Insects on Dried Fruits
Introduction to the Acrobat pdf edition

This Acrobat pdf of the 1975 U.S. Department of Agriculture, Agricultural Research Service publication “Insects on Dried Fruits” (Agriculture Handbook 464) is not an exact replica of the original and is somewhat dated. But it is still useful and in demand, so we are making it available with caveats.

The pdf was produced by Judy Johnson, a research entomologist with the ARS Commodity Protection and Quality Unit at Parlier, California, the lineal descendant of the Fresno, California, laboratory that created the original handbook. Dr. Johnson scanned the printed publication, converted the scanned images to raw text, proofread it, and reformatted it to match the formatting in the original. She scanned most of the photographs from original transparencies or, where these weren't available, from the printed publication. They have been kept small to keep the file size manageable, so they're adequate for screen viewing but not for printed reproduction.

The ARS editorial staff proofread the pdf and made a few typographical corrections. Some corrections affected line length on the right-justified copy. Because matching the original fonts exactly wasn't possible, the pdf has some line breaks that vary from those in the printed version, but page breaks are identical. For reasons now lost, pl. I, D (p. 23) is black and white in the original, though a color transparency exists, and this has been used for the pdf.

Dr. Johnson points out that while "most of the information is correct and useful," there are have been "changes in scientific names and some minor details of the biologies." She has listed those below.

Also, most importantly, she writes, "While the intent of the handbook was not issues of insect control, most of the references cited mention a control method that has essentially been banned (the use of malathion-treated raisin trays)."

We recommend citing this publication as follows (adjusted for your particular citation style]: Simmons, Perez, and Howard D. Nelson. 1975. Insects on Dried Fruits. U.S. Department of Agriculture, Agricultural Research Service, Agriculture Handbook 464. [Recreated and published as an Acrobat pdf in 2005, with an added list of updates and corrections, by Judy Johnson.]

2005 Corrections and Updates to Insects on Dried Fruits

Page 3: *Oryzaephilus* is now considered to be in the beetle family Silvanidae.

Page 8: *Cryptolestes* is now considered to be in the beetle family Laemophloeidae.

Page 13: *Vitula edmandsae serratilineella* is now considered to be *Vitula serratilineella.*

Page 13: *Paramyelois transitella* is now considered to be *Amyelois transitella.*

Page 16: *Bracon hebetor* is now considered to be *Habrobracon hebetor*

Page 17: *Devorgilla canescens* is now considered to be *Venturia canescens*, and is also known to attack other stored product pyralid moths besides raisin moth.

Page 18: *Mestostenus gracilis* has been shown to be an external parasite of several species of stored product pyralid moths, attacking prepupae and pupae within their cocoons.

INSECTS ON DRIED FRUITS

Agriculture Handbook 464

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

ACKNOWLEDGMENTS

This handbook summarizes the more important facts about dried fruit insects that have been accumulated through the efforts of research entomologists and their assistants stationed at the Fresno, Calif., entomological laboratory of the U.S. Department of Agriculture over a period of about 45 years. This laboratory is now the Stored-Product Insects Research Laboratory, Agricultural Research Service, USDA.

Others who have worked at the Fresno laboratory and made outstanding contributions include John. C. Hamlin, W. Doyle Reed, Austin W. Morrill, Jr., Heber C. Donohoe, George H. Kaloostian, Oscar G. Bacon, Charles K. Fisher, Dwight F. Barnes, Garth H. Spitler, and Albert P. Yerington. Valuable cooperation was freely contributed by Eugene M. Stafford, David L. Lindgren, and Ira J. Condit of the University of California; Dwight K. Grady, A. E. Thorpe, Charles D. Fisher, George W. Reilly, and other representatives of the Dried Fruit Association of California; Robert M. Warner and others of the California Fig Institute, and many packers and growers. The assistance of George T. Okumura, systematic entomologist, Chief of Laboratory Services, Department of Agriculture, State of California, in reviewing the manuscript of this bulletin is gratefully acknowledged.

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INSECTS ON DRIED FRUITS

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INTRODUCTION

[Note: Illustrations of insects appear in back of publication]

Successful production of dried fruit requires soils suitable for fruit growing, abundant water for irrigation, and hot rainless summers for sun-drying the fruits. In the United States, most dried fruit is produced in California, chiefly in the San Joaquin and Sacramento Valleys. Fruit is also produced and dried in many of the smaller California valleys. Only in southeastern California and in Arizona does hot weather last long enough to mature dates. Prunes and apricots are produced in various localities including the Santa Clara Valley.

In addition to the long-established method of preserving fruits by drying them in the sun, dehydration is widely practiced where ocean fogs or summer thundershowers are common. This method is used extensively for prunes. A relatively small part of the raisin crop is dried in dehydrators, which produce golden bleached raisins. Both farm-size equipment and large commercial dehydrators are common in the Santa Clara Valley and in the Sacramento Valley. The high temperatures used in this method of removing water are fatal to insects in the fruit.

In the United States, between 1965 and 1969, the average yearly production of dried fruits was 416,930 tons. Raisins, with 249,740 tons, and prunes, with 107,360 tons, accounted for most of this. Other dried fruits produced were: Dates, 20,650 tons; figs, 16,680 tons; apples, 13,150 tons; apricots, 5,230 tons; peaches, 3,580 tons; and pears, 530 tons.

Wherever dried fruits are produced, whether in the Mediterranean Basin, South Africa, southern Australia, or California, their chief insect pests are the same species. They have been distributed by commerce, probably for several thousand years. Losses caused by insects in dried fruits are difficult to estimate. The loss of weight from insect

[1] Retired

feeding is usually trivial. The most serious loss is in appearance and quality, which lowers or destroys market value. Also, the presence of insects or any other foreign material in dried fruit is objectionable to consumers. The Food and Drug Administration and the State Departments of Public Health insist that dried fruits be prepared in a sanitary manner, and regulations are strictly enforced.

Other losses from insects in dried fruit include the cost of construction and maintenance of facilities for fumigation, the cost of fumigants, and the expense of applying them. Insects are chiefly responsible for the waste involved in culling out damaged dried fruit, and the costs of screening and washing of fruit, general plant sanitation, and cold storage. Special packages designed to resist and exclude insects add to the expense.

The scope of this handbook is limited to the biology of the species involved and some of their relationships to their environment. A knowledge of the species and habits of the insects that damage dried fruits gives a basis for planning control programs. Control measures are not described in this handbook because they are dealt with in other U.S. Department of Agriculture publications. (See Literature Cited section, p. 22.)

BEETLES

The beetles associated with dried fruits develop through four stages—egg, larva, pupa, and adult. The rate of development, length of adult life, and number of eggs laid vary among the different species. Rate of development and available food supply control the number of generations per year. Other factors such as extreme summer heat, winter cold, and natural enemies, limit insect abundance.

Most of the eggs hatch within 5 days. The eggshells are thin, and embryos either hatch within 2 or 3 weeks or die. Larval life proceeds through a varying number of molts and abrupt size changes. Feeding is continuous except when the temperature falls below about 45° F. Overwintering larvae can feed occasionally on warm days.

