

HABITS

The subterranean life of the cicada ends late in May or early in June, but sometimes adults appear as early as the middle of April. Pupae issue from the ground during the night. On hot nights they crawl upward at a rate of about 1 foot a minute and rest for 1 to 20 minutes before their skins begin to split. The pupae fasten themselves to the under side of slanting surfaces (which permit better suspension while the wings of the adult are expanding and hardening), though such objects as vertical, smooth walls may be chosen. Not more than 30 minutes are required for the adults to emerge and expand their wings. After clinging briefly to the molted skins, they crawl away, usually upward, for 50 to 80 minutes, during which time they move from less than ½ foot to 4 feet before flying off. Less than 3 hours is needed for them to issue from the ground, emerge as adults, and fly away.

The adults are present in greatest abundance during June and the first week in July. Most of them disappear during the latter half of July, although in some years occasional males may be heard singing in September.

According to Quayle (*55*), this cicada requires 2 years for its development, which takes place on the roots of citrus trees and other plants.

Owing to the habits of this insect and to the fact that its damage to dates is of minor importance, control measures have not been worked out.

Giant Palm Borer

The giant palm borer (*Dinapate wrightii* Horn) is a cylindrical, dark-brown or black beetle. It is a borer in California fan palms in the foothills around the Coachella Valley and in Lower California, according to Michelbacher and Ross (*45*). This species has been known to damage date palms in the Palm Springs area, but fortunately those in the commercial date gardens on the floor of the Valley have not been attacked. Tunnels as deep as 16 inches are sometimes made in the growing tip of palms.

Observers have concluded that larval development in palm trunks requires at least 2 years. Adults reach a length of 2¼ inches.

Because this is the largest of the 400 species that comprise the family Bostrichidae throughout the world, and because its geographical distribution is restricted, the insect collector who discovered the species, about 1886, kept the location of his find, Palm Canyon, a secret. For some years the beetle had the distinction of being a collectors' prize of considerable value.

Palm Rhinoceros Beetle

The palm rhinoceros beetle (*Strategus julianus* Burm.) has been found in Georgia, Mississippi, Louisiana, Texas, and Arizona. Outside of the United States it occurs in Mexico, Guatemala, British Honduras, Honduras, Costa Rica, Panama, and Colombia. In the United States it is most common in the coastal areas along the Gulf of Mexico.

The adults attack the coconut palm (*Cocos nucifera* L.), Canary Island palm, California fan palm, and two fiber plants, zapupe and maguey. The larvae are found in rotting logs and decaying vegetable matter beneath leaves. Their development extends over 3 or 4 years.

This rhinoceros beetle has damaged small date palms in the lower Rio Grande Valley, Texas. Cockerell (*25*) reported injury to roots of date palms in Arizona. The adults are stout, shiny black beetles, 1½ inches long by nearly ¾ inch wide. The males are readily distinguished from the females by the large horns on the head.

The adults enter the soil at the base of palms and bore into the tissue. Several may attack one small date palm. They work in the basal parts, largely beneath the surface of the soil, but may bore up into the trunk. In small palms the vital terminal bud is close to the basal parts, and because the beetles seem to prefer small palms the plants may be fatally injured.

From year to year an increasing proportion of small palms in a planting may be killed or badly damaged, but many are able to survive and reach a size and vigor that make them immune from serious harm.

In the lower Rio Grande Valley most of the injury to date palms occurs from April to July. Nurserymen there have reported that in some years half of their nursery palms (of all species) have been killed by the palm rhinoceros beetle. The remedy has been to flood the beetles out of their holes with water, pick them up in a bucket, and kill them with kerosene. S. W. Clark, at one time entomologist of the Texas Agricultural Experiment Station at Weslaco, found that flooding the beetles out of their holes with water every few days during their active season was the best control measure.

