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PESTS AND DISEASES OF THE DATE PALM

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PESTICIDE WARNING

In the United States, the only pesticides authorized for use on date palms are inorganic compounds of copper or sulfur and the organic compounds ferbam and malathion. Other pesticides mentioned in the text for control of pests and diseases of the date palm are employed in countries other than the United States.

This paper contains the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.

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ABSTRACT

Carpenter, J. B., and Elmer, H.S.
Pests and Diseases of the Date Palm. U.S. Department of Agriculture, Agriculture Handbook No. 527, 42 pages.

This handbook is the most comprehensive publication available on pests and diseases of the date palm. The world literature is reviewed through January 1977. Depending upon the relative importance of a pest or disease, some or all of the following aspects of each are discussed: Distribution, economic importance, symptoms or injuries, nature and life cycle of causal agent, and control measures. The text is supplemented with a guide to the names and classification of the insects and mites on date palms, a glossary of terms used in the text, a list of common and chemical names of pesticides, and an extensive citation of literature on date culture as well as on pests and diseases of dates. Where available, citations are given to recent publications on pests and diseases in each of the principal date-growing countries.

KEYWORDS: Biological control, date bibliography, date breeding, date culture, date diseases, date fruit, date glossary, date industry, date insects, date mites, date nematodes, date palm, disease resistance, fruit fumigation, pesticides, *Phoenix dactylifera*, stored fruit pests.

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CONTENTS

PESTS AND DISEASES OF THE DATE PALM

By J. B. CARPENTER and H.S. ELMER[1,2]

INTRODUCTION

Date palms provide a primary article of food and commerce in the great desert areas extending from western North Africa to India, and are a commercial crop in many other subtropical desert areas. The principal date-producing countries of the world are Algeria, the Arab Republic of Egypt, Iran, Iraq, Pakistan, and Saudi Arabia. Dates are also produced in large quantities in Bahrain, Libya, Mauritania, Morocco, Oman, Sudan, the People's Democratic Republic of Yemen, Tunisia, and the United States. Smaller quantities of dates are produced in Chad, India, Israel, Mexico, and Somalia, and a few plantings occur in other countries. Munier *(193)*[3] discussed the world distribution of date palms. Persons involved in date pest and disease control should consult Rygg *(218)* and Dowson and Aten *(72)* on handling and processing the crop.

The first two sections of this handbook consider the insect and mite pests that have been of concern to date growers during the past 30 years. Taxonomic assignments, with appropriate authorities, are given in a list, page 37. Distribution, economic importance, injury, description, life history, and control are discussed. Excellent reviews of date palm pests by Lepesme *(157)* in 1947 and Stickney et al. *(227)* in 1950 provided a basis for the original preparation of this publication. Since 1968, Bindra and Varma *(17)*, Strumpel *(229)*, and Vilardebo *(252)* have reviewed some of the literature on date insects. Hussain *(116)* published the most comprehensive recent account of insect pests in Iraq, based in large part on research done in that country; many papers in Arabic are cited.

Kehat *(134)* made a study of temperature in date palms that is pertinent to entomological investigation of this crop. His summary is quoted as follows:

> "Temperatures in the natural habitat of date palm pests were compared at the macro- and microenvironmental levels. These data are important for evaluating the pests' survival capacity and preferred microhabitat under the temperature extremes prevailing in their natural habitat. The temperature of the date pinnae's surface varied with the absolute temperature and relative humidity, and with the age and position of the pinnae. However, the differences between air and pinnae temperature, as well as between pinnae, never exceeded 4°C. The mature exposed pinnae represented the hottest part of the tree, the young pinnae were much cooler, and the area beneath the trunk fibers was the coolest of the tree. A macroclimate which is considered nonbeneficial for insect survival may sometimes prove more favorable than expected, when considered at the microenvironmental level."

[1]Plant pathologist, Science and Education Administration, Indio, Calif. 92201, and entomology specialist, Department of Entomology, University of California, Riverside, 92521.

[2]Pests and diseases of the date palm, *Phoenix dactylifera* L., are discussed on a worldwide basis in this publication, which supersedes a paper with the same title, by Elmer et al., published in 1968. All pertinent literature available through January 1977 has been consulted.

[3]Italic numbers in parentheses refer to Literature Cited, p. 25.

Karschon *(128)* found that pinnae exposed to sun were warmer than the ambient air. Shaded pinnae were at or near air temperature.

Methods and materials for the control of various insect and mite species change rapidly. Currently recommended pesticides are mentioned; dosages and timing should be sought from local research or agricultural extension agencies. The common names of insecticides and acaricides are those approved by the Committee on Insecticide Terminology of the Entomological Society of America *(142);* see also Martin *(172)* and Appendix, page 40. No proprietary names are used for insecticides. Safe handling of pesticides is required *(218).*

Fumigation and packinghouse pest control procedures are described in the third section. The relatively limited information on nematodes is reviewed in the fourth section. Substantial research is needed on nematode problems associated with the date palm.

Diseases caused by fungi, mycoplasmalike organisms, and unidentified factors are considered in the fifth section. Neither bacterial nor viral diseases have been definitely associated with date palms; well-defined nutrient imbalances have not been identified.

Date palms demand large quantities of water for growth and fruiting in the hot deserts where they thrive, yet atmospheric moisture is their commonest enemy. Most of the important pathogens of palms are fungi, which, except for the destructive soil-borne species of *Fusarium* that causes bayoud, are dependent upon high humidity and rain for their development. Thus, the other fungal diseases of date palms are of only sporadic importance in favorable date-growing districts, but are increasingly common and damaging in date culture as conditions become suboptimal to marginal because of poorly distributed or excessive rainfall, high humidity, and unfavorable temperatures.

The economic importance of date diseases is emphasized, and estimates are reported wherever available on the losses caused by diseases, but few statistical data exist. Distribution, causal agent, symptoms, description of the causal organism, and control measures for the diseases are given where available or useful. Dosages of fungicides and timing of application should be sought from local research or agricultural extension agencies. Calcat *(38),* Chabrolin *(49),* Chohan *(50),* Fawcett and Klotz *(91,* Laville *(153),* and Viennot-Bourgin *(251)* have published useful reviews of date diseases.

MITES

Banks Grass Mite

DISTRIBUTION AND ECONOMIC IMPORTANCE

Banks grass mite, *Oligonychus pratensis* (Banks), commonly called date mite in California, is a major pest of date palms in the United States *(82).* This mite can cause extensive damage by ruining entire bunches of fruit, particularly those of the Deglet Noor variety, which consititutes over 85 percent of the California date plantings. This mite also occurs in North Africa and Sudan; it may cause serious damage to date palms in Iraq and Tunisia *(99).*

INJURY

O. pratensis rasps the leaf surface and causes affected areas to become grayish white or pale yellow. Infested green fruit may be scarred so badly that they turn brown. The skin on infested fruit becomes hard, and then cracks and shrivels, reducing the grade of the fruit. A heavy deposit of fine webbing is spun over much of the feeding area. This webbing collects dust that makes even a moderate infestation in tall palms easily observed from the ground.

DESCRIPTION AND LIFE HISTORY

The biology of this mite and its host range were determined by Stickney et al. *(227).* Pritchard and Baker *(211)* listed the host plants, which include many grasses in the United States. The body of the adult female is ovate and about 0.29 mm long. The color varies from yellowish white to pale orange, with more deeply shaded irregular spots along the side of the body. Adult males are bluntly subtriangular and smaller than the female, about 0.25 mm long, but of the same color. The egg is pearly white, spherical, and approximately 0.13 mm in diameter. Immature mites resemble adult females except that the larvae have only six legs; after molting they become eight-legged nymphs. The first infestations appear in early June when the fruits are small; peak populations occur on fruit in July and August. These mites usually do not remain on ripe fruit, but maintain themselves during the winter months on late-ripening or off-season green fruit and also on the foliage of the palm or on grasses, particularly Bermuda grass, *Cynodon dactylon* (L.) Pers., growing in or near the date gardens. Although the number of mites decreases and their activity lessens during the winter months, all

stages of development are present throughout the year.

The mites are incapable of flight and do not spin silk strands for the express purpose of floating on the wind as some mites do. Their main means of dispersal, besides walking, is probably transportation by wind. Strong, gusty winds are frequent in the date-growing regions of the United States and probably contribute to the rapid reinfestation that so often occurs in date gardens following successful initial control measures in early summer *(82)*.

CONTROL

Sulfur[4] dust is used almost exclusively to reduce injurious populations of the Banks grass mite. Mechanical dusters capable of reaching high bunches are commonly employed to deposit a light coating of sulfur over the entire surface of each fruit. Some growers prefer one sulfur dusting applied by aircraft before the date bunches are tied down, followed by a later application from the ground when mites appear on the bunches. The best mite control is obtained by blowing the sulfur directly upward into the bunches *(254)*.

Poor coverage and subsequent poor control result either when the equipment is incapable of blowing the dust to high date bunches or when dust is applied during excessively windy periods. Since sulfur dust is irritating to the eyes of persons applying it or working in dusted trees, experiments were conducted to determine whether sulfur and other acaricides might be applied as sprays *(79)*. Wettable sulfur sprays were less irritating to the eyes than dust and easily applied to high date bunches. The bunches were thoroughly drenched with spray applied with a conventional high-pressure citrus sprayer and a shade-tree gun operated by personnel on the ground. Spreaders and stickers, added to dusts and sprays, hold some promise for more lasting control. Wettable sulfur sprays were used commercially in a few date gardens during 1962 *(81)*, but dusting remains the principal method of application. Other acaricides *(254)* tested as sprays or dusts were more expensive than sulfur and no more effective; none are recommended in the United States, as they have not been registered for use on date palms.

Old World Date Mite

DISTRIBUTION AND ECONOMIC IMPORTANCE

The Old World date mite, *Oligonychus afrasiaticus* (McGr.), has long been known as a serious pest of date palms. It has been reported in Algeria *(230, 253)*, Chad *(191, 252)*, Iran *(99, 100)*, Iraq *(94, 115, 116, 152)*, Libya *(173, 174)*, Mali *(192)*, Mauritania *(194)*, Morocco *(207)*, Niger *(252)*, Saudi Arabia *(77)*, Tunisia *(204)*, and North Africa *(38)*, where up to 80 percent of the fruit has been infested.

P. Munier,[5] who during the past several years has published numerous surveys on date culture in countries bordering Saharan North Africa, noted the presence of the Old World date mite wherever dates are grown. In Libya *(174)*, this mite is a serious pest of date palms in inland oases, but not in coastal areas; in Iran *(99)* this mite may destroy 40 percent or more of the crop in some districts.

INJURY

O. afrasiaticus is similar to Banks grass mite and may cause the same type and degree of injury. In North Africa, the Old World date mite is reported to be especially abundant on unthrifty and neglected palms. Nixon *(200)* summarized observations on the tolerance of several date varieties to infestation.

NOMENCLATURE

Oligonychus afrasiaticus, orginally described in 1939 in the genus *Paratetranychus*, was referred to as *Oligonychus* by Pritchard and Baker *(211)*. Previously, this mite had been confused with *O. pratensis* (Banks). Some literature still refers to the Old World date mite as *P. simplex* (Banks), a name listed by McGregor *(177)*.

DESCRIPTION AND LIFE HISTORY

The biology of *O. afrasiaticus* was discussed by Hussain *(115,116)* who reported six overlapping generations of mites during the fruiting season in middle Iraq. The peak population occurred in July. In his discussion of the biology and control of this mite in Iran, Gharib *(100)* reported 10 to 12 generations per year and the continuous presence of this pest on palms. This mite is active up to 45° C *(100)*.

CONTROL

Sulfur dusts or sprays are recommended wherever the Old World date mite requires control *(38, 100, 116, 152, 194)*. Gharib *(100)* found Tedion an effective acaricide. He recommended its use with other pesticides in an integrated pesticide control program against the dubas bug, lesser date moth, and the palm stem borer.

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[4] See "Common and Chemical Names of Pesticides Mentioned in This Handbook," p. 40.

[5] Institut de Recherches sur les Fruits et Agrumes (formerly Institut des Fruits et Agrumes Coloniaux), Paris, France.

Miscellaneous Mites

Several minor and usually unimportant species of mites have been reported on date palms *(116)*. *Raoiella indica* Hirst is reported as an important pest on date and other palm leaves in Egypt, India, and Sudan *(97)*. Biological studies of *R. indica* and *Phyllotetranychus aegyptiacus* Say. have been made by Zaher et al. *(261)*. Control measures recommended for the major mite species may also suppress these minor pests.

Mites in Stored Dates

Many species of mites can be serious pests if once established in stored dates. Infestations are rare, however, and can be controlled by fumigation *(116, 227)*.

INSECTS

Parlatoria Date Scale

DISTRIBUTION AND ECONOMIC IMPORTANCE

The parlatoria date scale, *Parlatoria blanchardi* (Targ.), probably indigenous to Iraq *(38)*, is widely distributed throughout most of the date-growing regions of the world *(53, 99, 252)* except the United States. It is easily spread to new plantings on palm offshoots. If allowed to go unchecked, parlatoria date scale may become the most serious date pest in many areas. Losses of 70 to 80 percent of the fruit by direct attack of this scale insect have been reported by Smirnoff *(224)*, who published a comprehensive review of this pest, including his own extensive investigations. Useful reviews have been published by Vilardebo *(252)* and Hussain *(116)*. Other reports include those from Algeria *(230, 253)*, Argentina *(87)*, Egypt *(44, 220)*, India *(12)*, Iran *(105)*, Israel *(52, 141)*, Libya *(173, 174)*, Mauritania *(234, 237)*, Morocco *(207)*, Pakistan *(224)*, Saudi Arabia *(77, 175)*, Sudan *(222)*, Tunisia *(204)*, and other countries.