Beetle pupae develop in cracks in boxes, creases in dried fruits, under bark, or in cells in the soil or ground litter. During the pupal stage, the body structure is completely rearranged, and the resulting adult bears no resemblance to the larva from which it developed. This transformation may take only a week or so or may be prolonged several months by cold weather.

As a rule, adult beetles are active feeders. Because some of them live

longer in the adult stage than as a larva, they damage dried fruits even more than their larvae do. All of the principal species, except possibly the sawtoothed grain beetle, can fly. They infest commodities by flying or crawling into storage buildings or by being carried in with dried fruits.

Sawtoothed Grain Beetle

Oryzaephilus surinamensis (Linnaeus)

The adult sawtoothed grain beetle, family Cucujidae (pl. I, *A* and *D*), is less than one-eighth of an inch long, narrow, and flattened. It is chocolate brown and has six toothlike projections along each side of the margin of the body in front of the wings.

In raisins stored for a year or more, this insect can become very abundant. It is most numerous in spring; its numbers decline markedly during the hottest months. It is a general feeder. Both larvae and adults attack grain, cereal products, nuts, copra, dried fruits, botanical drugs, tobacco, candy, dried meats, and other commodities, even unrefined sugar. Fairly dry foods are preferred. Under certain conditions, the larvae are cannibalistic. Where sawtoothed grain beetles are numerous, populations of the Indian meal moth do not build up to high levels.

The white eggs of the sawtoothed grain beetle (pl. I, *B*) are elongate-oval and one twenty-fifth of an inch long. Hatching takes 3 to 5 days in midsummer and 8 to 17 days in spring and fall. The larvae (pl. I, *C*) are yellowish white, and when full grown are about one-eighth of an inch long. In summer, they develop in about 2 weeks, but in spring they feed and grow for 4 to 7 weeks, during which period they molt two to four times. The pupal period requires 6 to 9 days in summer. Pupae (p1. I, *C*) are white or yellowish white and are found in or near the larval food. They usually make a cocoon for protection, but a few do not. The cocoon consists of fine particles of food cemented together by a secretion from the mouth of the larva before it begins to transform.

The time from egg to adult ranges from 27 to 315 days. After the beetles emerge, they begin to lay eggs in about 5 days. From 6 to 10 eggs are laid each day, until they total from about 45 to 285. Sawtoothed grain beetles are long lived. Individuals have been recorded as having lived for more than 3 years. Optimum temperatures are between 86° and 95° F. In the Coachella Valley of California, adults and larvae remain active out of doors throughout the year in dropped dates.

This beetle crawls rapidly, even up most vertical surfaces, but it has not been observed to fly. Newly hatched larvae can enter very narrow crevices in search of food. Even the crack around the cover of press-top tin cans of dates has been penetrated by them.

Merchant Grain Beetle

Oryzaephilus mercator (Fauvel)

The merchant grain beetle (pl. I, *A* and *D*) is similar in appearance, life history, and habits to the sawtoothed grain beetle, but it is less common in dried fruits. It is capable of flight. During recent years, its populations have been increasing. It has been found in waste dates, on the ground in the Coachella Valley date gardens, and in cull figs in the Fresno district. It does not endure low temperatures as well as the sawtoothed grain beetle nor do the females lay as many eggs.

Although this species and *O. surinamensis* are remarkably alike in appearance, they do not interbreed and therefore are distinct species. Under magnification, they can be distinguished by a difference in the outline of the head, as shown on plate I, *D*.

Small Darkling Beetles

Blapstinus Species

Several species of small darkling beetles (pl. IV, *F*) are found in fig orchards. The commonest is *Blapstinus rufipes* Casey, a dull-black, somewhat flattened beetle about a quarter of an inch long. These beetles congregate on ripe figs that have fallen to the ground. They may be so numerous as to completely cover a fig.

Only fragments of their life history have been recorded. Adults appear in June at about the time the first crop of figs ripen and fall to the ground. The larvae probably develop on plant materials in the soil. As the season advances, small darkling beetles gradually disappear.

These beetles attack tender plants. Young bell pepper plants have been girdled at the soil surface, and as many as 75 adult beetles have been counted around a single seedling. Several species, including *B. rufipes*, have been observed attacking young plants of sugar beet, lima bean, and tomato.

Hairy Fungus Beetle

Typhaea stercorea (Linnaeus)

This is a polished, brown, elongate-oval beetle about one-tenth of an inch long (pl. I, *F*). The body is well covered with short, fine hairs. It is a member of the family Mycetophagidae, or fungus eaters. It is common in moldy dates lying on moist soil and in moldy raisins. Other foods eaten by this species include stored grain and seeds, tobacco,

and cacao. Adults fly in the evening for a short time after sunset, seldom at other times of the night or day.

On moist moldy raisins, this beetle develops from egg to adult in 21 days. It spends 3 days in the egg, 14 days as a larva, and 4 days as a pupa. Newly hatched larvae are unable to develop on clean raisins, but larger larvae can.

Driedfruit Beetle

Carpophilus hemipterus (Linnaeus)

Adult driedfruit beetles (pI. II, A) are about one-eighth of an inch long and black, with two amber-brown spots on each wing cover, one near the tip and a smaller one at the outer margin of the base. They are strong fliers, but fly only during the daytime when the temperature is above 63° F. Flight usually is at a maximum at about 11:30 am. They may travel as far as 4½ miles one way in a day.

These beetles of the family Nitidulidae are among the chief pests of ripening and drying figs. Adults and larvae may be found during the winter and at other times in fruit dumps, rotting melons, stick-tight pomegranates, dropped peaches, plums, citrus fruits, cull figs, and moist raisins. They do not attack sound fruit, but prefer overripe, fermenting, and rotten fruit. This species thrives in fermenting grape pomace, a winery byproduct. When raisins are being made, damaged grapes, especially those with bunch rot, attract these beetles to the drying trays. Fruit that is very dry or far advanced in decay ceases to attract them. However, larvae that begin growth in overripe figs, for example, may continue their development after the fruit is fairly dry. Much waste fruit falls to the ground under fruit trees and often squashes and cracks open. In date gardens, where frequent irrigation keeps the soil surface moist, driedfruit beetles find ideal breeding conditions in fallen waste dates.

Adults feed and larvae develop in a moist, dark environment of yeasty and often moldy pulp. These beetles carry yeasts and mold spores in and on their bodies and inoculate ripening figs with plant diseases. In addition, they carry peach brown rot and bunch rot of grapes. Adults also visit the sap flow of bark wounds in trees that produce a flow of sweet, and consequently fermentable, sap.

Larvae (pl. II, *A*) reach a length of a quarter of an inch when fully grown. They are white or yellowish; the head and the rear end of the body are amber-brown. They are sparsely hairy, and have two promi-

nent spinelike projections at the tail end, with two smaller ones in front of them.