MINOR PESTS INFESTING DATES

Navel Orangeworm

Larvae of the navel orangeworm moth (*Myelois venipars* Dyar) were found in 1936 infesting dates on the ground and to a lesser extent on palms near Tempe, Ariz. In 1946 specimens were taken from both dropped and picked dates in the Indio district. This species, which has become a pest of walnuts in Southern California, is related to such damaging insects as the Indian-meal moth, the raisin moth, and the waxworm. Essig (*32*) stated that the navel orangeworm attacks navel and Valencia oranges and injured lemons in Arizona and occurs also on the west coast of Mexico. Armitage [7] listed the following hosts of the insect in California: Almond, jujube, loquat, orange, peach (mummified), prune, quince, and English walnut. In 1948 the navel orangeworm was found for the first time in the San Joaquin Valley, by the second author. The host was waste figs.

In 1922 Mote (*48*) presented a report on a new pest in Arizona, the navel orangeworm, at a convention of the Western Plant Quarantine Board in Sacramento, Calif. Life-history records made by F. H. Gates in 1921 were presented. The eggs are white when first laid, and

[7] Armitage, H. M. [Mimeographed memorandum.] Calif. State Dept. Agr. E–27. 1947.

later turn orange or red. Incubation, in October, required 4 days and larval growth, 30 to 50 days. Full-grown larvae are ½ to ¾ inch long, pale pink or deep pink. The larva pupates in the rind near the navel of the orange, the pupa being enclosed in a cocoon composed of excreta and borings mixed with strands of silk. The pupal stage lasts 8 to 13 days.

According to Essig (*32*) the moth has a wingspread of nearly ¾ inch and is "pale grayish marbled with brown and black."

The inner part of dates that have been fed upon by larvae of the navel orangeworm is littered with large pellets of excreta. Consequently, fouling of fruit by this insect is more noticeable than is that by larvae of the Indian-meal moth and the raisin moth.

Date Stone Beetle

One of the most interesting of the insects that attack dates is the date stone beetle (*Coccotrypes dactyliperda* (F.)). This minute dark-brown beetle is a close relative of the bark beetles (Scolytidae) that are so destructive to coniferous forests in this country. In addition to burrowing into date seeds, this beetle has been recorded by Lepesme (*41*) as a pest of sweet almonds in the Orient and of vegetable ivory in Africa.

Because of its fondness for vegetable ivory—the seeds of several species of palm from which buttons are made—it has been called the button beetle. Van Der Merwe (*67*) found that buttons attached to clothing were more subject to attack than were loose buttons. He reported that damage was most common in the warm, coastal climate of Durban, Natal, Union of South Africa.

According to information obtained by Van Der Merwe the white eggs, 1/30 inch long, are deposited in the burrow. The incubation period is completed in 5 days, pupal development in 5 to 7 days, and the life cycle in 28 to 30 days, in summer. In winter the time from the entrance of the female into the host material to the appearance of the first adult offspring may be 69 days. The white, footless larvae cannot develop if the mother is removed from them. Details of larval development are not known because, when a burrow is opened the female bores deeper, leaving the young to die.

Linsley (*43*), in his summary of information on the date stone beetle, lists Los Angeles and Indio, Calif., and Loreto, Lower California, as infested locations, and he adds betel nut, the seeds of several other palms, and nutmeg to the host materials previously mentioned. In the Coachella Valley the writers found the date stone beetle infesting fallen dates near Indio for the first time in 1932. Since only waste dates are attacked in that region, no blame for damage can be assigned to the date stone beetle.

European Grain Moth

The European grain moth (*Nemapogon granella* (L.)) was recorded infesting stored dates at Rivera, Los Angeles County, in 1932 by the Fresno, Calif., laboratory of the Bureau of Entomology and Plant Quarantine. Identification was made by H. H. Keifer. This instance is a rare type of date infestation.

This insect, also known as the wolf moth, has a wing spread of about ⅜ inch. The wings are light brown and the forewings are ornamented with irregular spots of darker brown.

Hairy Fungus Beetle

The hairy fungus beetle (*Typhaea stercorea* (L.)), a brown beetle of the family Mycetophagidae, or fungus eaters, is common in moldy dates lying on moist soil. It is elongate oval in outline and about 1/10 inch long. The polished surface of its body is well covered with short, fine hairs. This widely distributed insect feeds upon a variety of moldy vegetable materials. The authors have collected it on dropped dates in the Indio, Calexico, Yuma, and Phoenix districts.