INJURY

Under favorable conditions, parlatoria date scale can spread over the surfaces of the foliage and fruit of the date palm, covering them with live and dead insects. The scale feeds on the white succulent tissues at the base of the leafstalk, one of the most protected and inaccessible places on the palm. As the population increases, the insects move from these areas on to the pinnae. Heavy infestations on the pinnae cause them to wither and die. In commercial plantings, date palms are seldom killed by parlatoria date scale, but feeding by these insects definitely affects the vigor of the palms and decreases yields. Infestations on fruit reduce its commercial value and may render it unfit for human consumption.

DESCRIPTION AND LIFE HISTORY

Descriptions and life histories of the various stages of the parlatoria date scale have been published *(116, 225, 227, 252)*. The adults average about 0.7 mm long; the female is broadly ovate and somewhat flattened in all stages. The male, after five nymphal stages, emerges as an adult with well-developed wings; adult females remain stationary for life and, after mating, produce numerous eggs. After the eggs hatch, the nymphs crawl out from under the female and move about, feeding at various locations until the third molting. These nymphs are pink to red; female adults are gray. The egg period varies with temperature, ranging from 2 to 11 days. An almost continuous overlapping of egg, nymph, and adult stages occurs throughout the year, so that the generations are not clearly defined. Kehat *(130)* reported three generations and sometimes a partial fourth in Israel, with population increases in spring and autumn. Egg mortality may exceed 50 percent *(116)*. In Mauritania *(237)*, the maximum occurrence of parlatoria is in the temperate periods *(21° to 32°C)* from April to May, and a second peak occurs in December. Infestations abate between these periods and are lowest in August, at temperatures of 39° to 40° and above, and again in February during cold weather.

CONTROL

Each date-growing area has specific problems of control, but a concentrated effort will generally reduce population levels so that injury is negligible. Martin *(173, 174)* found that both diazinon and parathion gave satisfactory control in Libya. In Sudan, Siddig *(222)* found that these chemicals and malathion, in various formulations, were effective. Diazinon and malathion would be preferred because parathion is too toxic for use by unskilled labor in most areas. In Israel, Kehat and Swirski *(139)* tested several materials for the control of this scale and found dimethoate the most effective. However, they also showed that insecticides applied to the date palm or to adjacent crops interfered with biological control of parlatoria date scale. Siddig *(222)* obtained substantial control by removal of 7 to 10 of the oldest lower leaves of infested palms and recommended this procedure for small plantings.

This pest was introduced into the United States in 1890 with the first successful importation of date palm offshoots from Algeria and Egypt. Efforts were made to eliminate the scale at that time, but it proved to be very difficult to eradicate with the techniques then available. An elaborate system of inspection, quarantine, and control by stripping the leaves and burning, was initiated around 1914. The last parlatoria date scale was observed in 1934. Apparently, this scale has been successfully eradicated from the United States *(24)*.

Smirnoff *(225)* investigated this scale insect intensively, especially its biological control; his list of predators includes: Sarcoptidae (Acarina), 1; Coccinellidae, 26; Nitidulidae, 5; Chrysopidae, 1; Mycetaeidae, 1; and Anthocoridae, 1. In a typical situation, a 6 to 8 year-old palm might be host to 30 to 50 million live parlatoria date scales, a predator population of 8,000 Nitidulidae, and 3,000 to 4,000 Coccinellidae *(Scymnus* sp.and *Pharoscymnus* spp.). Another 100 million dead scales might be present in the form of crusts on leaves and other parts of the palms.

Predators are strongly influenced by climatic conditions and populations vary widely in component species and total numbers. In a single large oasis, the distribution of parasites will be governed by a wide range of microclimates. Substantial diminution of parlatoria date scale populations has followed some parasite introductions. Biological control is especially valuable for those areas where consistent chemical control is impractical. In newly infested areas, the scale may build up rapidly and become very damaging, but when predators are introduced under favorable conditions the scale populations are reduced to tolerable levels.

Recent investigations on biological control of parlatoria date scale include work on *Pharoscymnus numidicus* Pic. and other predators *(131, 132)*, *Cybocephalus nigriceps* (J. Sahlberg) *(22)*, *Aphites mytilaspides* (Le Baron) *(149)*, *Chilocorus bipustulatus* L., C. *bipustulatus* var. *iranensis* Iperti el al., *Pharoscymnus anchorago* Fairmaire, and other predators *(116, 119, 120, 121, 122, 133, 150, 233, 236)*. In 1975, a series of papers from Mauritania *(234, 235, 237, 238)* reported extensive investigations on parlatoria scale and its predator, *C. bipustulatus* var. *iranensis;* a valuable bibliography is provided by Tourneur and Hugues *(234)*.

Red Date Scale

The red date scale, *Phoenicococcus marlatti* (Ckll), is probably found wherever the date palm is grown. Although at one time it was considered an injurious insect in the United States, Stickney et al. *(227)* concluded that it was seldom damaging. They felt that this insect might contribute to general unthriftiness of some palms that had unusually heavy infestations by causing drying of fruit on the palm and premature senescence of some older leaves. This scale insect is regarded as unimportant in the Old World and elsewhere *(87, 99, 204)*.

The red date scale normally stays out of the light and is found massed on the white tissue at the bases of the leaves and fruitstalks, where the scales are protected by fiber and leaf bases. Stickney et al. *(227)* provided a comprehensive account of the biology of this insect. Hussain *(116)* gave information on infestation by this scale in Iraq. Under conditions of very heavy infestations, the underlying tissues were damaged to a depth of a few millimeters. The most effective control measure was to subject infested offshoots detached for transplanting to a temperature of 50°C for 65 hours in an insulated room. Chemical control in the field, although sometimes recommended *(116)*, is hazardous to insect predators of other date pests. A few general predators are found in the United States *(227)*, and in North Africa *Pharoscymnus anchorago* is an active predator.

Green Scale

The green scale, *Asterolecanium phoenicis* (Ramachandra Rao), occurs on date palms in Egypt *(88)*, Iran, Iraq, and Israel *(99, 140)*; and Saudi Arabia *(198)*. Gharib *(106)* employs the name *Palmaspis phoenicis* (Ramachandra Rao) for this insect. It may cause severe injury by feeding on all parts of the leaves and on the fruit. Infested parts of the pinnae turn yellow and die. Heavily infested fruits are scarred and reduced in value. In southern Iran, 70 percent of the palms are infested *(106)*. In Iraq, green scale on palms is especially severe where the relative humidity is high *(116)*.

The biology of this scale insect has been studied by Kehat and Amitai *(135)*, Hussain *(116)*, and Gharib *(106)*. Three generations occur annually, with a protracted autumn-winter generation and short generations in early summer and autumn. Nymphs are present continuously, but are most abundant in autumn and early summer, at which times control measures may be applied.

Green scale may be controlled by spraying with malathion, azinphosmethyl, diazinon, or other materials *(106, 140)* combined with oil for control of nymphs in spring and in late autumn. In case of severe infestations, a summer spray may be applied to kill first-instar scales before the crawlers settle on the fruit.

Other Scale Insects

In India, coconut scale, *Aspidiotus destructor* Sign., is an abundant scale pest in winter *(36)*. This scale may form an extensive yellowish crust on pinnae and lead to premature death of leaves. Occasionally, fruit are attacked. Diazinon may be used to control this scale insect. Infestations by several other species of scale insects have been reported *(10, 99, 116, 157, 174, 198, 204, 230)*.

Date Bug

The date bug, *Asarcopus palmarum* Horv., was first noticed in date plantings in the United States in 1922 *(227)* and has been reported from Egypt *(99)*. These bugs sometimes infest weak, young palms, but generally do not affect healthy young or mature palms. Date bugs usually feed on the white tissues of leaf bases, on the unexpanded parts of terminal leaves, and on the bases of the fruitstalks.

The injury consists of superficial, irregular brown areas of damaged tissues. At times, date bugs become numerous enough on small, weak palms to cause the terminal leaves to droop, but control of this pest is not usually necessary in the United States. Date bugs are active throughout the year, though less so in the winter. Populations on date palms consist primarily of nymphal stages. The bugs excrete honeydew, which attracts ants.

Dubas Bug

DISTRIBUTION AND ECONOMIC IMPORTANCE

The dubas bug, *Ommatissus binotatus* var. *lybicus* Berg., also called the Old World date bug or date palm leafhopper, is a serious pest of the date palm. It occurs in Iran *(71)*, Iraq *(69, 94, 113, 116, 152)*, Libya *(252)*, Egypt, Oman, North Africa, Spain, and southeast U.S.S.R. *(99)*. Hussain *(116)* gives the most recent comprehensive discussion of this insect.

If unchecked, the dubas bug periodically develops large populations that ruin the date crop. No quantitative estimates of damage are available, but Dowson *(69)* reported extensive damage among the 7 million palms (approximately 28,000 ha) in the Basra area of Iraq in 1934 and very severe damage in an area of about 800 ha. In 1935, the loss was estimated at U.S. $400,000. In 1957, more than 2 million trees were treated for dubas bug control in Iraq *(99)*.

INJURY

The first infestations occur about May, when nymphs begin to feed on the pinnae. Honeydew is excreted by these insects. Heavy accumulations of honeydew on pinnae and fruits cause them to become discolored, dry, and shriveled. Heavy infestations of dubas bugs, in which thousands feed on each young leaf, are readily observed because of the black drops and crusts formed as dust and fungi collect in the honeydew. Repeated heavy infestations cause weakening and death of some palms *(69, 113, 116)*.

DESCRIPTION AND LIFE HISTORY

The adult female is 5 to 6 mm long and yellowish green. Two black spots are found at the base of the fronds and two on the pronotum. Often, two or more spots are on the vertex and one on each side of the seventh and eighth abdominal segments. Adult males are 3 to 3.5 mm long and lack the four spots on the abdominal segments. The eggs are bright green changing to yellow; they are laid on all green parts of the palm except the fruit, with most deposited on the upper surface of the pinnae. Developmental stages include five nymphal instars. Two generations occur each year in Iraq *(113, 116)*: (1) the overwintering generation, beginning in November, which is initiated with egg laying on leaves; the eggs hatch in April, and (2) the summer generation that arises from eggs laid on leaves in early summer by first generation adults.

CONTROL

Sprays or dusts should be applied when egg hatching reaches 75 percent *(116)*. Among insecticides used for control of the dubas bug in Iran and Iraq, malathion was effective in ground sprays when applied early and thoroughly *(71, 116)*.

Aerial application with ultra low volume (ULV) spray gave good control in both countries *(161)*. Dichlorvos has been used successfully in ULV aerial sprays *(1, 78, 152)*.

The eggs of the dubas bug are parasitized by a small chalcidoid wasp. Larvae of the lace wing, *Chrysopa carna* (Steph.), and adults of *Coccinella septempunctata* L., *C. undecimpunctata* L., and *Chilocorus bipustulatus* prey upon the nymphs and adults *(113)*. Ants are reported to be useful in keeping the insect confined to a small part of the palm *(116)*.

Apache Cicada

DISTRIBUTION AND ECONOMIC IMPORTANCE

The adult Apache cicada, *Diceroprocta apache* (Davis), may be found in large numbers during summer months in the desert regions of the southwestern United States. They infest dates sporadically, and sometimes cause severe damage

in individual palm plantings. During 1961, a considerable loss in date tonnage in California was attributed directly to oviposition by the female cicada *(80)*. Comparable losses recurred in 1962 and 1963 and, in most instances, resulted from heavy migrations of cicadas from adjacent plantings of asparagus, the roots of which are a preferred host of immature stages of this cicada.

INJURY

The primary damage to date palms is the loss of crop caused by female cicadas laying their eggs in the date strands. The injury is easily recognized as a typical wedge-shaped oviposition puncture; each series of punctures is made upward from the basal date to the insertion of the strand into the fruitstalk. On severely damaged strands, the dates shrivel, dry, and fall. Secondary damage to palms may result from immature cicadas feeding on the roots.

DESCRIPTION AND LIFE HISTORY

The adult of both sexes is stout, broad across the anterior end, and from 3.5 to 4.1 cm long. The general color is brown, light to dark brown on the dorsal side and lighter brown on the remainder of the body, with a prominent light-brown band across the back at the base of the transparent wings, which have brown veins. The nymphs are brown and thickset and have strongly developed front legs fitted for burrowing in the ground. This cicada is believed to require 2 years to develop in the ground, where it feeds on the roots of many different plants.

CONTROL

No insecticidal control is feasible on dates because of the flight habits of the female. Paper covers, which in California are normally placed over ripening date bunches to protect them from rain, birds, and certain insects, were used earlier than normal during 1962 for protection against the Apache cicada *(80)*. Complete protection from ovipositing was obtained in all cases where covers where used early enough. Uncovered control bunches had from 25 to 80 percent loss of dates. It would be possible, however, for females to oviposit so early in the season that paper covers installed at such an early date might cause more damage than the cicada. Checking may occur on dates that are covered while still green; this results from increased humidity and sunburn due to intense heat under the paper covers.