Pupae (pl. II, *A*) are about one-eighth inch long, white or pale yellow, and somewhat spiny. No cocoon is formed. The species usually survives the winter as pupae in cells in the upper few inches of soil near the food in which development took place. Larvae and pupae of nitidulids have been found as deep as 2 feet in dry soil in a fig orchard, but most of them are in the upper 8 inches and directly under the individual trees. Hundreds of full-grown larvae, pupae, and recently transformed adults may be present under each tree in early spring. New adults emerge late in February and early in March. By late April, all have left the soil. A combination of light rainfall and a mild winter favors above-average survival of driedfruit beetles, but a cold, wet hibernation period reduces the population. On warm days in winter, a few adults have been captured in rotary net flight traps.

This species has a short developmental period and a long adult life. At 90° F the incubation period is 1 day, the larval period is 12.4 days, and the pupal period 5.8 days. The total from egg to adult is l9.2 days, but may be as short as 12 days. Mated females may average 103 days of life and males 146 days. A few live for a year. About 3 days after adults emerge, the females begin to lay white eggs, which are scattered over the food. Total egg production may average more than 1,000. The record for one female is 2,134 eggs, laid over a period of 79 days.

Corn Sap Beetle

Carpophilus dimidiatus (Fabricius)

The adults of this species (pl. II, *B*) resemble driedfruit beetles, but they have no spots, and their color ranges from brownish-yellow through brown to black tinged with red. Their size varies according to favorable or less favorable food and other conditions. They are $^1/_{16}$ to $^1/_8$ inch long and average smaller than the driedfruit beetle. They may be seen flying at any time of the day, but most of their flying is done after 2 pm.

Their food habits are much the same as those of the driedfruit beetle. They are very common in cull grapefruit and in cull dates. Corn sap beetles are particularly fond of developing ears of sweet corn that have been damaged by insects or birds. Among their host foods are apple pomace, rotten watermelons, stored peanuts with split hulls, inferior copra, sago flour, coarse bran, and brazil nuts.

The time required for development from egg to adult, at 90° F, is

about 15 days. In summer, the adults live about 60 days, but, over the winter, some live 200 days. Total egg production is 175 to 225.

Yellow Nitidulid

Haptoncus luteolus (Erichson)

These beetles (p1. II, *C*), about three thirty-seconds of an inch long, are shorter than the driedfruit beetle or the corn sap beetle. They have a blunt shape and are yellowishbrown. Their food is the same as that of the driedfruit beetle and the corn sap beetle. Unlike the corn sap beetle, they fly very little during the middle of the day but are numerous in the air early in the morning and late in the afternoon. Large numbers have been trapped in the San Joaquin and Coachella Valleys.

Development time from egg to adult can vary from 9.6 days at a temperature of 90° F to 25.4 days at 70°. The incubation period averages 1.6 days; the larval period, 12.6 days; and the pupal period, 2.4 days.

Pineapple Beetle

Urophorus humeralis (Fabricius)

Pineapple beetles are larger than most other nitidulids. The adults are shiny black beetles nearly three-sixteenths of an inch long (p1. II, *D*). They are daytime flyers and are more numerous in date gardens than in the fig orchards and other plantings farther north. Pineapple beetles feed in bunches of dates ripening on the palms. They are the dominant species in Hawaiian pineapple fields, where they feed on fermenting trash left from harvesting. In sugarcane fields, they develop in souring cane trash and damage seed pieces of cane underground. In the Coachella Valley, they are abundant in waste grapefruit.

At 90° F, this species can complete development from egg to adult in 16.5 days. Females lay an average of about 880 eggs, but may lay more than 1,000. Adults reared on pieces of pineapple stump lived from 23 to 113 days, averaging 89 days.

Leadcable Borer

Scobicia declivis (LeConte)

Leadcable borers (pl. II, *F*) are cylindrical, dark-brown or black beetles, 1/8 to 1/4 inch long. They develop in dead parts of trees. In central California, they are on the wing between 6 and 8 pm beginning in March, and some may be found until late in July.

These beetles only rarely enter figs. They sometimes bore holes in the laminated paper covers used to enclose raisin stacks for fumigation. They cause losses in wineries by boring into wine barrels and casks. In the past, the adults have caused considerable trouble by boring holes in the lead sheaths of telephone cables, thereby allowing rain to enter and cause shortcircuits. Leadcable borers are attracted to the products of fermentation, including ethyl alcohol, that occur in wine, brandy, and fermenting dried fruits. Baits made of ethyl alcohol and water attract them.

Date-Stone Beetle

Coccotrypes dactyliperda (Fabricius)

The date-stone beetle (pl. II, *E*) is minute, cylindrical, shiny, and dark brown. It is a close relative of the bark beetles, family Scolytidae and is common in seeds of waste dates in the Coachella Valley. They also infest sweet almonds in the Orient and the hard seeds, known as vegetable ivory, produced by several species of palm in Africa. Buttons made from vegetable ivory are also attacked, hence another common name, button beetle. Other hosts are betel nut, nutmeg, and cinnamon bark.

Miscellaneous Beetles

The rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) (pl. I, *E*), of the family Cucujidae, is rather common in stored raisins. It prefers raisins that have been damaged by rain and have become moldy. It infests dates both in the field and in storage. The adults do most of their flying between 6 and 9 pm.

Cryptophagus laticollis Lucas, a member of the family Cryptophagidae, is found in raisins in storage. This beetle does most of its flying just after sunset, but it also shows a period of activity in the early morning twilight.

Two spider beetles of the family Ptinidae, *Trigonogenius globulus* Solier and *Ptinus gandolphei* Pic, infest raisins, as does a member of the family Lathridiidae, *Lathridius protensicollis* Mannerheim.

A considerable number of darkling ground beetles (pl. IV, *F*) (Tenebrionidae) are found in raisins. Two examples are *Blapstinus dilatatus* LeConte and *Blapstinus sulcatus* LeConte. *Apsena rufipes* (Escherich) is at times very numerous on both raisins and fallen figs. Large numbers of another darkling beetle, *Blapstinus rufipes* Casey, have been observed flying out-of-doors during the day on several occasions. *Cnemeplatia*

sericea Horn, a small tenebrionid beetle, also feeds on raisins and fallen figs. Its flight habits are controlled very strictly by light—it is on the wing for only 30 to 45 minutes in the evening when the light is dim.

The confused flour beetle, *Tribolium confusum* Jacquelin duVal, and the red flour beetle, *Tribolium castaneum* (Herbst), are sometimes found in dried fruits. They are able to develop to maturity on stored raisins but for the most part probably fill the role of scavengers. The red flour beetle is seldom seen flying except for a short period in the evening, between about 6 to 7 pm.

Several beetles of the family Dermestidae that are found in dried fruits are *Trogoderma variabile* (Ballion), *T. simplex* Jayne, *T. sternale* Jayne, and the black larder beetle, *Dermestes ater* DeGeer. These beetles fly during the day, but not at night.

During one harvest, a beetle of the family Curculionidae, *Dinocleus capillosus* Csiki, was abundant in vineyards and later in the boxed raisins. The insects were about the same size and weight as Thompson Seedless raisins. Raisin-cleaning machinery did not remove them; expensive hand-sorting was necessary.