In the course of a study of the flight habits of 12 species of dried-fruit insects, Barnes and Kaloostian (*10*) recorded the capture of some 39,000 hairy fungus beetles in a rotary net that was operated in a raisin storage yard. The beetles were taken most abundantly in May. Records of their daily flight habits showed them to be predominantly evening fliers. In warm weather, activity began at sunset and the beetles were on the wing until twilight ended, an hour or more later. None were taken in flight when the temperature was lower than 64° F.

Details of the life history of the hairy fungus beetle were worked out by George H. Kaloostian in 1938, when he was stationed at Fresno. His findings are published here for the first time.

Mold spores were the first food taken by newly hatched larvae. Those placed on clean raisins and walnuts were unable to develop, but larger larvae could do so. Reared on moldy raisins and walnuts in a moist plaster of paris chamber, the species developed from egg to adult in 21 days. The incubation period was 3 days, the larval stage 14 days, and the pupal period 4 days.

Mites in Stored Dates

Stored dates sometimes become infested with mites, usually after prolonged storage. The mushroom mite (*Tyrophagus lintneri* (Osborn)) is a pest of stored dates. This is a gray-white species, widely distributed in the United States.

Infestations by storage mites are sporadic and, generally, uncommon. For these reasons few investigators have worked extensively on their life histories and methods of controlling them. Shepard (*58*) summed up the storage mite situation as follows:

> Mites of various species occur in all cereal products, dried fruits, cheese, dried meats, and many other articles of food. They are common in neglected corners contaminated with moldy flour, sour milk, and the like.
>
> It may safely be said that there is no more difficult pest to combat. Its small size, rapidity of multiplication and development, and peculiar habits fit it for life in stored food products. Under certain conditions, some pass into a resting stage known as the "hypopus." In this condition they are covered with a hard crust which prevents them from drying out and allows them to live without food for months, during which time they may be blown about with dust or carried about on mice or flies. If at any time conditions are favorable, they will emerge from this peculiar stage and reproduce. All the mites may seem to have disappeared from a bin that was formerly infested, but as soon as new material is stored in it they reappear.

Infested dates should be destroyed and the area of the building infested with the mites should be treated with a contact spray of the flyspray type, care being taken to avoid danger of fire, inhalation of the spray, and contamination of foodstuffs.

Rusty Grain Beetle

The rusty grain beetle (*Laemophloeus ferrugineus* (Stephens)) is a slender, flattened, brown beetle, about 1/12 inch long. It is closely related to the saw-toothed grain beetle, with which it is found associated as a date pest, both in the field and in storage. In dates it usually is less abundant than the saw-toothed grain beetle. Both are cosmopolitan insects found in a variety of food materials.

Sheppard (*59*) has contributed details of the life cycle of the rusty grain beetle. At 83° F. the eggs hatched in about 5 days and the larvae developed, through four molts, in 32 to 37 days. Pupation lasted 5 days. The egg-to-adult period ranged from 28 to 53 days, being influenced by the food provided. Larvae fed insect eggs, including those of their own species, showed the most rapid larval development. High humidity was essential.

Vinegar Flies

Small yellow or brownish flies of the genus *Drosophila* are abundant in many kinds of fermenting vegetable materials, including sour dates. They are known also as pomace flies, from their fondness for apple and grape pomace, and as vinegar gnats. No survey to determine the species that breed in dates has been made.

The larvae, or maggots, of vinegar flies may be mistaken for the larvae of nitidulid beetles, which they resemble in color and size. Unlike the beetle larvae, however, the fly larvae have neither legs nor eyes and are pointed at the head end, which is provided with a pair of dark-colored mouth hooks.

Although vinegar flies ordinarily infest only fermenting fruits, if the adults become very abundant they lay eggs on fruits in which yeast cells have not begun to multiply. They become more numerous toward the end of summer, after the hottest days have passed.

Information on the life history of a common species of vinegar fly, *Drosophila melanogaster* Meigen, has been assembled by Ditman, Cory, and Buddington (*28*). The white eggs, too small to be seen by unaided eyes, usually are inserted into soft host tissue and hatch, as a rule, within 24 hours. Temperature conditions most favorable for egg production are lower than those for most insects. Egg laying may begin before the females are 48 hours old, and some individuals lay more than 2,000 eggs.