Date Stone Beetle

The date stone beetle, *Coccotrypes dactyliperda* (F.), occurs in Algeria *(230)*, Egypt *(37)*, India *(12)*, Israel *(138)*, the coastal areas of Libya *(174)*, and Mexico and the United States *(227)*. Damage is usually negligible, although substantial losses have been reported: 12 percent in the Aglawy variety *(37)*, 45 percent in Bikrai *(174)*, and more than 25 percent in Hadrawi [Khadrawy?] *(138)*.

The beetle is small, 2.4 by 1.06 mm, and dark brown. Larvae are 4 to 5 mm long. The adult female penetrates unripe fruit and lays its eggs on the seed. The larvae penetrate the seed and further generations may develop within the fruit. Buxton *(37)* reported finding single seeds with a total of 40 eggs, larvae, pupae, and adults. In Israel *(138)*, spraying with malathion (25 percent wettable powder) during July gave good control. In the United States, only fallen fruit are attacked, and the pest is unimportant.

Fig Beetle

The fig beetle, *Cotinis mutabilis* Gary and Percheron (= *C. texana* Casey) is found on dates in the United States. A few instances of serious damage to dates have been recorded during years of above-normal humidity. Fermenting fruit are preferred by these beetles but, like the nitidulid beetles, they will puncture and enter uninjured dates. Nichol *(196)* gave a detailed account of the fig beetle.

Nitidulid Beetles

DISTRIBUTION AND ECONOMIC IMPORTANCE

Four species of nitidulid beetles are of economic importance on dates in the Coachella Valley of California *(160)*. They are the corn sap beetle, *Carpophilus dimidiatus* (F.); the driedfruit beetle, *C. hemipterus* (L.), also called fig beetle or two-spotted beetle; the pineapple beetle, *Urophorus humeralis* (F.); and the yellowish nitidulid, *Haptoncus luteolus* (Erich.). Dates on untreated palms in commercial growing districts may be completely ruined by these beetles. Although several species of nitidulid beetles are worldwide pests on dates, there are few estimates of damage from Old World date-growing areas, where *C. hemipterus* is the usual species *(2, 44, 116, 118, 138, 173, 174, 230)*. In 1971, Hussein et al. *(118)* reported 89 percent infestation in untreated fruit at Aswan, Egypt. This beetle seems to prefer certain varieties *(174)*; in 1959, 30 percent of the fruit of the Bikrai variety was damaged by *C. hemipterus* in Tripoli, Tunis. *H. luteolus* was found on date palm in India in 1969 *(14)*.

INJURY

Nitidulid beetles damage ripening and curing dates on the palms, on the ground, and in storage

by entering the fruits, usually at the calyx end, and feeding on the pulp. In addition to the primary damage caused by feeding, the unsightly and unpalatable frass that accumulates, and the presence of larvae, the fruit are also subject to extensive damage by yeasts, other fungi, and bacteria introduced by the beetles. Extensive spoilage may follow a heavy infestation, especially under humid conditions.

DESCRIPTION AND LIFE HISTORY

Carpophilus dimidiatus is oblong, 2 to 3.5 mm long, slightly shiny, and varies from black with a reddish tinge to brownish yellow, with the elytra always paler. *C. hemipterus* is oblong, 2 to 4 mm long, with blackish buff spots on the elytra. It has been reported from the United States and the Old World. This species is very similar to *C. dimidiatus* in appearance. *Urophorus humeralis* is oval to rather broadly oblong, with a length of 3.3 to 4 mm and a width of 1.6 to 1.9 mm. The upper surface of this beetle is very shiny and polished and brown to black, usually with a small pale spot within the humerus of each elytron. This is the largest of the four species described here, and is generally distributed throughout the world. *Haptoncus luteolus* is oval to oblong, 2 to 2.5 mm long, moderately shiny, and uniformly brownish yellow. This species is the smallest of the four. Several other species of nitidulid beetles not listed here are occasionally found feeding on dates in storage.

These nitidulid beetle species develop best at daily mean temperatures averaging about 32° C, which coincide with daily mean temperatures found in the Coachella Valley of California from June to September. High humidity at this time appears to be very important for the development of large populations of beetles. The first new source of food in the date orchards is provided during June when many green fruit drop *(138, 160).* Fallen dates are infested by the first beetles of the season and develop the populations that later infest dates on the palms. Over a period of several months, a single female may produce 500 to 1,000 eggs. The larvae pupate in the soil and overwinter in this manner, although adults can be found in almost any month feeding on fallen dates or on other decaying vegetable matter such as fruit and truck crop refuse. Lindgren and Vincent *(160)* discussed marked variations in the composition of beetle populations in the Coachella Valley. During the 1920s and 1930s, *C. hemipterus* was the dominant species in fruit picked from bunches, but by 1947, *C. dimidiatus* had assumed that role. During the 5-year period 1947-51, inclusive, *C. dimidiatus* made up 90 percent of the population in 4 years and 75 percent in 1949 only, when *C. hemipterus* increased from about 5 to 22 percent; the following year, *C. hemipterus* declined to less than 1 percent. The other species, *U. humeralis* and *H. luteolus,* averaged less than 2 percent annually in fruit picked from bunches during the same 5-year period.

CONTROL

Several investigators have determined the initial and residual toxicity of insecticides to nitidulid beetles *(118, 160, 256).* Residues are reduced to less than one part per million by adequate washing. Malathion was selected for intensive testing as it was effective and less toxic to warm-blooded animals than parathion and dieldrin, the other effective insecticides. In 1952, when beetle infestations were unusually high, malathion dust reduced the number of live beetles in the fruit bunches from over 9,000 to 60. No live beetles were found in treated bunches for 2 weeks following application of malathion dust, and the bunches tended to remain relatively free from live beetles for up to 8 weeks. Since 1953, malathion dust has been recommended for beetle control although other materials have been tested *(79, 85, 256).* In Egypt, malathion, carbaryl, and heptachlor have been used to control nitidulids *(118).* Spraying with malathion emulsion was effective and left no residue in Israeli trials *(138);* it was preferred to 25 percent wettable powder. With the advent in the United States of mechanically harvested dates, early control of these beetles with malathion has become imperative because intact bunches of ripe fruit are left on palms for 1 to 3 months *(84).* An improved pesticide duster developed by Brown et al. *(28)* is used in California. Nitidulid beetles in stored dates may be controlled by fumigation *(38).*

Beetles In Stored Dates

In the United States, the rusty grain beetle, *Cryptolestes ferrugineus* (Steph.), the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), and the merchant grain beetle, *O. mercator* (Fauv.), feed on dates in storage and cause fruit spoilage in much the same manner as the nitidulids. *Oryzaephilus* spp. occur in all date-growing areas of the Old World and are commonly reported as minor pests. They are typical packinghouse and storage insects and are seldom found in newly picked dates. Fumigation and sanitation in the packinghouse keep these three pests under control. Hussain *(116)* discussed several species of beetles that infest stored dates.

Palm Stem Borer

The palm stem borer, *Pseudophilus testaceus* Gah., infests the leaves and trunks of date palms in Egypt *(99),* Iran *(101),* Iraq *(116),* and Saudi Arabia *(77, 175).* Infestations of 79 percent of

palm trunks have occurred in Iraq *(114, 116)*, especially in the relatively humid southern part of the country. This borer causes severe damage in the El-Hofuf district of Saudi Arabia *(77)*. Gharib *(101)* studied the biology of this insect in Iran. A mass of dark-brown gum marks the entrance holes of larvae. During emergence, the adult beetle eats its way out of the trunk, making an oblique tunnel 1 to 14 cm long in the stem. This insect has one generation per year. The adults appear from May to August, depending on the location, and lay their eggs in the crown of the palm. The eggs incubate for about 15 days, and newly hatched larvae burrow into leaf bases. About 3 months later, they migrate and bore into the stem to overwinter in a pupal cell. Palms in dense humid locations are especially subject to attack by this borer *(101)*.

The presence or absence of this borer and the number of emergence holes are major factors in determining the sale price of date orchards in parts of Iraq. Control of the borer is directed at adults before egg laying begins in June and July. In Iraq, the crown of the tree is dusted with aldrin, endrin, or DDT *(116)*.

Indian Palm Weevil

The Indian palm weevil or red weevil, *Rynchophorus ferrugineus* Olivier., is a pest of date palms in the northern arid regions of India and Pakistan *(36, 99, 182)*. It is of questionable occurrence in Iraq *(116)*. Gentry *(99)* also mentioned *R. phoenicis* F. as a pest of date palm. Butani *(36)* gives the most recent account of this weevil in India. Damage is difficult to detect, and when discovered it is usually irreparable. The beetles oviposit in the young leaf bases of the palm, in other succulent tissues, and in cuts made by the rhinoceros beetle, *Oryctes rhinoceros* L.

The larvae and beetles may feed in the crown of the palm or attack young palms at the places where offshoots have been removed. When the crown is attacked, the larvae burrow down to the bud. As the insects mature and reproduce, both immature and adult insects feed on and destroy the crown of the palm. Larvae and adults bore into trunks and make extensive galleries filled with plant fiber and frass. Severely damaged palms collapse. The beetles have a long flying range and may start new infestations over a wide area. The females lay around 200 eggs; the interval from egg to adult is 50 to 90 days. Adults are 35 mm long by 12 mm wide, reddish brown, cylindrical and have a long proboscis. The insects live 2 to 3 months. In India, chemical control consists of treating leaf bases and the crown area with benzene hexachloride or chlordane. Other wounds should be treated with tar or an insecticide.

Fruitstalk Borer

The fruitstalk borer, *Oryctes elegans* Prell, sometimes occurs as a serious pest in Iran *(71, 104)*, Iraq *(114, 116)*, and Saudi Arabia *(99, 175)*. This borer has one generation annually. Adults emerge mostly in April and May just after fruit set and may live until October. Egg laying begins in May, and eggs are laid on both living and dead tissues of the palm; the borers pass the winter as larvae that pupate and emerge in early spring. Larvae are usually present inside the stem of dying or recently killed palms. Adult borers mine the surface of leaf rachises and of fruitstalks. A few to all of the fruitstalk strands may be affected, resulting in poorly developed fruit and heavy cullage. Leaves and fruitstalks may break as a result of severe mining. In Iraq, not more than 2 percent of the fruitstalks are severely damaged; 5 to 20 percent of the crop may be lost as a result of damage by this borer *(104)*. Losses are especially high in young, low trees. Gharib *(104)*, Hurpin and Fresneau *(112)*, and Hurpin *(111)* have studied the biology of *O. elegans*. In Iran *(104)*, a bait containing lindane is recommended for use in the crown of the trees; sanitation is also recommended, including pruning and burning of dead leaves and palms. A few natural enemies were listed by Hussain *(116)*.

Rhinoceros Beetle

The rhinoceros beetle, *Oryctes rhinoceros* L., is reported to be a pest of date palms in India *(36)*. This large, reddish-brown horned beetle emerges in May and is most active during the monsoon season, when it eats into young leaves, unopened spathes, and the soft tissues of the growing point. In addition to primary damage, secondary rots may develop. Young trees are especially subject to attack. The rhinoceros beetle does not fly far from its breeding gounds in dead and rotting vegetable and animal waste. Sanitation to destroy the breeding grounds and a variety of organic insecticides may be used to combat this pest. Insect and animal predators of the larvae are numerous.

Other Coleopterous Borers

Several species of the genus *Oryctes* attack date palms, although only two of the species are of sufficient importance to warrant separate treatment. De Mire *(63)* presented an account of the taxonomic relations, association with date palms, and distribution of seven species: *O. boas* F., *O. elegans*, *O. monoceros* Olivier., *O. nasicornis prolixus* Woll., *O. rhinoceros*, *O. sahariensis* De Mire, and

O. sinaicus Walk. (= *O. agamemnon,* Burm.). *O.* sp. has been reported from People's Democratic Republic of Yemen *(44).*

Apate monachus F. is a pest of date palms in Algeria *(240),* Libya *(174),* Tunisia *(204),* and North Africa *(38).* The larvae bore into the rachis of date leaves and may make one or more galleries up to 12 cm long and 6 to 8 mm wide, with occasional side galleries. The attacked leaves are subject to damage by wind and often break partially or completely. Although it is a minor pest, Pagliano *(204)* urged that broken leaves be pruned back to the trunk and that the affected leaves be burned immediately to destroy the insects. Calcat *(38)* reported that this insect also bores into trunks of weakened palms. He recommended control with paradichlorobenzene or carbon disulfide introduced into the galleries as fumigants.

Adults of the frond borer, *Phonopate frontalis* Fahr., may mine the rachises of date palm leaves *(114).* This borer occurs in Libya *(174)* under the name of *P. frontalis uncinata* Karsch. *P. frontalis* has been reported from Egypt, Iraq, Saudi Arabia, and tropical Africa *(99, 116).* In California *(227)* the giant palm borer, *Dinapate wrighti* Horn, whose usual hosts are *Washingtonia* spp., occasionally may tunnel into the crown of date palms. During 1977, a small infestation of this beetle occurred in Coachella Valley in Halawy and Deglet Noor palms. The palm rhinoceros beetle, *Stratigus julianus* (Burm.), may attack young date palms in Texas and Arizona. Gentry *(99)* and Hussain *(116)* noted the distribution and economic importance of several coleopterous borers of date palm in the Old World.