Species of beetles uncommonly found in figs include the foreign grain beetle, *Ahasverus advena* (Waltl), and the fruit notoxus, *Notoxus calcaratus* Horn. The foreign grain beetle does most of its flying just after sunset. In dates, several other species of *Carpophilus* occur sparsely, including *C. obsoletus* Erichson and *C. decipiens* Horn. Other species taken during dried-fruit insect research include *C. discoideus* Lecanto, *C. marginalia* Motschulsky, and the dusky sap beetle, *C. lugubris* Murray.

A few species of beetles that are found in dried fruit do not feed on the fruit, but on other insects that may be present. *Plochionus pallens* (Fabricius), a member of the predaceous beetle family Carabidae, is found in raisin storages. It flies mostly after sunset, occasionally during the night, and for another brief period during the dim light very early in the morning. A species of dermestid beetle, *Trogoderma inclusum* LeConte, has been found in the United States in raisins that contain remains of dead insects. It is unlikely that it feeds on dried fruits.

MOTHS

The moths that damage dried fruits develop through a cycle of egg, larva, pupa, and adult. As in beetles, the time in each stage varies among species and with temperature and food supply. Some moths show marked fluctuations in population caused by parasitism, but parasites are believed to influence stored-product insects less than they do

species that develop in more accessible locations. A bacterium, *Bacillus thuringiensis* Berliner, kills many moth larvae.

Most moth eggs hatch within 5 days. The larvae molt a variable number of times as they grow. Feeding is continuous in warm weather, except that the growth of some moth larvae is interrupted, for reasons not well understood, by a hibernation period called diapause. Larger larvae ordinarily survive long periods of low temperature better than pupae, because they can feed on warm days.

Moth larvae spin silk during feeding and growth. The pupae usually are encased in light webbing or a more protective tough silken cocoon. Pupae are formed in cracks in boxes, creases in dried fruits, under bark, or in cells in the soil or ground litter. During the pupal stage, the body structure changes to that of an adult moth. The time needed for this transformation varies from a week or so in warm weather to several months in cold weather.

None of the adult moths can feed, although they do drink liquids, such as plant nectar. The damage is done while they are larvae.

Raisin Moth

Cadra figulilella (Gregson)

These are small gray moths (p1. III, *A*) formerly known as *Ephestia figulilella*. The larva and pupa are shown in plate III, *A*. Larvae were first noticed in the Fresno area in 1928 on muscat raisins. They reached a peak of abundance in 1930.

These insects live and develop primarily out-of-doors, although they are often brought into storages with infested commodities. The larvae attack all the usual varieties of drying and dried fruits, fallen figs, and damaged or moldy clusters of grapes on the vines. Raisins are attacked until they become too dry. Cottonseed cake, cacao beans, and cashew kernels are among the host foods. Fallen mulberries are important because they are available to the insects early in spring when other food is scarce.

Female raisin moths deposit eggs on all common varieties of drying and dried fruits. The rate of development of the eggs, larvae, and pupae varies with temperature. From egg to adult, the elapsed time is about 43 days at 83° F. At that temperature, eggs hatch in 3 to 6 days, and larvae reach full growth in about 32 days.

Larvae molt several times, usually six, with a range of from four to eight times. Larval life is greatly extended during the winter. In raisin storages, any larvae that escape fumigation continue to feed, and in the spring they pupate and emerge. In vineyards, most of the larvae pass

the winter in cocoons in the upper few inches of soil near the vine trunks and along under the wires or under the rough bark of the grapevines. In fig orchards, many larvae overwinter in a 6-inch band of soil around the tree trunks. The overwintering larvae pupate in the spring. The prepupal period lasts 1 day and the pupal period, about 10 days. Emergence of the adult moths begins in April and reaches a peak in May. No adults or eggs are found during winter. There are about three overlapping broods of adults a year, and a partial fourth. The males live for an average of 1l days and the females, for 16 days.

The raisin moth is a prolific insect. In summer, mated females provided with water averaged 351 eggs. The record was 692. Most eggs are laid in the first few hours of darkness during the daily flight period. On warm nights, these moths are in the air from about one-half hour after sunset until sunrise, chiefly during the earlier part of that period.

Dusky Raisin Moth

Ephestiodes gilvescentella Ragonot

This species, formerly called *Ephestiodes nigrella* Hulst, resembles the raisin moth in size and appearance, but both the adults and the larvae are darker. Their food and habits are, as far as known, the same as those of the raisin moth. They are found in vineyards and in raisin storages. They fly mostly during the night, especially before midnight. In the laboratory, adults on a mixture of raisins, prunes, walnut screenings, and. pulverized irradiated yeast produced a generation in about 2 months.

Indian Meal Moth

Plodia interpunctella (Hübner)

Indian meal moths are attractively marked insects (pl. III, *C*) of variable size, generally about three-eighths inch long. The outer two-thirds of the forewings is reddish brown with darker markings; the inner part of the wings is gray. There is a coppery band between the two contrasting areas. This is one of the commonest of storage insects. It usually flies for several hours after sunset and occasionally during the remainder of the night. It rarely flies during daylight. This species is of worldwide distribution.

The Indian meal moth has an extensive food list which includes grain, nuts, chocolate, Indian meal (cornmeal), flour, and beans. In the San Joaquin Valley, it is partly a field insect. In the field, it infests drying and dried raisins, waste fruits, and fruit refuse, including mulberries,

cherries, apricot pits, and peach pits. Some dates are infested on the palms.

Females may produce an average of 170 minute, opaque-white, and slightly lustrous eggs, which are deposited singly or in small clusters. They hatch in 2 to 4 days in summer, but in cooler weather incubation may require as long as 22 days.

Newly hatched larvae are one twenty-fifth of an inch long, and they reach a length of about one-half inch when full grown (pl. III, *C*). They usually are dull white but may become yellow, pink, or greenish. The youngest larvae can enter crevices as small as five one-thousandths of an inch, unexpectedly infesting commodities in containers thought to be insect proof. As they crawl about, the larvae spin a thread of white silk. After awhile, a heavy infestation produces a sheet of silk. Larvae may complete development in 21 days in hot weather, but in unheated buildings development may take 5 to 8 months.

Full-grown larvae pass the winter enclosed in silk cocoons constructed in cracks, under boards, between sheets of paper, and in other dark, preferably dry, places. They rarely hibernate out-of-doors in the San Joaquin Valley, but in the Coachella Valley partly grown larvae survive the winter, feeding on warm days. Overwintering larvae pupate in the spring. This stage may last 4 to 9 days. A pupa is shown in plate III, *C* and the eggs in Plate III, *B.*

Indian meal moths have short adult lives, from 2 or 3 days in hot weather to 30 days during the cool weather of spring and fall. The cycle from egg to adult may be as short as 33 days. In the Fresno area, Indian meal moths produce four generations a year. Larvae of a partial fifth generation survive the winter and produce adults in the spring. Overlapping of broods is common.

Almond Moth

Cadra cautella (Walker)

This species resembles the raisin moth but is much less abundant on dried fruits. Until recent years, it did not occur among the moths associated with dried fruits, but it is now present in numbers that vary a good deal from one year to another. Plate III, *D* pictures the adult, larva, and pupa.