At 67° to 77° F., egg production averaged 26 a day, the lifetime average was 941 eggs, and the average length of life of the females was 39 days. At 65°, female flies lived an average of 71 days, whereas the males survived for 43 days.

Good housekeeping around fruit-processing plants is one of the practices required to reduce vinegar fly populations. Ditman, Cory, and Buddington (*28*) advised that household sprays should not be employed for frequent use in a plant, because they contain oil that will

impart an undesirable odor to fruit. They recommended a spray containing alcoholic extract of pyrethrum, 1 part to 200 parts of water, with soap added.

Western Leaf-Footed Bug

The western leaf-footed bug (*Leptoglossus zonatus* (Dallas)) is a sucking bug ¾ inch long with threadlike antennae extending an additional ½ inch beyond the head. The insect is dull chocolate brown, with a zigzag yellow band across the folded forewings and two yellow patches just behind the head. A portion of the lower half of the hind legs is expanded into a wide, thin structure that resembles a small leaf, from which the species gets its common name.

Essig (*32*) recorded that in Arizona the western leaf-footed bug prefers pomegranates, but also feeds on green oranges and green and ripe peaches. In Lower California dates, limes, and watermelons make up part of its food list.

Quayle (*55*) stated that the bug breeds chiefly on pomegranates, the eggs being deposited in rows on the twigs. First-stage nymphs are red and black. In the Imperial Valley control has been attained by confining turkeys to eat the bugs as they are jarred from the trees early in the morning.

Injury to dates in the Phoenix area of Arizona has been reported in correspondence. Cracked pomegranates in a hedge near one of the date gardens were heavily infested in May 1940. Two fruits contained 4 adults, 26 large nymphs, and 72 small nymphs.

According to Caffrey (*23*), the nymphs of the western leaf-footed bug may be controlled by spraying them with 40-percent nicotine sulfate, 1 part to 500 parts of water, with enough soap added to give the mixture a foamy appearance.

CONTROL OF INSECTS ON DATES IN STORAGE

Fumigation

The chemical now in general use for fumigating dates is methyl bromide, a liquid boiling at 40.1° F., producing a gas that is about 3.3 times as heavy as air. An understanding of the properties of methyl bromide, of the equipment needed for its effective application, and of the precautions that must be taken at all times to insure the safe use of this effective insect killer is so important for those in charge of the fumigation of dates that the following recommendations are quoted from literature.

Walker and Mitchell (*68*) included the following recommendations:

> Fumigation of all fruit as it enters the packing house arrests infestations that commonly occur in the gardens, and helps to prevent a high insect population within the house. . . . Houses of moderate size and tight construction may periodically be given a complete fumigation at small cost and with very beneficial results. Complete plant fumigation is harder to achieve in the larger house, but here the separate rooms used for maturation, drying, or fruit storage at room temperature should be fumigated at frequent intervals. Cull dates should not be stored in rooms where good fruit is handled.
>
> It is virtually impossible to maintain a packing house entirely free of insects, so the opportunity for reinfestation of fruit is ever present. A thorough fumigation after the fruit has been packed for shipment is good insurance against deterioration while it is on its way to the consumer.

Armitage and Steinweden (*2*) stated that a dosage rate of 1 pound of methyl bromide per 1,000 cubic feet should be used, with an exposure of 24 hours. Temperatures should be above 60° F. Fumigation should be followed by adequate airing, and the dates should be protected from reinfestation. They recommended that the fumigation chamber should be—

1. Located to conform with requirements of the State Industrial Accident Commission. Under no circumstances should the fumigation chamber be located within a closed room. The gas should not be used where confined workers will be exposed to residual methyl bromide vapors.
2. Constructed in the proper manner which permits a minimum of leakage. A slatted floor is advisable to facilitate circulation.
3. Equipped with proper accessories for measuring the fumigant and allowing it to be applied from outside the chamber into a shallow pan located at the top of the chamber.
4. Equipped with proper fans to circulate the fumigant and to assist in its removal at the end of the cycle.
5. Equipped with nonglow heaters to permit temperature control if fumigation is attempted when the atmospheric temperature is below 60° F.
6. Insulated to avoid temperature fluctuation.
7. Equipped with a thermometer which can be read from outside the chamber.