Indian Meal Moth

DISTRIBUTION AND ECONOMIC IMPORTANCE

The Indian meal moth, *Plodia interpunctella* (Hbn.), is a long-established pest on date palms in the United States. Although worldwide in distribution, it has been mentioned only as a pest of stored dates in Algeria *(230),* Israel *(67),* and Libya *(174).* The larvae of this moth are commonly associated with those of the raisin moth, and damage of up to 8 percent of Medjool dates has been reported in the United States *(159).*

INJURY

The larvae of this species feed on ripe dates in the bunches, in the packinghouse, and on the ground. They enter through any break in the surface or calyx end of the fruit or bore into intact fruit. They seem to prefer the drier, more mature dates in the bunches and even attack the hard date seeds. As the larvae feed, they spin a web in which masses of frass are retained, and a web is also formed over the entrance hole. This damage renders fruit unsalable.

DESCRIPTION AND LIFE HISTORY

The short-lived adult moth is about 1 cm long. The outer half of the forewing is reddish brown with dark markings, and the inner part is gray with a copper-colored band separating the two areas. The life cycle varies from 36 days in summer to 5 months in winter. Eggs are deposited on the skin of the dates and average 170 per female moth. The eggs hatch in 4 to 20 days; the larval period is 3 to 4 weeks and that of the pupa is 2 to 3 weeks *(116).*

The dull-white larvae reach a length of about 13 mm. When mature, they leave the fruit to pupate among dates in bunches, palm trunks, or picking boxes. The pupae are light to dark brown and about 9 mm long.

CONTROL

The Indian meal moth was formerly a packinghouse control problem, and fumigation of all newly harvested dates was mandatory. During the past few years, an effort has been made to reduce populations in the bunches on the palm.

Malathion dust applied about 3 weeks prior to the first fruit pick is recommended for combined control of this moth, the raisin moth, and nitidulid beetles *(256).*

Raisin Moth

DISTRIBUTION AND ECONOMIC IMPORTANCE

The raisin moth, *Cadra figulilella* (Greg.), infests fruit in the bunch and harvested fruit in the United States; in the Old World it is chiefly a pest of stored dates *(2, 55, 67).* This moth is a serious pest of ripening fruit in Israel *(137)* where Kehat et al. *(136)* considered the raisin moth as one of the most important pests. This insect may damage Deglet Noor fruit while on the tree; up to 49 percent damage was found in Deglet Noor fruit and 63 percent damage, in Zahidi fruit *(136).* Larvae of this moth and of the Indian meal moth have caused up to 8 percent loss of Medjool dates in the United States *(159).*

INJURY

Larvae of the raisin moth feed in ripening dates and, if the fruit is not fumigated, develop into adults. In addition to rendering the fruit unsightly and unpalatable, the larvae open the way for secondary organisms to invade and cause spoilage. This species and the Indian meal moth account for a large percentage of the so-called hidden culls, which cause a reduction in fruit grade in the packinghouse.

DESCRIPTION AND LIFE HISTORY

Donohoe et al. *(68)* and Kehat and Greenberg *(137)* studied the biology of the raisin moth. The adult is about 1 cm long and gray, with a few obscure dark bands and spots on the forewings. It lives about 2 weeks in warm weather; during this time, the females lay an average of 350 eggs with a maximum of 690 being recorded *(68)*. In Israel *(137)*, at 30° C, the moth requires 54 to 65 days for full development. Females lay about 160 eggs, especially on the second and third nights after emergence. Eggs are laid on the surface of the dates and hatch in about 4 days. The larvae closely resemble those of the Indian meal moth, but instead of being uniformly white the body is streaked with six rows of lavender-colored dots. Larvae feed for about 1 month on dates in the early khalal stage; full-grown larvae are about 16 mm long. The pupae are brown and enclosed in a silken cocoon, which is spun in hiding places on the palm, in the topsoil, in storage buildings under boards and boxes, or in convenient cracks. Adult moths are most active in the early evening and remain in shaded protected areas during the day.

CONTROL

Malathion dust is used in a combined treatment for control of raisin moth, Indian meal moth, and nitidulid beetles *(256)*. This treatment has kept the percentage of infested fruit low. In Egypt *(2)*, carbaryl and malathion, and in Israel *(137)*, malathion and diazinon, are used effectively as preharvest sprays or dusts. In storage, fumigation with methyl bromide gas kills all stages of the raisin moth. Ethylene oxide is an effective fumigant in date packages. The use of an 80 to 99 percent vacuum, or heating to 60°C for 4 hours, gave 100 percent kill of *Cadra* spp. Kehat et al. *(136)* preferred exclusion of the raisin moth and other insects by wire-mesh bag covers. Insect control is good, and biological control of scale insects and other pests is not upset by application of chemicals. The cost of the bags is rather high, but they last for 8 to 10 seasons, which makes the annual cost reasonable.

Almond Moth

The almond, or fig moth, *Cadra cautella* (Walk.), is the most serious pest of harvested dates in Iraq; infestation may exceed 90 percent in untreated, stored, windfallen fruit *(116)*. El-Baker *(77)* reported this moth in Saudi Arabia. Hussain *(116)*, Teotia and Pandey *(231)*, and Hammad et al. *(107)* have studied the biology of this insect. The fig moth seldom attacks dates on the tree except those of late-ripening varieties. This moth and other *Cadra* spp. may be chemically controlled by the methods used for the raisin moth. Prompt fumigation of harvested fruit and strict sanitary procedures in packing houses and storage facilities control this pest *(116)*. Studies of *Habrobracon hebetor* Say. as a potential predator showed that this insect is not an effective biological control agent for the fig moth *(116)*.

Other Cadra Moths

In addition to the raisin moth and fig moth, other species of *Cadra* whose larvae damage dates during and after harvest include *C. calidella* (Guen.), *C. dowsoniella* (Rich. and Thomp.), *Ephestia (= Cadra) elutella* (Hbn.), and *Anagasta (= Cadra) kuehniella* Zell. *(31, 37, 116, 260)*. *C. calidella* is the most important of these and damages stored dates in many countries, including Egypt, Iraq, Libya, Morocco, and Saudi Arabia *(175)*. The life cycle of *C. calidella* was studied by Prevett *(209)*. Pereau-Leroy *(207)* reported that, in southern Morocco, fumigation was not used, and losses from these insects were sometimes ruinous in the field and in storage.

Lesser Date Moth

DISTRIBUTION AND ECONOMIC IMPORTANCE

The lesser date moth, *Batrachedra amydraula* (Meyr.), causes serious damage in some oases of the Fezzan in Libya *(174)*, but in coastal areas the damage is slight. This moth is a serious pest in the southern and central plains of Iran *(102)*, in Iraq *(72, 94, 116, 152)*, and in the Sinai Peninsula, where Michael *(179)* estimated damage at 75 percent of the crop. At Midiana, Iraq, the quarter million palms may lose practically all of their fruit within 2 months after pollination. No difference in degree of infestation by the lesser date moth has been noted among some 40 date varieties near Basra *(116)*. This insect is reported also from Egypt, India, People's Democratic Republic of Yemen, and Saudi Arabia *(77, 99, 175)*.

INJURY

The lesser date moth is a pest on immature dates in the bunch and in storage. Several investigators *(102, 116, 179, 180)* have studied this insect, which may attack and damage large numbers of young fruits from April to July. In Iran, losses may vary from 20 to 70 percent of the crop *(102)*. The larva spins a web around the fruit to be attacked and attaches some of the fruit to the strands or to other fruit before perforation. The larva then perforates the fruit near the calyx, or less frequently elsewhere, and feeds on the pulp and immature seed. A larva seldom eats more than a third of the fruit before it seeks another and may damage three or four fruit during its

lifetime. About 4 weeks are required for the attacked fruit to darken, dry, and fall. In severe infestations, most of the fruit falls; the bunches cease growing, and then dry *(179)*. The larvae, which attack fruit just before ripening, leave frass and other debris, so that affected fruit must be culled.

DESCRIPTION AND LIFE HISTORY

The adult moth has a wingspread of 11 to 14 mm and is brownish marked by a gray longitudinal central stripe on the narrow forewings. The eggs are small, about 0.7 mm in diameter, and yellow with a pearly sheen. The larvae, when full grown at about 2 weeks, are 8 to 12 mm long. They pupate in 7 to 17 days and develop directly into adult moths. During the summer, two or three generations occur in Iraq, Iran, and the Sinai Peninsula. Martin *(174)* believes that even more generations may occur in Libya. The first spring generation is the most dangerous *(180)*; in Iran, it appears in April *(102)*. The second generation appears in late May, and the third generation appears in July. The larvae of the last generation overwinter in the cocoon and then attack young fruit before they pupate and start the first spring generation of adults. In Libya, Martin *(174)* found that only the last generation larvae developed normally when reared in captivity.

CONTROL

To control this moth, Michael *(179)* recommended the use of one application, 10 days after fruit set, with thionazin or fenthion, with high volume application. This should be supplemented with good sanitation to remove populations of overwintering larvae in fruitstalks, dry fruit, and fiber. In Iraq, Hussain *(116)* recommended DDT malathion, trichlorfon, or diazinon applied about 1 week after fruit set and again 15 to 35 days after the first application. Gharib *(102)* listed several effective insecticides.

A few predators are listed in the literature *(102, 116, 179)*. In Baluchistan, the lesser date moth is excluded from developing fruit by a date fiber covering that is removed 45 to 50 days after pollination *(102)*.

Greater Date Moth

The greater date moth, *Arenipses sabella* (Hmpsn.), occurs in Algeria, Egypt, India, Iran, Iraq, Israel, and Libya *(13, 99, 103, 116, 137)*, where it is a pest of ripening dates and of stored fruit. Hussain *(116)* has published the most recent account of this insect. In Iraq, 50 percent of the spathes and fruit bunches on 70 percent of the palms in some localities may be attacked *(114)*. In Israel *(137)*, *A. sabella* attacks Deglet Noor, Sayer, and Zahidi palms more severely than Khadrawy, Halawy, and Barhee. Damage to palms is more severe in the southern part of Israel than in the northern part. The intensity of infestation fluctuates widely from year to year. In Iran, damage amounts to 5 to 15 percent of the crop *(103)*.

Wiltshire *(259)* and Hussain *(114)* reported that the first damage is seen in March when young larvae are found eating the tips of unopened spathes. When the spathes open, the larvae enter and may strip the flowers and young fruits from whole strands. Their depredations are marked by a coarse silken tunnel, which becomes littered with frass and plant fragments, and which may be 35 cm long when the larva is full grown. Larvae may bore into the base of fruit stalks and mine a gallery 5 to 8 cm long in which bacteria and fungi cause secondary damage. Severely attacked bunches wither and the fruits shrivel, but do not fall. Larvae bore into young leaf midribs and also feed on tender leaflets and immature dates. Adult moths are most commonly seen in April, but are found from March to October.

The biology of *A. sabella* has been investigated by Hussain *(116)*, Kehat and Greenberg *(137)*, and Gharib *(103)*. The egg is 0.2 to 0.3 mm long, somewhat round and white, and requires 4 to 5 days to develop. Larvae and pupae develop in 30 to 40 days; the full-grown larva, 20 to 23 mm long, has a dark head and reddish-brown body. Adults live for one to a few weeks. Two generations a year are produced; the first hatches in March and April from overwintered larvae at the base of leaves and in the fiber. This generation, including all stages, lasts about 12 to 14 weeks. Larvae of the second generation, which hatches in July to September, spin cocoons in which they overwinter for several months. In the vicinity of Baghdad, more than 30 hibernating larvae may be found in a single palm crown. In the spring, the pupal stage lasts about 2 weeks.

Hussain *(116)* recommended the same control measures for this moth as for the lesser date moth; timing to kill the first brood of moths is important. In Egypt, Hussein et al. *(118)* recommended malathion and heptachlor for control of this moth on ripening fruit. *A. sabella* has several natural enemies, including pseudoscorpions and hymenoptera *(116)*.

Phycitine Pyralid Moths

SYSTEMATICS AND DISTRIBUTION

Ectomyelois ceratoniae (Zeller) is widespread in the Mediterranean areas of Europe, Africa, and Asia, where it is a pest on a variety of fruit and nuts. Through introduction in dried fruit, the pest also occurs in central Europe, England, and in the

New World in Florida, Puerto Rico, Jamaica, and Argentina *(55, 108)*. Prior to Heinrich's inclusion of this species in his new genus *Ectomyelois (108)*, this moth was placed in the genus *Myelois* Hübner, where it still stands in much of the economic literature. Five additional names have long been recognized as synonyms of *E. ceratoniae: ceratoniella* Fischer von Roeslerstamm, *pryerella* Vaughan, *zellerela* Sorhagen, *phoenicis* Durrant, and *oporedestella* Dyar; the last name is based on specimens from Florida. Wertheimer's *(258)* reference to *Myelois decolor* Zeller (now *Ectomyelois decolor)* is presumably a misidentification, since this moth apparently occurs only in the New World, in the West Indies, and in northern South America *(108)*. According to Whalley *(259)*, some European authors have erroneously placed *ceratoniae* in the genus *Spectrobates* Meyrick, which was erected for a moth from Java.