The life history of the almond moth resembles that of the Indian meal moth. Its food list is long. Under the best conditions, development from egg to adult may be completed in 30 days.

Driedfruit Moth

Vitula edmandsae serratilineella Ragonot

The adults of the driedfruit moth are mottled gray and nearly three-fourths of an inch long. They were first reported in California from Santa Clara County in 1903. They are not abundant, but they have been collected from stored figs, raisins, and prunes in the Santa Clara and San Joaquin Valleys. They were more numerous in early years when large tonnages of raisins were stored in the San Joaquin Valley for 2, 3, or even 4 years without protection from insects.

The larvae are larger than larvae of the Indian meal moth. From egg to adult, the elapsed time averages 88 days. In the summer, the incubation period is about 9 days, larvae develop for 69 days, and the pupal period lasts 10 days. Adults live about 9 days and lay eggs for about 6 days. Their egg production varies from 63 to 200 but averages 128. These moths pass the winter as larvae.

Dried-Prune Moth

Aphelia glares (Zeller)

This insect is now uncommon in California, but methods of prune storage in former years favored its survival more than they do at present. At one time, prunes were bulk-stored in wooden bins in masses 6 or 8 feet deep. In addition to prunes, the larvae infest peanuts and honeycombs and are of considerable importance as pests of walnuts in western France.

The larvae are capable of serious damage. When fully grown, they are more than 1 inch long and produce considerable webbing and coarse excreta. Before spinning a cocoon for pupation, they frequently excavate a shallow depression in the wood of bins or boxes

A. gularis has a limited distribution in California. Surveys have shown that its favorite area is the San Francisco Bay area. Extensive collections in the Fresno area have never included this species.

Navel Orangeworm

Paramyelois transitella (Walker)

Navel orangeworm moths (pl. III, *E*) are silver gray with forewings marked with irregular black patterns. The females are considerably larger than the males.

In the United States, navel orangeworms were first noticed on navel oranges in Arizona in 1920. About 20 years later, they became an important pest of walnuts in southern California. By 1948, they were infesting figs in the San Joaquin Valley. Since then, they have become a leading pest throughout the almond and walnut growing areas of the State.

Besides oranges, walnuts, and figs, the food list of navel orangeworm larvae includes damaged lemons, fallen dates, dates on the palms, Valencia oranges, jujubes, loquats, mummified peaches, prunes, quinces, apples, apricots, nectarines, pecans, pomegranates, and seed pods of honey-locust, carob, bottle tree, and yucca. Most infestations originate in the field and are carried into storage with harvested products. In storage, navel orangeworm larvae may continue to feed; however, the adults do not reproduce there.

The creamy-white lustrous eggs are laid in small groups. During incubation, they change color to pink and reddish orange. Total egg production per female ranges from 3 to 244, with an average of 85. At 82° F the incubation period is 5 days

The larvae (pl. III, *E*) are ½ to ¾ inch long. They are reddish orange when first hatched, changing to cream color after the first molt. Later, their color depends on the color of their food. As the larvae feed, they produce abundant silken webbing, and the interiors of figs and dates that have been occupied by them are littered with coarse pellets of excreta. The larvae develop more rapidly when relative humidity is high. At 55 percent, they take 55 days to develop, but at 95 percent they require only 22 days.

Pupation lasts for about a week. The pupae (pl. III, *E*) are dark brown. At 82° F, the egg-to-adult period is only 36 days at 95 percent relative humidity, but 69 days at 55 percent.

FLIES

Vinegar Flies

Drosophila species

The vinegar flies, also called fruit flies or pomace flies, include species of *Drosophila* that are common wherever damaged or overipe fruit and vegetable garbage accumulate. In the mild weather of late summer and early fall, *Drosophila melanogaster* Meigen and *D. simulans*

Sturtevant become abundant in the San Joaquin Valley but do not thrive in the hottest part of summer. In cool weather, *D. pseudoobscura* Frolowa is more common. More than 50 other species are probably in the area, most of them of minor economic importance.

D. melanogaster, the dominant species in the central valley of California is a small, clear-winged fly with bright-red eyes and a shining black abdomen, the first three segments of which have a yellow band (p1. IV, *E*). The body is from $^{2}/_{32}$ to $^{3}/_{32}$ inch in length.

These flies are attracted to fermenting fruit waste, melons, piles of peach and apricot pits, damaged grapes, tomatoes, or other fruits. They are common in wineries and in and around tomato and fruit canneries. Cull-fruit dumps on farms and along roadsides swarm with vinegar flies. By leaving rotting fruit and entering figs, these flies inoculate the ripening figs with yeast cells, and cause souring. They also contribute to the spread of bunch rot of grapes.

Activity of adult vinegar flies in the field is controlled chiefly by temperature, light intensity, and air movement. They are strong fliers, and can fly more than 6 miles in a day. They do not move in winds of 5 miles per hour or more. The optimum light intensity for them is about 40 foot-candles, and light more intense than 150 foot-candles tends to immobilize them. Fly activity may be fairly brisk in a fig tree with heavy foliage while, outside the canopy, bright light and a breeze may combine to keep activity at or near zero. Flies do not congregate in a tree with light foliage because both light and breezes penetrate it. They are active only during the day, chiefly from 9 to 11 am and from 7 to 8 pm.

The microscopic white eggs have two filaments near one end. Larvae or maggots (pl. IV, *E*) are dusky or whitish, without legs or eyes. They are up to one quarter of an inch long when fully grown. The head is pointed and has a pair of dark-colored mouth hooks at the end. They pupate in a yellowish-brown case near the drier edges of the food. Pupae are shown in plate IV, *E*.

Drosophila melanogaster has the most rapid reproductive rate of any driedfruit insect. These flies spend only about 24 hours in the egg, 3 days as a larva, and 3 days as a pupa, a total of 7 days. Under some, conditions, mature eggs are retained in the body of the female, and such eggs may hatch within t hour after they are laid. Adults may lay as many as 2,000 eggs, but average nearer 1,000. Females live about 39 days at 67° to 77° F. At 65°, females live average lives of 7l days; males, 43 days.

Soldier Fly

Hermetia illucens (Linnaeus)

Soldier flies are black, two-winged insects that resemble some of the four-winged mud-dauber wasps in color, size, and in the habit of flitting their wings as they walk about. The larvae or maggots are large, brownish, and flattened and have a tough skin.

The larvae feed in accumulations of rotten fruit that are dried out, decayed, and black. In New Zealand, they sometimes damage honeybee colonies by feeding on wax, pollen, and honey.

Eggs hatch 1 or 2 weeks after they are laid. The larvae go through six molts and reach maturity in about a month; then they pupate for 9 or 10 days. There are one or two generations a year. These flies pass the winter as larvae.

House Fly and Blow Flies

Drying fruit is sometimes subject to contamination by flies that come from barns, stables, or other nearby installations. These flies are not a primary pest of the fruit, but may be a considerable nuisance. The most common species are the house fly, *Musca domestica* Linnaeus and several kinds of blow flies, *Phaenicia coeruleiviridis* (Macquart) *Phaenicia sericata* (Meigen), and *Orthellia caesarion* (Meigen).