Caution.—The following precautions should be taken (Dean and Cotton *27*):

> All persons using methyl bromide as a fumigant and all persons engaged in unloading or removing fumigated materials from cars, sheds, or rooms in which commodities have been fumigated should be warned of the toxic properties of methyl bromide. The dangers from inhaling the gas and the absence of odor should be stressed. Although methyl bromide is less toxic to man than certain other fumigants, all persons fumigating with methyl bromide or mixtures containing methyl bromide, or persons entering fumigated rooms, cars, or sheds to open ventilators or to unload fumigated materials, should observe the same precautions as with other fumigating gases. The following precautionary measures are recommended in the use of methyl bromide as a fumigant:
>
> 1. Avoid breathing air containing methyl bromide by wearing a gas mask at all times when handling it outside of the original container.
> 2. Provide in advance for thorough ventilation of cars, rooms, or buildings after fumigation and before anyone enters them.
> 3. When necessary to enter spaces containing methyl bromide, use a gas mask provided with a canister giving protection against organic vapors, or a positive pressure-hose mask. (Masks and canisters to be approved under U. S. Bureau of Mines Schedules 14D or 19A. Canisters to be black, type B. Workers should be provided with these approved masks for use when necessary in handling this fumigant or commodities that have been fumigated with it. All mask canisters have a limited life period. For this reason special precautions should always be taken to see that masks are fitted with fresh or fully effective canisters.)
> 4. Avoid spilling methyl bromide. Go into the fresh air immediately in case of spillage. Remove any clothing which has become impregnated with the liquid.
> 5. Post signs warning that methyl bromide is being used and that the gas is poisonous.
> 6. Store containers of methyl bromide in a cool, well-ventilated place, well removed from any buildings in which people work or live. Avoid leakage by seeing that valves on cylinders are tightly closed.

Where walk-in fumigation rooms are not available, small fumigation units may be successfully used. Barger (*9*) described such inexpensive equipment, and suggested that a liquid fumigant consisting of three parts of ethylene dichloride and one part of carbon tetrachloride be applied as a fumigant. These chemicals can be obtained in small quantities.

Low Temperatures

The differences in date varieties and the normal wide range in the physical and chemical condition of harvested fruits within the varieties combine to make uncertain the use of extremes of temperature for killing insects in dates. With reference to cold, Albert and Hilgeman (*1*) pointed out the probability that "different types of dates can not be stored to best advantage under the same temperature and humidity conditions."

Powers (*54*) recommended that soft dates be kept in cold storage at 32° F. or lower.

Insect species that infest stored dates vary considerably in their resistance to low temperatures, but infestation already present cannot develop, nor can new infestation take place, at 40° F. or below. Research carried on at Fresno has provided some basic data on the killing effect of several temperatures on a number of dried-fruit insects.[8] In part, the results are given in table 5.

Table 5.—*Effect of cold storage on certain dried-fruit insects*

Species and stage	Temperature	Duration	Mortality
	° *F.*	*Days*	
Raisin moth larvae	30–34	100	Incomplete.
	32	188	Total.
	36–37	115	Incomplete.
	40	188	Do.
Indian-meal moth larvae	0	1/12	Total.
	30–34	28	Do.
	36–37	50	Do.
Saw-toothed grain beetle larvae	32	10	Incomplete.
	32	15	Total.
	36	20	Do.
Dried-fruit beetle larvae	4–6	1/3	Do.
	7–12	1	Do.
	32	7	Do.
Saw-toothed grain beetle adults	0	1/24	Do.
	30–34	27	Do.
	36–37	38	Do.
Indian-meal moth adults	32	3	Do.
Indian-meal moth eggs	7–10	1	Do.
	32–33	11	Do.
Raisin moth eggs	32	5	Incomplete.

The records given in table 5 show that some insects may survive for considerable periods at freezing temperature. Unless a temperature considerably below 32° F. is used for a part of the storage period, dates taken from a freezing temperature may need to be fumigated upon removal.

[8] From records obtained by Charles K. Fisher, Bureau of Entomology and Plant Quarantine, at Fresno, Calif.

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