E. ceratoniae is widely distributed in Algeria where losses of 10 to 30 percent or more may occur *(158, 253)*. Calcat *(38)* reported that losses in North Africa from infestations by lepidopterous larvae, primarily those of *M. decolor (= E. ceratoniae)*, amounted to 5 to 10 percent of harvested dates and might exceed 12 percent. Losses in the same range were reported by Wertheimer *(258)*, but with some more severe infestations. Recently, Toutain *(240)* reported 80 percent or more infestation by *Ectomyelois* sp. in some lots of dates in Moroccan markets.

INJURY

The larvae attack maturing fruits, especially the drier ones, and cause damage by feeding and by accumulation of frass. Moreover, the larvae work at the base of the fruit and sever the pedicel, causing the fruit to drop. If fruit is not fumigated promptly and stored properly, serious losses may occur.

DESCRIPTION AND LIFE HISTORY

Wertheimer *(258)*, Lepigre *(158)*, and Vilardebo *(253)* have published studies on the *Ectomyelois* moths on date palms. Adult moths have a wingspread of 22 to 24 mm and are creamy white to gray, brownish, or even dark brown. Eggs hatch in 3 to 7 days, and the larval stage may last from 1 to 8 months. Little is known of the pupal stage. The adult lives only 3 to 5 days, during which time the female may lay 60 to 120 eggs; three or four generations are produced annually, in the approximate sequence of April — May, June — July, August — November, and November — March. Although the insects overwinter as larvae in various places, according to Lepigre *(158)* the moths that breed during spring and summer in dates left in the crown of the palms during the previous harvest are a primary source of reinfestation of maturing dates. Calcat *(38)* noted that only the last two generations of moths develop on dates in the bunch.

CONTROL

In recent years, control of *Ectomyelois* spp. by preharvest treatments has reduced the loss of fruit damaged prior to fumigation. Calcat *(38)* reported that benzene hexachloride applied at the beginning of the ripening period reduced infestations to about 1 percent. This treatment should be supplemented by fumigation with methyl bromide and careful storage of the fruit. *Ectomyelois* larvae are aggressively cannibalistic and destroy great numbers of their own kind.

Phanerotoma flavitestacea Fisch. is considered by Biliotti and Daumal *(16)* as a potentially useful predator of *E. ceratoniae*. Other microhymenopterous predators of larvae are unimportant.

Desert Locust

The desert locust, *Schistocerca americana gregaria* (Forsk.), occurs throughout the Old World date-growing areas *(37, 38, 52, 207, 213, 250)*. A recent book on the desert locust *(11)* gives a valuable account of this major insect pest. Many papers pertaining to taxonomy, physiology, behavior, predations, dynamics of the desert locust, and the international organizational structure designed for study and control of this insect may be found in Hemming and Taylor *(109)*. Recent FAO reports *(95, 96, 97, 98)* provide further information on this pest. Dirsch *(66)* revised the genus *Schistocerca*; he designated this insect as *S. americana gregaria* (Forsk.) and discussed the ecology and geographical distribution of this important insect.

INJURY

Heavy migrations into palm plantings are sporadic, but may be devastating. The locusts eat leaves and fruit and may destroy an entire crop; they eat their own weight in food daily, and swarms are measured in terms of square kilometers. Thus, a swarm of 50 km^2 represents about 3,500 metric tons of locusts and a comparable daily loss of crop and other vegetation as a result of their feeding. During a 2-week period in 1954, locust swarms totaled about 2,590 km^2 in the Sous Valley of Morocco and caused extensive damage to orchard and other crops. The damage was estimated at US$ 3 million *(212)*. During the winter of 1958-59, an invasion of this locust in Israel lasted 14 days *(52)*. Palms were completely defoliated and did not renew growth until the following April. Heavy defoliation of palms is undoubtedly reflected in reduced crops for several years, because renewal of an acceptable crown of leaves requires at least 3 years under optimal growing conditions.

CONTROL

Chemical control is effective if applied properly and timed to kill the locusts before they attack the palms. The coordinated use of baits and dusts in breeding and swarming areas and the use of aerial spraying on both ground and flying swarms of locusts have been successful. Since 1959, aerial spraying has come into widespread use. Examples of kills obtained by spraying locusts from aircraft, in terms of locusts killed per gallon of spray, were: 20 percent dieldrin, 2 million; 30 percent dieldrin, 3 million; 11 percent lindane, 1 million *(73)*; 85 percent diazinon, 3 million *(212)*. The numerous factors that affect the success of spraying, baiting, and dusting are summarized in various reports *(15, 64, 73, 74, 75, 76, 226)*.

Hymenoptera

Many different species of bees, hornets, and wasps feed on all kinds of fresh fruit and quite often members of this group cause some damage to dates, particularly soft-fruited varieties *(116, 203)*. This has occasionally led growers to use various types of cloth covers over the ripening fruit to protect it against these pests as well as against rain and birds *(21)*. Hussain *(116)* discussed several species of wasps. The Oriental wasp, *Vespa orientalis* L., may damage up to 35 percent of the fruit in home gardens. The damaged dates are readily infested by larvae of the fig moth, *Cadra cautella*.

Termites

In Mauritania, Lefevre *(156)* reported that termites of the genera *Bellicositermes, Coptotermes, Ibostoma* and *Psammotermes* damaged date palms. Control of termites on individual palms was considered more practical than trying to eliminate the subterranean galleries in which most of these species breed. Benzene hexachloride (25 percent active material) in water applied around the base of each palm provided protection from termite attack for several months.

Another termite, *Microcerotermes diversus* Silv., is a pest of date palms in Iraq *(114)*. This termite attacks roots, trunks, and leaves. It makes galleries in the trunks of weak palms and may cause them to collapse. Newly planted offshoots may be killed by termites. Dieldrin applied around the base of palms in winter and spring provided effective control *(116)*. *Odontotermes sudanensis* Sjost. may heavily infest date palms in Sudan *(99, 202)*. *O. obesus* Rambur is reported to attack date palms in India *(36)*.

Aphids

Date aphids, not identified in text *(94)*, were reported to have become widespread in Iraq during the past 45 years and caused substantial reduction in quality and loss in yield of dates. Malathion spray is recommended for control. Dichlorvos (DDVP) is a potentially suitable insecticide for aerial spraying of this insect. Hussain's *(116)* recent publication makes no mention of aphids in Iraq.

Other Insect Pests

Other insect pests on date palms are mentioned by several authors *(63, 99, 116, 157, 203, 219.)*

FUMIGATION AND PACKINGHOUSE PEST CONTROL

Fumigation of all newly picked dates as they are brought into the packinghouse arrests insect infestations that occur within the fruit *(83, 160, 218, 227, 257)*. Fumigation also helps prevent reinfestation within the packinghouse before the fruit reaches the consumer. Techniques for fumigating dates and the types of chambers and equipment employed in packinghouses in California are described in the papers cited. Methyl bromide is now used almost exclusively in the United States, although carbon disulfide, hydrogen cyanide gas, and a mixture of ethylene oxide and carbon dioxide had been applied previously.

Armitage and Steinweden *(9)* in the United States, Junaid and Nasir *(126)* in Pakistan, and Hussain *(116)* in Iraq have reported on the use of methyl bromide as a date fumigant. Brown and Heuser *(32)* found that methyl bromide penetrated boxes of compressed dates more effectively at reduced pressure than at atmospheric pressure. Methyl bromide is a particularly satisfactory fumigant for date insects because of its high toxicity to all stages of insect life. Its apparently low chemical reactivity with date tissue and low sorption lessen residual odors and flavor changes in the fruit. Methyl bromide is highly toxic to man and should be used with safety precautions. California date packers at the present time use 1 kg of methyl bromide per 62.3 m^3 of storage space at temperatures between 16° and 32° C for 4 hours. Recommendations call for a 24-hour exposure time, but apparently 4 hours is sufficient to kill all pests and to meet packinghouse requirements in the United States *(83)*.

In Iraq, recent recommendations of fumigation of dates with methyl bromide *(116)* call for 1 kg/41.6 m^3 of enclosed space for 24 hours, which gives a complete kill of fig moth larvae and larvae and adults of the saw-toothed grain beetle and other insects. A circulating fan should be used in the chamber. Temperature should not be below 15° C. Outdoor fumigation of dates in field boxes covered with polyethylene tarpaulins at the rate of 1 kg/62.3 m^3 was reported in 1966 *(94, 116)*. A similar method of fumigation is used in California. Outdoor fumigation has been investigated in Israel *(39)*. Recent experiments with hydrogen phosphide and ethyl formate by Vincent and Lindgren *(225)* and with aluminum phosphide by Nelson et al. *(195)* suggest that fumigants other than methyl bromide and ethylene oxide may be useful in controlling pests in stored dates *(160)*. Safety precautions essential in handling fumigants are listed in Dowson and Aten *(72)* and in Hussain *(116)*. Spraying of packinghouses before the date-packing season with malathion has been recommended.

ROOT-KNOT NEMATODES

Root-knot nematodes were found in the Coachella Valley of California on date palms in 1925 *(248)* and are now known to be widely distributed there in commercial date plantings. Buhrer et al. *(34)* first reported the occurrence of root-knot nematodes on this host. Jensen *(125)* reported *M. incognita* (Kofoid and White, 1919) Chitwood, 1949, on roots of date palms in western nurseries. Authors after 1950 identified the nematodes as *Meloidogyne* spp. Carpenter *(40)* reported that root-knot nematodes, principally *M. javanica* (Treub, 1885) Chitwood, 1949, can severely damage or kill date palm seedlings. Young seedlings of 50 date varieties were susceptible to infection by root-knot nematodes; more than 90 percent of the seedlings were killed prior to emergence when seeds were sown in heavily infested soil. Secondary damage by fungi to roots of infested field-grown palms seems to be an important factor in the deterioration and death of roots. Minz *(185)* reported the occurrence of *M. arenaria* (Neal, 1889) Chitwood, 1949, *M. hapla* (Chitwood, 1949), *M. incognita* var. *acrita* (Chitwood, 1949), and *M. javanica* on date palms in Israel.

In Algeria, Lamberti et al. *(148)* reported frequent occurrence of *Pratylenchus penetrans* (Cobb) Filipiev and Schuurmans Steckhoven on date palm roots in the crescent of oases from Beni Ounif to Biskra; *Meloidogyne* sp. was reported only from Sidi Yaïa.

DISEASES

Bayoud

INTRODUCTION

Bayoud, or fusariose, is the most important disease of date palms. It is confined to Morocco and southwestern Algeria, but is a threat to date palms everywhere. The causal organism is a fungus, *Fusarium oxysporum* Schlect. f. sp.[6] *albedinis* (Kill. and Maire) Malençon. Cipolla *(51)* reported studies of a fusariose on date palms in Argentina that might be related to bayoud. Hussain *(116)* noted *F. oxysporum* Schlect. as a pathogen on date palm, but bayoud symptoms were lacking. Pereau-Leroy *(205, 206, 207)* summarized the history of bayoud and previous investigations, including the extensive and valuable contributions of Malençon. Teisseire *(230)* emphasized means for controlling bayoud. In 1965, Toutain *(239)* reviewed the bayoud problem in Morocco and Algeria; Jamoussi *(124)* reviewed bayoud in relation to the threat it might pose for Tunisian date growers. Several recent accounts should be consulted for information on all aspects of the bayoud problem *(42, 65, 164, 165)*.

DISTRIBUTION

Bayoud was first observed in Morocco north of Zagora in the Drâa Valley sometime before 1890. Since then it has spread continously, and, by 1956, the only date-growing area in Morocco still free from bayoud was at Marrakech. It spread more rapidly toward the east than the west *(239)* and by 1898 was recognized at Figuig on the edge of the Algerian Sahara. Thereafter, bayoud appeared in several locations in Algeria south and west of El Golea; it appeared in date plantings at Metlili, north of El Golea, sometime between 1949 *(239)* and 1958 *(38)*. Bulit et al. *(35)* noted recent advances of the disease in Algeria and discussed the potential hazards of further spread. Recent studies in Algeria have shown that bayoud is

[6] f. sp. = forma specialis; a physiologic rather than a morphologic form of a fungus within a species.

definitely at Ghardaia *(41, 127)* and possibly somewhat farther east at Zelfana, according to Brochard and DuBost *(25, 26)* and others *(183)*. Louvet and Toutain *(165)* have recently reviewed the bayoud problem in Algeria. Mercier and Louvet *(178)* found *F. oxysporum* attacking *Phoenix canariensis* Hort, ex Chab. in southern France. The fungus appeared to be identical to the bayoud pathogen and attacked date palm seedlings more readily than those of *P. canariensis*. In the Department of Liguria, Italy, Corte *(56)* identified *F. oxysporum* f. sp. *albedinis* as the cause of a serious bayoud-like disease in *P. canariensis*.