WASPS AND BEES

Bracon hebetor Say

Large numbers of minute *Bracon hebetor* wasps are sometimes seen flying over dried fruit in storage in the fall, They are parasites of storage moth larvae, including the Indian meal moth and the raisin moth. Larger larvae of the moths are paralyzed by the female wasp. Although this wasp kills many moth larvae, its value in suppressing moth infestations has not been determined.

The female wasp stings the moth larva, injecting venom to paralyze it. After the host stops moving, about five eggs are deposited under or beside the victim. These eggs hatch in 1 or 2 days. The wasp larvae feed on the paralyzed host for 3 or 4 days, after which they pupate nearby in tough, white silken cocoons. Adult wasps emerge 4 or 5 days later. From 8 to 11 days are needed for egg-to-adult development. Females live for about a month; males, about 10 days. In the laboratory 14 generations per year can be reared. Unmated females produce only

male progeny. Production of young from unfertilized eggs is called parthenogenesis. This kind of reproduction is common in wasplike insects but does not occur in the moths and beetles found in dried fruits.

Most of the overwintering adult *B. hebetor* are females. The wasp is quiescent in cold weather, but on warm days it is active, stinging and paralyzing its host larvae. Egg laying on paralyzed hosts, however, does not begin until spring, sometimes as early as the middle of April. Frequently, the female wasp feeds on fluid that seeps from the punctures in the larva. The wasp may paralyze many larvae with her venom, but some recover. Raisin moth larvae under grapevine bark are attacked in considerable numbers, but those hibernating in the surface layers of soil are harder to reach. Full-grown moth larvae are commonly parasitized as they leave the stored fruit in search of pupation sites in the spring. The adult and pupa are illustrated in plate IV, *A*.

Cephalonomia tarsalis (Ashmead)

This very small black wasp is a common external parasite of the larvae and pupae of the sawtoothed grain beetle. Its length is only six one-hundredths of an inch.

The fertilized female of *Cephalonomia tarsalis* paralyzes a larva or pupa of the beetle by stinging it. She then deposits on the victim two eggs, a female egg and a male egg. Total production of eggs averages about 85, and hatching takes place within 24 hours. The larvae feed on the host for 4 days, then spin a yellowish silk cocoon for pupation. Female *C. tarsalis* live for an average of 35 days, but the males, who do not feed, live only about 6 days.

Winter is passed in the pupal stage. The cocoons of this parasite are frequently seen where sawtoothed grain beetles are plentiful. However, it is not considered to be very effective in controlling this beetle.

Devorgilla canescens (Gravenhorst)

These wasps of the family Ichneumonidae are considerably larger than *Bracon hebetor* but are less numerous. They sometimes occur in moderate numbers in the field and in storages, especially in May. Their larvae are internal parasites of the raisin moth. Female wasps lay eggs inside the body of raisin moth larvae. The wasp eggs hatch, and the larvae that emerge develop within the bodies of their hosts, which continue to feed as they support the parasites.

At 82° F, the wasps develop from egg to adult in about 23 days, but those wasp eggs deposited in raisin moth larvae, as they hibernate under grapevine bark or in the upper part of the soil, pass the winter in the

hosts. These parasites are less effective than *Bracon hebetor* because the moth larvae are not paralyzed and can continue their damage to the fruit.

Mesostenus gracilis Cresson

These internal parasites of the raisin moth are not common, but a few are found in vineyards. Like *Devorgilla canescens*, they are ichneumonid wasps, and their habits are much the same. The eggs are laid inside the body of the host larvae, where the parasite larvae live and develop until they are ready to pupate. The moth larvae are not paralyzed, but continue to feed. Hibernating larvae of the raisin moth sometimes contain parasitic larvae from eggs deposited in them the preceding fall. These wasps probably have little effect on the moth population.

Fig Wasp

Blastophaga psenes (Linnaeus)

This minute, shining, amber-brown wasp is nearly indispensable to Calimyrna fig production because of its role in pollination or caprification.[2] No other insect successfully pollinates commercial varieties of figs. Thus, fig varieties that require pollination develop no fruit unless this wasp is present to pollinate them. Before caprifigs containing *Blastophaga* wasps were introduced into California from Algeria in April 1899, attempts to produce Smyrna-type figs on a commercial scale had been unsuccessful.

The remarkable arrangement whereby the male fruits of various species of fig provide food and shelter for the larvae of these small wasps is one of the more complex relationships between a plant and an insect to be found in nature. The caprifig (male) tree supports a population of these wasps throughout the year. It bears three crops of caprifigs—one in winter, another in spring, and a third in summer and fall.

The spring crop of caprifigs produces an average of about 500 female wasps and about 30 wingless males per fig. This crop of caprifigs has a barrier of pollen-bearing flowers around the opening or eye. A cycle of wasp development begins with the laying of eggs in the gallflowers of a caprifig. The wasps develop to maturity inside these flowers. As the

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[2] Experiments by University of California scientists have shown that a hormone spray applied to the fruit and foliage at the proper time will cause the fruit to set without pollination, but the method has not been adopted because the resulting quality of the fruit was inferior.

females escape through the eye, they become dusted with pollen. During the first half of June, the female wasps fly to other caprifigs and also to edible figs produced by female trees. In the caprifigs, the insects' cycle is repeated, but the attempts by females to lay eggs in the galls of edible figs result only in pollination and setting of the fruit.

One disadvantage in the visits of these wasps to edible figs is that they carry into the figs the spores of a mold, *Fusarium moniliforme* (endosepsis), that causes spoilage. The insects also carry a bacterial disease, *Serratia plymuthica*, and a yeast, *Candida guilliermondii* variety *carpophila*.

Plate IV, *B* and *C* shows this insect and a result of its instinct to penetrate figs.

Leaf-Cutting Bees

Each season a few harvested figs are found in which the large eye has been entered by a leaf-cutting bee for the purpose of making a nest for its young. This nest consists of a cylindrical case of leaf segments, filled with pollen-nectar paste, and sealed with a cap of leaf segments.

ANTS

In raisin storages, when infestation by the raisin moth is not controlled by fumigation, ants may become numerous. They act as scavengers, carrying off dead and dying larvae of storage moths that have been stung by parasites.

The ant most common among stored raisins in the Fresno area is a large brown species, *Formica fusca* (Linnaeus). This ant digs extensive tunnel systems in the ground, extending to depths of 3 feet or more.

OTHER INSECTS

Fig Scale

This insect, *Lepidosaphes ficus* (Signoret), is a fig orchard pest, but traces of its presence may persist on the fruit after harvest. When infestation on the leaves becomes heavy, crawlers go to the developing fruit, settle, and feed on the green fig. Heavy infestations result in dried figs that are somewhat spotted and deformed. The oystershell-like adult scales occasionally persist on the dried product.

Winter, when fig trees are leafless, is passed by fertilized females established on succulent bark. Egg laying begins in February in the San Joaquin Valley. There are three generations per year—an overwintering brood, a first summer brood, and a partial second summer brood. Plate IV, *D* shows the insect on a fig leaf.