ECONOMIC IMPORTANCE

By 1950, bayoud had killed 10 millon palms in Morocco *(207)*, including the greater part of the vigorous and productive palms of the best commercial varieties, such as Medjool and Bou Feggous. The remaining 5 million palms were predominently seedlings and varieties of only local interest. Areas that formerly had 300 to 400 palms per hectare, and where intercrops were virtually unknown, such as at Bou Denib and at Haut R'teb, were reduced to 5 to 10 palms per hectare. The losses are compounded by the fact that in many oases with an intermittent surface water supply the loss of date palms removes the staple food crop and medium of exchange for which there are no adequate substitutes. Even in oases receiving a regular supply of surface water, no other food crop gives yields comparable to those of the date palm nor the numerous byproducts required for oasis life. The ravages of bayoud have forced the inhabitants to emigrate from some severely affected areas. In Morocco, a well-organized oasis rehabilitation program is underway *(42, 242, 243, 244, 245)*.

Since the fine commercial Deglet Noor date is susceptible *(38, 163, 239)*, bayoud is a particular threat to the principal date-growing areas of Algeria and Tunisia because of intra-Saharan traffic among desert peoples *(124)*.

SYMPTOMS

Symptoms of bayoud appear first on one or more of the recently matured leaves. Typically, some spines or pinnae toward the base of one side of the leaf become white; then, adjacent pinnae whiten as the disease progresses upward along one side of the rachis to the apex. After one side has been affected, the whitening and dying of pinnae progress down the opposite side of the leaf until it is killed. This may take a few days to several weeks. As the pinnae die, a brown stain appears on the dorsal side of the rachis, and the surface of the diseased area becomes depressed. The stain and depression may extend the length and width of the rachis, except on the part hidden under the fiber, which remains alive and turgid indefinitely. A transverse cut through the affected parts of the rachis reveals brownish-red necrotic areas.

Concurrently, adjacent or opposite leaves are affected in like manner, until, finally, one or two whorls of leaves are killed. The old leaves wither naturally as on unaffected palms, but no new leaves form and the terminal bud dies, leading to death of the palm. The average time from the appearance of symptoms to death is 6 months to 2 years; however, palms may die in 1 month or linger for 10 years or more.

Sometimes, the symptoms develop differently. A brownish lesion may appear on the back of the rachis and extend upward until the rachis becomes so narrow that all tissues are affected, and the whole tip of the leaf whitens and dies. The other pinnae then die downward to the base. Other minor variations in the early symptoms may occur, and diseased pinnae may be tinged brownish or reddish depending on the variety. Experienced observers may detect a general slight yellowing in some recently matured leaves 1 or 2 months before the appearance of typical symptoms.

When the trunk of an affected palm is split, vertical reddish bands of diseased tissue, a few square centimeters in extent, are found as well as individual discolored vascular elements. Bulit et al. *(35)* traced the fungus in diseased palms from the roots through the trunk, to the leaf bases, and to the terminal bud. The causal fungus was isolated from typically discolored tissues in all parts of the palm. Diseased roots are present on affected palms. E. Laville (correspondence, 1966) indicated that 4 or 5 diseased roots, among the 800 to 1,000 adventitious roots, on a large palm are sufficient to insure infection. Bulit el at. *(35)* amplified the information on root infection. Malençon *(170)* and Pereau-Leroy *(207)* suggested that death of bayoud affected palms might result from some toxic effect of the fungus rather than from simple congestion of the vascular tissues. They thought this might explain why the offshoots of a diseased palm may persist and develop for up to 10 years after the death of the parent.

PATHOGEN

The causal organism, *F. oxysporum* f. sp. *albedinis*, occurs as a hyaline mycelium between and within the cells in infected, discolored tissues, particularly in the base of the rachis. Microconidia usually occur in groups in vessels and other cells, but they may occur singly.

In culture *(35, 207)*, this fungus produces a rose to violet stain in the medium. Great numbers of spherical to elongated and slightly curved, mostly unicellular, hyaline microconidia are formed, measuring 3 to 15 by 3 to 5 μ The falcate macroconidia are usually four celled and measure 20 to 35 by 3 to 5 μ. The intercalary and terminal

chlamydospores are spherical and occur singly or in groups of two or three. Sclerotia are dark blue to black, 1 to 2 mm in diameter, and occur rarely.

The optimum temperature range for growth of the fungus is 21° to 27.5° C, but it grows reasonably well in temperatures as low as 18° or as high as 32°. Thus, irrigated soils in infested areas of Morocco maintain favorable temperatures for development of the fungus from May through October. The fungus may sporulate abundantly on date trash on moist ground. Substantial differences in pathogenicity among strains of the fungus and among isolates from various parts of the same palm were reported by Bulit et al. *(35)*. They studied isolation of the fungus from soil, where it is found commonly at depths of 30 cm or more and where it may persist indefinitely.

Bounaga *(23)* presented an extensive literature review on *Fusarium* spp. and a detailed account of in vitro studies on the physiology of *F. oxysporum* f. sp. *albedinis*. Among the many aspects of physiology discussed, those dealing with the interaction of soil and water salinity, the date palm, and the pathogen are of special interest to the Algerian bayoud problem. These same interactions and other aspects of bayoud in Algeria were considered by Louvet and Toutain *(165)*, who reported that spread of bayoud was not affected by soil salinity.

INFECTION

The fungus is soil-borne and can be spread by water, wind, diseased offshoots (which carry soil from diseased areas), or infected date tissues, especially infected wood or pieces of rachis. Henna *(Lawsonia inermis* L.) and alfalfa *(Medicago sativa* L.), often grown among date palms, are symptomless carriers of the fungus *(35, 94)*. Infection takes place mainly through the roots, but Pereau-Leroy *(207)* and Malençon *(169, 170)* were unable to find a satisfactory technique for consistently infecting palm roots and producing symptoms. Laville *(151)*, working with seedlings, showed that *Fusarium* does attack roots and can enter the plant through the root system and cause death. Bulit et al. *(35)* used artificially infected seedlings in studies of strains of *F. oxysporum* f. sp. *albedinis*. Malençon *(168)* demonstrated floral infection by this fungus, but this mode of infection is rare, and establishment of bayoud in the palm as a result of floral infection was not demonstrated.

The spread of bayoud to isolated oases and larger date-growing areas was ascribed by Malençon *(170)* to movement of the fungus in articles made of palm tissues, such as packsaddles, baskets, and ropes. Pereau-Leroy *(207)* found that the pathogen persisted for at least several weeks in infected rachis tissues. When such articles are discarded in a moist place favorable to the fungus, it may resume growth, become established in the soil, and infect palms. Bayoud assumes epidemic proportions only when a combination of the pathogen, a susceptible variety, and abundant surface irrigation water exist.

Laville and Lossois *(154)* and Brochard and DuBost *(27)* studied the spread of bayoud at In Salah, Algeria, and discussed the factors involved. About 60,000 palms existed there in 1940; bayoud was first observed in 1943. By 1969, more than 21,000 palms were killed by the disease. The progress of bayoud in a planting of several hectares of Bou Feggous at Zagora, Morocco, was studied by Bulit et al. *(35)* and by Louvet et al. *(163)*. From a small initial infection in 1956, the disease spread to 9 percent of the palms in 1958. By 1964, 60 percent (340 palms) were affected and most were dead. This planting had been cropped with alfalfa and henna at the time of the initial infection; these crops require large amounts of irrigation water in summer, which would favor rapid spread of the fungus on susceptible crops. Toutain *(241)* studied the spread of bayoud in an experimental block in which 83 percent of the young palms died in less than 2 years. After 5 years, 114 of 125 palms were dead. Increased irrigation and soil cultivation apparently hastened spread of the disease.

Diseased palms of susceptible varieties probably never recover, but the advance of infections may be retarded by drastically reducing irrigation. This, however, renders the palm unfruitful so that the crop is lost either through drought or disease.

CONTROL

The use of resistant varieties is the most practical means of controlling bayoud *(165)*. Among six resistant varieties listed by Pereau-Leroy *(207)*, only Takerboucht and Bou Ijjou were of acceptable quality although certainly not equal to Deglet Noor or Medjool. In Morocco *(164, 243, 246)*, extensive data are available on the bayoud resistance of many date varieties, which include the resistant Bou Feggous ou Moussa, Bou Stammi Noire, Iklane, Outoukdim, Sair Layalat, Tadment, and Takerboucht. Louvet et al. *(163)* tested four Tunisian varieties and found all susceptible to bayoud—Deglet Noor de Kabili, Deglet Noor de Tozeur, Ftime, and Okhouet-Ftimi. Breeding might combine resistance to bayoud with the desirable fruit and growth characters of some of the superior commercial varieties. A long-term program for breeding and selection of superior, resistant date varieties for local use and export was begun in Morocco by Pereau-Leroy *(206, 207)* and, after a period of inactivity, has been renewed and greatly augmented *(35, 94)*. An intensive program is underway in Morocco for breeding and selecting bayoud-resistant male and female date varieties *(45, 243, 246)*. Nearly 100,000 hybrid seeds were produced from 1972 to 1974, including hybrids of bayoud-resistant Moroccan female

palms with backcrossed "varietal" male palms (from pollen produced at Indio, Calif.), hybrids between Moroccan female and male lines resistant to bayoud, and other classes of hybrids *(45, 242, 244, 245)*.

Successful utilization of small offshoots would facilitate propagation of desirable resistant varieties; Bulit et al. *(35)* have established small offshoots weighing 2 to 2.5 kg with up to 55 percent survival.

Meanwhile, moderate yields of dates and some mitigation of bayoud may be obtained by careful irrigation and the planting of resistant or semiresistant varieties. Irrigation of infested soil has a profound direct influence on the development of bayoud, and intercrops, especially henna and alfalfa, may have an indirect influence by maintaining high levels of inoculum, according to E. Laville (correspondence, 1966) and Bulit et al. *(35)*. Palms of susceptible varieties growing in infested soil cannot withstand surface irrigation at any season, but may be grown successfully on sites having a permanent water table at a depth of 1 to 2 m.

Semiresistant varieties may be grown successfully if surface irrigation is used primarily for intercrops and applied between October and May only. Resistant varieties tolerate surface irrigation and intercrops at all seasons.

As a precautionary measure, date seed should not be moved from bayoud-infested to noninfested areas. Recently, Locke and Colhoun *(162)* have shown that the fungus *Fusarium oxysporum* f. sp. *elaeidis* Tooney, closely related to *F. oxysporum* f. sp. *albedinis*, can be borne by seed of the oil palm, *Elaeis guineensis* Jacq.

The need for strict quarantine measures to prevent or delay the spread of bayoud and other pests and diseases of the date palm has been recognized by Crossa-Raynaud *(57)*, Delassus and Pasquier *(62)*, Maire *(166)*, and others. The first FAO International Technical Meeting on Date Production and Processing *(93)* recommended enforcement of quarantine measures against bayoud. Algeria *(239)* enacted quarantine legislation in 1942 and 1949, and strong quarantine measures have been enforced in the Sahara and North Africa *(38)*. Mauritania adopted quarantine measures against bayoud in 1953 *(189)*. The United States *(249)* and some other date-growing countries have quarantine regulations covering the movement of date palms and date palm products.

Khamedj

INTRODUCTION

Khamedj, or inflorescence rot, is present in date-growing areas in North Africa from Morocco to Libya *(48, 173, 240)*. It has also been reported from Egypt *(181)*, Iraq *(7, 117, 152)*, Israel *(214)*, Italy *(49, 90)*, Mauritania *(189)*, Saudi Arabia *(3)*, and Tunisia *(57)*. Although inflorescence rots had been known for a long time, the first technical reports on this disease were published in 1925 by Cavara *(46, 47)*, followed by those of Chabrolin *(48, 49)*. Khamedj is a general Old World term for inflorescence rots *(38)*, but refers primarily to that caused by the fungus *Mauginiella scaettae* Cav. *(38, 214)*. Michael and Sabet *(181)* and Al-Ani et al. *(4)* have studied the biology and control of khamedj in the Sinai Peninsula. Inflorescence rots of minor importance are caused by species of *Ceratocystis* (see black scorch) and *Fusarium (30)*.

ECONOMIC IMPORTANCE

Khamedj is a common but usually minor disease problem; however, losses may occasionally be substantial. *M. scaettae* is destructive principally in areas with excessive or prolonged winter and spring rains, on neglected palms in marginal areas of oases, or in waterlogged soil, salty depressions, or low-lying lands. Male palms, which frequently grow in these marginal areas and are communal property, may be particularly heavily infected because they receive little attention except as pollen sources and because the old inflorescences are not removed regularly. Infected inflorescences of both sexes can harbor the fungus. Inflorescences should be removed annually to reduce the possibility of infection of new inflorescences in years favorable to the disease. Al-Ani et al. *(4)* reported that the fungus may persist in inoculated trees at least 5 years, and that the pathogen may spread to adjacent palms.

Infected leaf bases are especially important in perpetuation of *M. scaettae* because they press tightly against the emerging, tender spathes, which may be readily attacked by the fungus under suitable conditions of moisture and temperature. Michael and Sabet *(181)* have implicated the unique pollination spears used in Sinai as carriers of *M. scaettae* spores in contaminated pollen from infested to healthy inflorescences. Fortunately, the affected palms, both male and female, are usually scattered, and the disease does not seem to spread rapidly.

Chabrolin *(48)* estimated that the losses might average 30 to 40 kg of fruit per year on severely affected palms. Trabut *(247)* ascertained that 5 percent of the palms were affected by khamedj in the southern Constantine area of Algeria. Chabrolin *(49)* indicated that up to 10 percent of the palms may be affected in plantings in heavy, wet soil. The disease is so important in some Saharan oases *(48)* that the inhabitants developed empirical means of control, including sanitation and crude chemical treatments, prior to the establishment of modern control measures. Inflorescence rot is the only date disease of eco-

nomic importance *(7, 152)* among the 30 million palms in the Tigris and Euphrates valleys, principally between Baghdad and the Persian Gulf. In Iraq, important outbreaks are sporadic and occur only after prolonged cold, humid weather in the winter. Al-Ani et al. *(4)* found more than 65 percent of palms affected by khamedj in some districts. Fawcett *(90)* considered inflorescence rot the most important disease of date palms in Tunisia. Losses up to 40 percent of the crop have occurred in the Sinai Peninsula.

SYMPTOMS

The disease appears when the spathes begin to emerge in late winter or early spring. At first, affected spathes are barely distinguishable from normal ones. Brownish or rusty areas develop on the unopened spathe after the fungus has already invaded the floral tissues. Lesions may be confluent and are most common near the top of the spathe, which, at the time of infection, is soft and still hidden in the leaf base. The internal face of the spathe, under the lesions, is yellow and translucent and may show brown dots corresponding to points of contact with diseased flowers. The fungus attacks flowers and strands and may move on to the stalk of the inflorescence. Spathes, severely damaged when young, may remain closed; however, the spathe usually splits and reveals partial to nearly complete involvement of the flowers and strands. Typically, certain infected palms develop symptoms every year, whereas others in the same planting show symptoms in the inflorescences only occasionally, even under conditions favorable for disease development.

PATHOGEN

In culture, *M. scaettae* develops a flat, white to cream-colored mycelial mat that is soon covered with chains of hyaline conidia, which give it a powdery appearance *(48)*. The conidial chains fragment into units of one to several cells 10 to 50 μ long and 5 to 10 μ wide. One and two-celled units predominate. The same type of sporulation occurs on infected palm tissues. Germination is much better in tissue extracts or decoctions than in water.

Germination is best at about 21° C, which is in the range of daily maxima from 16° to 24° in Sinai during spathe development *(181)*. Optimum temperature for mycelial growth in vitro is about 20°; the fungus is sensitive to temperatures above 25° and growth is arrested at 30° to 35°.

On infected tissues, the fungus forms a distinctive white mycelial web, which later disappears, leaving a whitish bloom of spores on the surface. Spores are considered to be short-lived and not of much importance in the persistence of the fungus, which presumably survives in old tissues as mycelium. The fungus, which is capable of direct penetration of the spathes, is an aggressive parasite. The role of contaminated pollen in the spread of the disease was ignored, in spite of R[ayner's?] *(214)* comments on the lack of study of this and other aspects of khamedj, until the recent work of Michael and Sabet *(181)*. R[ayner?] considered *M. scaettae* unable to spread readily into uncontaminated areas because the spores are short-lived and transportation of infected tissues would be negligible. Nevertheless, in France, Anselme and Baltzakis *(8)* found this pathogen occurring as a rot of packed date fruit where a piece of infected strand was present. Fancy packs of Deglet Noor dates from North Africa often contain a piece of date strand for decoration.

CONTROL

Good sanitation is the first step in the control of khamedj. All diseased parts of the inflorescence should be collected and burned immediately after harvest, and in all palms the old flowerstalks and spathes should be cut out as completely as possible and removed from the planting. Fungicides should be applied immediately after harvest to the old flowering area of diseased palms, and in early spring on the new flowering area just before the spathes emerge. Chabrolin *(48)* reported good control by spraying with bordeaux mixture or a strong lime-sulfur solution, or by dusting with a copper sulphate-lime mixture, essentially powdered bordeaux mixture. Laville *(152)* recommended sprays of dichlone and thiram *(172)*. Dust was cheaper and more easily applied than spray in small plantings.

In Iraq, Al-Ani et al. *(5)* obtained good control of khamedj with one spray of Tuzet applied sometime from November to January. In the coastal oases of Sinai, Cupravit and Du-Ter were the most effective fungicides *(181)*, when applied three times — postharvest, December, and January-February. Michael and Sabet *(181)* emphasized that sanitation, consisting of removal of old leaves, leaf bases, and inflorescences, and application of fungicide should be organized on a community basis for really effective control. Al-Ani et al. *(4)* reported differences in susceptibility of 15 date varieties. In vitro studies on the effect of several fungicides on *M. scaettae* were made by Ismail *(123)*.

According to Teisseire *(230)*, the Ghars variety is more susceptible than Deglet Noor, and Tafezouine, Hamraia, and Takermest are resistant. Zahidi and Hillawi are somewhat resistant, but Khadrawy and Sayer may be severely attacked *(4, 152)*.

Fruit Rots

DISTRIBUTION AND ECONOMIC IMPORTANCE

Preharvest fruit rots may be caused by one or more of a large number of fungi *(29, 91)* and occur

wherever dates are grown. The economic importance of fruit rots varies greatly, since their incidence is governed by the occurrence of rain and high humidity during the khalal and later stages of ripening. Darley and Wilbur *(61)* reviewed fruit spoilage in California. Although losses of 25 percent or more occurred sporadically in individual gardens or districts, they estimated the annual loss from fungus spoilage at about 5 percent when paper covers, fungicidal dusts, and spreader rings were used. The cost of control measures and the cost of damaged fruit make fruit rots the most important economic disease of dates in California.

Estimates of loss from fruit rots are seldom reported from the date-growing areas of the Old World, although such rots occur. Kearney *(129)* noted that rains at harvest-time in Tunisia sometimes caused serious losses of fruit. To circumvent rain damage, dates are often harvested either individually or in bunches while in the late khalal to the early rutab stages, and the fruit are then ripened on mats, on racks, and in other ways *(38, 70, 72, 182)*. In Algeria *(38)*, late-maturing varieties like Deglet Noor may be damaged by rain and fruit rots in unfavorable years, with losses reaching 25 to 30 percent. In Israel *(52)*, fruit rots occur in late varieties such as Deglet Noor and Barhee.

PATHOGENS AND DISEASE DEVELOPMENT

Species of *Alternaria, Helminthosporium,* and *Macrosporium* may infect fruit directly, beginning in the khalal stage. Fawcett and Klotz *(91)* also found *Citromyces ramosus* Bain & Sart. and *Aspergillus niger* van Tiegh. causing a calyx-end rot in the late khalal or early tamar stages. Rieuf *(216)* discussed *A. niger* and *A. phoenicis* (Cda.) Thom in relation to date fruit rots. Zambettakis and Nicot *(262)* made a recent detailed study of *A. phoenicis*. These and numerous other species of saprophytic fungi, among which yeasts are important, also invade ripening fruits through wounds, especially during periods of rain and high humidity when fruits may crack or split and provide easy entry for fungi. The Deglet Noor variety is especially liable to such injury. The discussion by Nixon *(203)* of the factors involved in fruit rots is of general application in date culture.

CONTROL

Losses from fruit rots may be reduced by several means *(61, 203)*. In the United States, the following procedures used alone or in combination, and mostly on Deglet Noor palms, have been effective in reducing fruit rots. Prior to the khalal stage, wire rings may be inserted in the bunches to promote good ventilation and drying of wet fruit. Even in the absence of rain, dew may form on low-hanging fruits of young palms. In the late green or early khalal stage, Deglet Noor bunches are covered with paper wraps or bags to exclude rain; some growers cover other varieties. During the mid- to late-khalal stage, dust may be applied to the fruit bunches to reduce fungal spoilage and to control insects *(20, 256)*. The dust, which is available under several trade names *(203)*, consists of 5 percent ferbam, 5 percent malathion, 50 percent sulfur, and 40 percent inert carrier. Fruit rots may be aggravated by cultural conditions that increase humidity, such as weeds, intercrops, and standing water. These conditions should be taken into account in planting and maintaining date orchards.

Graphiola Leaf Spot

DISTRIBUTION AND ECONOMIC IMPORTANCE

Graphiola leaf spot is caused by *Graphiola phoenicis* (Moug.) Poit. It is the most widespread disease of date palms and probably occurs wherever the palm is cultivated under humid conditions *(91, 153)*, which prevail in many suboptimal to marginal date-growing areas. Dates are, nevertheless, an important crop in such areas; however, crop yield may be reduced by premature death of Graphiola-infected leaves.

Graphiola leaf spot is common on palms in the Punjab *(182, 223)* where rainfall ranges from 150 to 600 mm during March to August, inclusive. Fawcett *(90)* found leaf spot to be the most common disease of dates in Egypt, especially in the Delta and at Fayoum. He believed that the commonly severe infections near the coast "must interfere considerably with the growth and production of the palms." In Egypt, old and diseased leaves are removed as a sanitary measure; Fawcett *(90)* implied that excessive pruning could reduce date yields. Leaf spot often occurs in the humid coastal areas of North Africa and the Near East *(3, 77, 173, 198, 199, 201)*, but the disease is of little importance in the principal interior date-growing areas of North Africa *(49)*. Graphiola causes serious damage to palms in several of the southernmost, humid date-growing areas of Mali, Mauritania, Niger, and Senegal *(171)*, and occurs in Argentina *(87)*.

PATHOGEN AND DISEASE DEVELOPMENT

G. phoenicis was described by Fischer *(92)*, and Killian *(145)* established its taxonomic position as one of the smut fungi. The fungus develops subepidermally in small spots on both sides of the pinnae and on the rachis. Finally, the fruiting structures emerge as little, black, covered sori, which are often numerous. In India, sori are absent on 1-year-old leaves, conspicuous on 2-year-old leaves, and their numbers continue to increase during the third year. Sori are most abundant on apical pinnae *(223)*.

The sori are 1 to 3 mm in diameter and consist of two layers; the outer peridium is hard, dark, and persistent, but the inner hyaline peridium is thin and degenerates after the spores mature. Spores are produced in fertile areas of the sori and are interspersed with groups of sterile filaments. At maturity, the sori open to liberate masses of yellow spores. Individual spores are spherical to ellipsoidal, 3 to 6 μ in diameter, and have a thick, smooth, hyaline wall. After the spores are disseminated, only the rough black craters of the sori remain. Heavily infected leaves die prematurely. The histopathological effects of *G. phoenicis* were studied by Shiam and Sharma *(221)*.

CONTROL

Leaf pruning *(90, 182)* is the usual practice for reducing damage from *Graphiola* leaf spot. Spraying with bordeaux mixture has been recommended by Milne *(182)* and later authors. Nixon *(199)* studied the relative susceptibility of date varieties in Texas and concluded that a few varieties, especially Kustawy, were tolerant to *Graphiola*. Sinha et al. *(223)* studied the *Graphiola*-tolerance of 25 date varieties. The seven resistant varieties included Barhee, Adbad Rahman, Gizaz, Iteema, and three Egyptian selections. Tolerant varieties might be useful either directly or in breeding improved varieties *(45)*.

Black Scorch

Black scorch, which includes medjnoon, or fool disease *(110)*, is a minor disease of sporadic occurrence. It is caused by *Ceratocystis paradoxa* (Dade) C. Moreau. The fungus is normally present on date palms only in the imperfect form *(Thielaviopsis)*. Black scorch has been reported from Algeria *(90)*, Egypt *(31, 90)*, India *(90)*, Iraq *(152)*, Saudi Arabia *(198)*, Tunisia *(90)*, and the United States *(146)*. In Mauritania, Brun and Laville *(33)* found this fungus associated with the bending-head disease described by Munier *(190)*. No estimates of loss are available.

The investigations of Klotz and Fawcett *(146)* and Streets *(228)* provide the principal information on black scorch. All parts of the palm are susceptible to infection by *C. paradoxa*. Symptoms are usually expressed in four fairly distinct forms: black scorch on the leaves, inflorescence blight, heart or trunk rot, and bud rot on palms of all ages. Infections are all characterized by slight to extensive death of the tissues. Bud rot and heart rot, though uncommon, are the most damaging manifestations of *C. paradoxa* and may kill the plant. Some palms recover, probably by development of a lateral bud, and these show a characteristic bend in the region of infection. This is the medjnoon or fool disease symptom.

In Iraq, this fungus is associated with a decline and death of palms in the Shatt al Arab region. Laville *(152)* believes that infection is associated with sudden changes in the level and salinity of the water in this region.

The imperfect form of *C. paradoxa* develops rapidly on host tissues or in culture. Two types of spores are produced — hyaline, cylindrical microconidia, measuring 5 to 15 by 3 to 7 μ, and dark, egg-shaped macroconidia, measuring 11 to 17 by 7 to 15 μ. Between the two types may be found all gradations in size and shape and in intensity of brown coloration.

Infected tissues become blackish brown, then shrivel and form conspicuous lesions with a scorched, carbonaceous appearance. Dark conidia may develop abundantly on the lesions. With bud rot and inflorescence rot, where the tissues invaded are relatively succulent, secondary organisms may develop rapidly and augment the damage. Black scorch has been observed on 17 date varieties *(146)*. No infections were found on the Tazizoot variety, and Deglet Noor seemed less affected than other commercial varieties; Thoory was the most susceptible. *C. paradoxa* may be partly controlled by removing and burning all infected leaves and inflorescences. Dusting of the area where the inflorescences emerge with powdered bordeaux mixture in early spring is a suggested control measure.