Bark Lice

Bark lice, also known as book lice or psocids, are very small light-colored, active insects that resemble true lice. Most of them are wingless. The common ones are one twenty-fifth of an inch long. Species identified include *Liposcelis divinatorius* (Muller) and *Proisotoma minuta* Tullberg.

These insects are relatively harmless. They are common in newly harvested raisins but seem to leave the fruit during storage. A female produces about 100 eggs. They develop into adults in about 3 months.

ARACHNIDA

Mites

No special study has been made of the mites found on dried fruits in California. There are few records of identified species from these products. *Tyrophagus longior* (Gervais) and *Tyrophagus putrescentiae* (Schrank) have been recorded in California.

Unlike insects, mites breathe through their skins rather than by means of a system of tubes that branch from openings in the body wall. Their small size and thin skin expose them to dehydration. More than other stored-product pests they require high humidity for rapid development and increase. Most storage mites thrive in cool climates. The long season of heat and dryness in most parts of California where fruits are dried and stored probably accounts for the relative freedom from mite damage.

Black Widow Spider

Latrodectus mactans (Fabricius)

Populations of this shiny-black, poisonous-spider vary within wide limits in the San Joaquin valley. Although it is a timid species, humans are bitten and severely poisoned from time to time when its coarse tough webs are disturbed. Its life cycle is about 4 months.

The black widow can thrive on diet of raisin moth larvae. Piles of wooden trays and empty fruit boxes are favorite harbors for this spider. Some establish webs in rolled paper, i.e., raisin-drying trays.

CONDITIONS THAT FAVOR OR OPPOSE INCREASE OF DRIEDFRUIT INSECTS

Some driedfruit insects, of which the driedfruit beetle is a good example, prefer ripe and overripe fruits. As fruits dry, they become less favorable, and when drying is complete the driedfruit beetle finds them unsuitable.

In contrast to the driedfruit beetle, the raisin moth prefers partially dried products. The much longer larval period of this species extends the development of its progeny from the vineyard tray or drying yard into the storage period. There are no more favorable conditions for raisin moth infestation than the period during which drying is being completed on stacked wooden trays. Such fruit, spread out in shade, is available each evening for egg-laying moths to infest it. Paper trays folded and rolled in the "biscuit" roll, provide more protection from insects than the openend "cigarette" roll.

Other insects find dried fruits attractive down to a moisture content of 10 percent. Normally, dried fruits have moisture contents above this level and, therefore, are liable to attack by all species. Should fruits be dried to a level where insects could not exist on them, they would also be unattractive to consumers. A fairly soft pliable product is desirable.

There is evidence that wet weather affects the population of insects that infest dried fruits, and general observations suggest that cold winters reduce insects' ability to survive and to build up to large numbers in spring and early summer. Freezing of the host caprifigs greatly reduces survival of *Blastophaga*. Also, small larvae of the raisin moth that attempt to overwinter in wet locations are largely unsuccessful. However, since the effects of weather on driedfruit insects have not been widely studied, little is known about its role in regulating populations of specific pest species.

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Plate I →

Developmental stages of some beetles found on dried fruit. *A*. Adult sawtoothed grain beetle (left) and merchant grain beetle. *B*. Eggs of sawtoothed grain beetle greatly enlarged, photographed beside common pin. *C*. Three larvae (left) and three pupae of sawtoothed grain beetle. *D*. Comparison of heads of two species. Sawtoothed grain beetle on left, merchant grain beetle on right; arrows indicate areas to compare. *E*. Rusty grain beetle adult and larvae. *F*. Hairy fungus beetle adult and larva.

A B

C D

E F

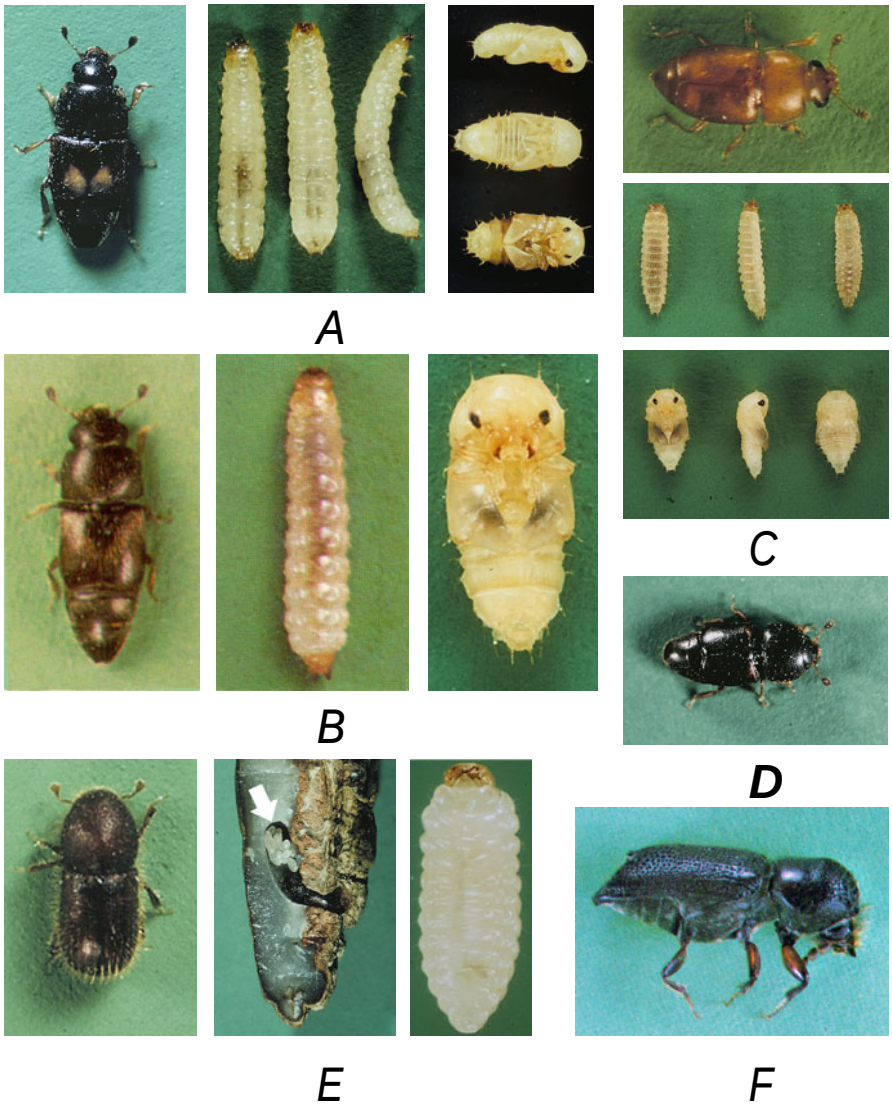

Plate II

Developmental stages of some beetles found in dried fruit. *A*. Driedfruit beetle adult, larvae and pupae. *B*. Corn sap beetle adult, larva, and pupae. *C*. Yellow nitidulid adult, larva and pupa. *D*. Pineapple beetle adult. *E*. Date-stone beetle adult, eggs in damaged date stone (arrows), and larva. *F*. Leadcable borer adult.

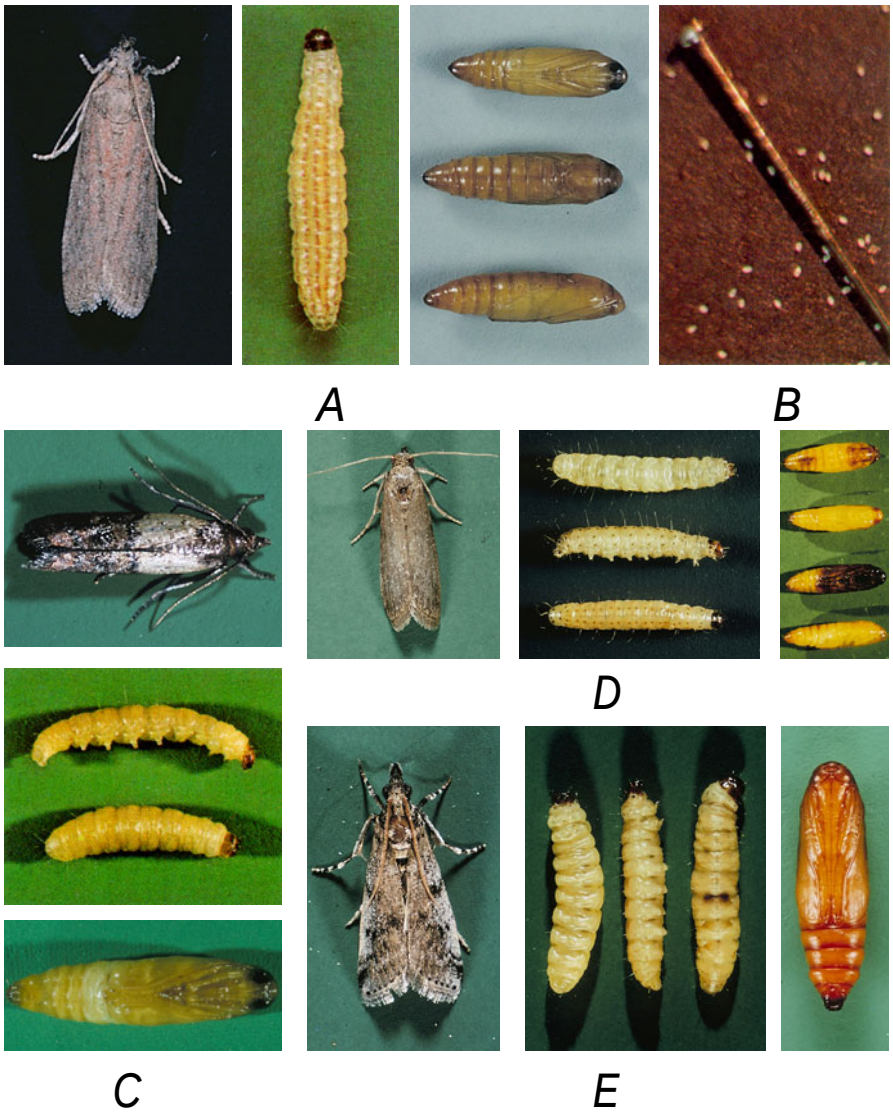

Plate III

Developmental stages of some moths found on dried fruit. *A.* Raisin moth adult, larva, and pupae. *B.* Indian meal moth eggs photographed beside common pin. *C.* Indian meal moth adult, larvae and pupa. *D.* Almond moth adult, larvae, and pupae. *E.* Navel orangeworm adult, larvae, and pupa.

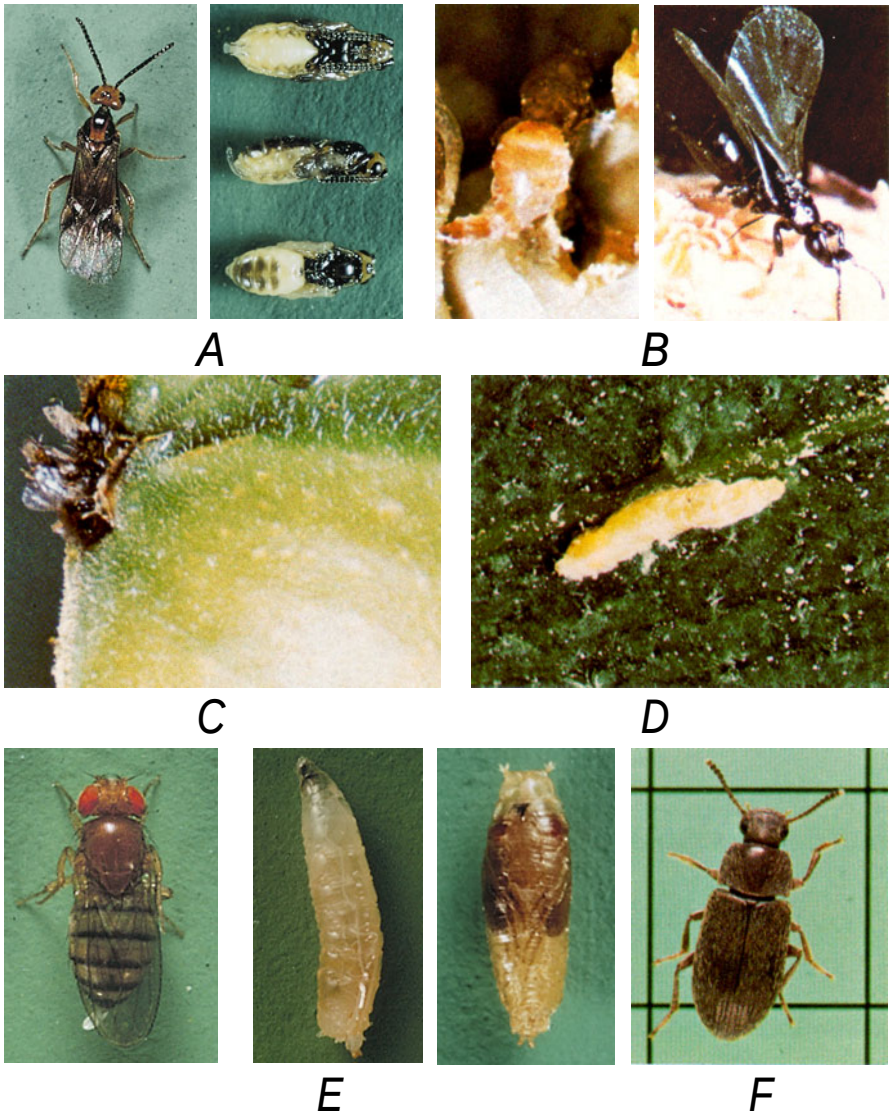

Plate IV

A. Parasite of moth larvae: Adult and pupae. *B.* Fig wasp wingless male (left) and female. *C.* Wings of female fig wasps in eye of green fig. *D.* Fig scale on fig leaf. *E.* Common vinegar fly adult, larva, and pupa. *F.* Darkling ground beetle, *Blapstinus* sp.