Diplodia Disease

Diplodia disease is a minor disorder caused by *Diplodia phoenicum* (Sacc.) Fawc. & Klotz *(91)* in the United States; a second species, *D. natalensis* P. Evans, was reported on date palms in Israel *(184)*. The disease has also been reported from Egypt and Morocco *(90, 240)*. No estimates of loss from *Diplodia* disease are available. Fawcett *(89)* investigated this disease in California, where at one time it caused considerable damage. The fungus may infect and even kill young offshoots at the base of palms; it may infect the outside leaves and then finally kill the younger leaves and terminal bud, or the central leaf cluster may die before the older leaves. Yellowish-brown streaks, 15 cm to about 1 m in length extend along the leaf base and rachis. The lesions become brownish; internal infection and necrosis may be extensive in leaf tissues. The disease was observed on 17 varieties in California.

The most common spores of *D. phoenicum* in culture or in dead tissues are hyaline. Mingled with them are the typical dark, septate spores of *Diplodia*, which measure 22 to 24 by 10 to 12 μ. The light-colored spores are somewhat larger and mostly unicellular. Dark, intercalary chlamydospores are produced abundantly in cultures. Pycnidia may develop on dead leaf tissues.

Fawcett *(89)* believed that the fungus usually enters palms through wounds. Faulty irrigation, causing some roots to die back to the base of the palm, may be associated with the disease. In Israel *(44),* benomyl is used as a spray or slurry to spray young offshoots or to dip detached offshoots, respectively. Disinfection of pruning tools is suggested.

Omphalia Root Rot

Omphalia root rot *(19, 143, 144)* is a minor disease of date palms in the United States. The causal fungi, *Omphalia tralucida* Bliss and *O. pigmentata* Bliss, are fairly widely distributed in palm plantings in the Coachella Valley of California and have been isolated from the roots of many varieties and seedlings. Although *Omphalia* spp. are pathogenic on palms *(19),* apparently no constant association exists between the presence of these fungi and visible decline symptoms. The fungi have been isolated from both healthy and declining palms, but not all declining palms — as indicated by loss of vigor, stunting, and unfruitfulness — yielded these fungi *(143).* Poor cultural practices apparently produced identical decline symptoms, especially in Deglet Noor, which at one time was considered especially susceptible to *Omphalia.* KenKnight's *(143)* data showed plantings of Deglet Noor to have a lower percentage of infected palms than those of any other commercial variety at the time of his survey in 1945-48. In 1965, Sachs *(219)* found both species of *Omphalia* in Mauritania on four palm varieties. He reported studies on the fungi and their control.

Belâat

Belâat is a minor disease of the date palm in Algeria caused by *Phytophthora* sp. It was first described in 1935 by Maire and Malençon *(167),* and Maire *(166)* published a more detailed account. Monciero *(186)* and Calcat *(38)* also have discussed belâat. Toutain *(240)* implied that the disease occurs in Morocco. No estimates of the losses caused by belâat have been published.

Belâat usually occurs in neglected plantings. On affected palms, the entire central cluster of young leaves may turn white fairly rapidly. Infection occurs near the growing point in the form of a wet heart rot that kills the bud and the bases of the youngest leaves. The infection may be arrested a short distance below the bud or continue downward. Secondary organisms rapidly follow the initial infection. Some affected palms recover by producing a lateral bud. Offshoots of diseased palms usually remain healthy.

Brown Leaf Spot

Rieuf *(217)* described a brown leaf spot of date palms, incited by *Mycosphaerella tassiana* (De Not.) Johns., in the Ziz and Draa valleys of Morocco. Dark lesions are clearly delimited on green leaves, and on dying leaves the margin of the lesion remains reddish brown as the center becomes pale and whitish. Lesions also occur on the rachis and spines. Perithecia appear on the lesions either singly or alined parallel to the vascular strands. This minor disease also occurs in Tunisia. A review of species of *Mycosphaerella* and *Didymella* that occur on Palmaceae is given by Rieuf *(217).*

Bending Head

Bending head, or "le coeur qui penche," is an uncommon, but fatal, disease of unknown cause reported from Tunisia *(110),* Egypt *(31),* and Mauritania *(190),* where Brun and Laville *(33)* found *Thielaviopsis (= Ceratocystis paradoxa)* and *Botryodiplodia theobromae* Pat. associated with it. They suggested that these fungi are essentially secondary parasites, attacking palms weakened by drought or poor cultural practices.

The symptom from which the common name derives *(190)* takes the form of a grouping of the terminal leaves into an erect fascicle with a bent tip. These leaves eventually die and fall. Meanwhile, older leaves die and hang vertically. These symptoms are commonly associated with a basal heart rot in the palm. Where bud rot or infection of the upper stem occurs, the leaves may die and fall more or less to one side. The symptoms may be intermediate and are not always diagnostic of the type of rot involved; after the palm dies, the trunk bends and may break. To limit spread of the disease, Munier *(190)* recommended that all portions of infected palms be burned on site.

Other Fungi on Date Palms

A black leaf spot of date palm in Egypt, incited by *Chaetosphaeropsis* sp., has been described from Egypt *(187).*

Fungi described as occurring on *Phoenix* spp. were listed by Rieuf *(217).* The fungi may be of some importance locally or under unusual circumstances; the leaf pathogens can probably be controlled by systemic and/or persistent surface fungicides. The host plants are: *P. dactylifera, P. canariensis, P. hanceana* var. *formosa* [nomen nudum], *P. natalensis* [nomen nudum], *P. reclinata,* Jacq., *P. sylvestris* (L.) Roxb., and *P.* spp.

Lethal Yellowing

Symptoms of lethal yellowing, a major disease of the coconut palm, *Cocos nucifera* L., were first reported in Florida in trees of *Phoenix canariensis* and *P. reclinata* in 1974 *(232)* and later in *P. dactylifera (176)* and *P. sylvestris (208).* About 15 other species of palms have been reported as hosts

of this devastating disease, which has been known in coconut palm plantings for nearly a century in the West Indies, the circum-Caribbean countries, and West Africa *(210)*. Diseased coconut palms were found in Florida at Key West in 1955 and at Miami in 1971. In less than 5 years, 80 percent (280,000) of the coconut palms in the Miami area were killed *(176)*.

The symptoms of lethal yellowing, as described for coconut palms, are given *(176, 188)*. Premature falling of nuts is an early symptom, followed, in the next set of flowers, by blackening of the tips of the inflorescences, so that most of the male flowers may be discolored, even in the unopened spathe. Spathes may be discolored, rather than creamy-yellow. In the next stage, the lower leaves turn yellow and deteriorate. Disease symptoms progress upwards, through the leaves of the crown, until the youngest leaves are affected; light-brown, watery streaks appear in the leaf tips of the youngest leaves and move downward. Secondary organisms may invade the terminal bud area and produce a foul-smelling rot. Finally, the top of the palm may fall off. In date palm and some other palm species, the leaves do not yellow, but become dry and gray-brown; again, the older leaves are the first to be affected.

The characteristic mycoplasmalike organism associated with lethal yellowing has been observed by electron microscopy in tissues of the *Phoenix* species listed here. The organism is presumed to be transmitted from tree to tree by an unknown insect vector as evidenced by rapid field spread that may approach epidemic proportions. Nearly 100 percent of the susceptible palms in an infested area are eventually affected. Coconut palms are usually killed in 4 months.

In Florida, where the coconut palm is a valuable ornamental tree, preventive treatment of diseased palms with oxytetracycline is recommended *(176)*. Quarantine measures *(54, 176)* have been taken to prevent spread of this disease within Florida and to other parts of the United States. Countries in which dates and other palms are grown should undertake suitable quarantine measures to prevent spread of lethal yellowing into their territories. Since the disease is presumably vector-spread, infected ornamental palms could provide localities from which the disease may spread to commercial date palms.

Faroun

This is a local name for a rapid and fatal date palm decline of unknown cause reported from Mauritania in 1967 by Laville and Sachs *(155)*. Female and male palms are affected. The first symptom is a failure of apparently normal palms to flower for one or two seasons before foliage symptoms appear. Affected trees become conspicuous when they assume a parasol form produced by the old and middle rank leaves being held somewhat horizontally. Subsequent new leaves and their pinnae are reduced and distorted, until finally the central portion of the crown becomes a grotesquely stunted rosette. These symptoms are accompanied by abortion of the axillary buds, which would account for failure of the palms to flower. Offshoots are affected on some diseased palms. Internally, palms in advanced stages of decline have numerous brown gum pockets and long dark-colored cracks in the crown tissues. Similar cracks occur in leaf bases near the point of attachment to the trunk. No causal agent has been identified; an insect, *Piezodorus pallescens* [no authority in text] has been found frequently in the crown tissues of affected palms.

Rapid Decline

Rapid decline, or rhizosis, is a minor but fatal disease of unknown cause, which has been observed on date palms in California for more than 40 years. Darley and Wilbur *(60)* reviewed previous work on this disease and reported new investigations. The onset of symptoms is rapid. Typically, vigorous female palms in full production suddenly shed a large part of the immature fruits in summer, but if a palm is affected later, the fruits shrivel on the bunch. A reddish-brown discoloration occurs on pinnae of the oldest leaves, and, almost simultaneously, the unexpanded young leaves wilt. Mature leaves die rapidly and progressively toward the top of the palm. Offshoots, if any, usually die with the parent plant, and, thus, the disease tends to be self-limiting. Male palms are also affected. There is no indication of a disease pattern since single affected palms occur at random. No varietal resistance has been noted. Serious losses have occurred in only a few plantings.

Al - Wijam

Al-Wijam is a minor date palm disease of unknown cause in Saudi Arabia *(77, 198)*. Affected palms of several varieties are stunted, become unfruitful, and eventually die. The only unique symptom is "a faint, narrow, yellow, longitudinal line" on the midribs of the younger leaves. The decline occurs whether conditions for growth and fruiting are favorable or unfavorable. El-Baker *(77)* recommended that the areas where such plants are growing be avoided when selecting offshoots for propagation.

Barhee Disorder

Barhee disorder is the name given to a bending of the crown of Barhee date palms *(58, 59)* that occurs in most of the fruiting plantings of this variety in California and at Basra, Iraq *(116)*. The Barhee palms in California are all derived from a single importation from Basra in 1913. Affected

palms are usually over 3 m high and bend to an angle of from 5° to nearly 90° from the perpendicular; 80 percent of them lean to the south. About 50 percent of the palms in a 10- to 33-year-old planting have been affected for at least 15 years. The number of fruiting bunches is reduced in direct relation to severity of bending. Affected palms may recover and resume upright growth. Neither the cause nor the control of this disorder is known. Barhee disorder does not appear to be related to bending head *(33, 70, 190)*.

Blacknose

Blacknose is a physiological disorder of date fruits reported from the United States *(203)* and Egypt *(31)*. The melanose described by Munier *(190)* appears to be the same disorder and is reported to occur in Mauritania and throughout North Africa. Although no official statistics are available, in California the annual loss from blacknose on Deglet Noor dates may approach 5 percent of the crop. About 80 percent of the acreage in California is planted to this variety. Exceptional losses of 50 percent or more in individual plantings have been reported *(197)*. In Egypt *(31)*, Hayani is the most susceptible variety and the one most widely grown.

Blacknose results from excessive checking of the epidermis,especially in the form of transverse cracks at the stylar end of the fruit, and subsequent drying and deterioration of the underlying tissues. Aldrich et al. *(6)* summarized the literature on blacknose and reported on physiological investigations of checking in Deglet Noor dates. Nixon *(203)* gave a more recent account in 1969. Checking is induced by high humidity and rainfall at the late green stage just before the fruit acquires its khalal color. Therefore, conditions that tend to increase humidity, such as standing water, excessive soil moisture, presence of intercrops, and weeds should be avoided, especially at this stage of fruit development. Overthinning can also increase the incidence of checking and subsequent development of blacknose. Careful attention to irrigation, cultivation, thinning, and ventilation may mitigate the damage.

Whitenose

This is a disorder of Halawy and Zahidi dates in Iraq *(116)* that occurs as a whitish, dry ring at the calyx end of ripening fruit. Prolonged dry winds in the early rutab stage cause rapid maturation and desiccation of the fruit, which results in the appearance of this symptom. The incidence of this physiological disorder is low in humid areas along the Shatt al Arab, but may amount to 20 to 70 percent in inland desert areas. The affected fruits have a high sucrose content compared with that of normal fruits. Use of heat and moisture (hydration) will correct the condition in harvested fruit. This disorder may be comparable to that called "hard-end" of dates by growers in California.

Internal Browning

Internal browning designates a disorder found in California in young to ripe fruit of several date palm varieties *(43)*. The cause of this disorder is unknown; no pathogen or other incitant has been identified. There is no degeneration of ripening fruit involved in this disorder. Discrete brown lesions are found in the tannin cell layer of fruits from shortly after pollination until the khalal stage. As the fruit increases in size, the original lesions may become diffuse, apparently by intrusion of normal parenchyma into the tannin cell layer. New lesions may develop during the growth of the fruit. External evidence of the lesions is uncommon, although lesions may be visible during the yellow khalal stage of some varieties. In Deglet Noor fruit, a small, dark depressed area may appear near the stylar end of ripe fruit. The fruit of Medjool is especially susceptible to this disorder. During the rutab stage, the symptoms of internal browning are obscured by darkening of the fruit. Because internal browning becomes inconspicuous and does not seem to have any adverse affect on commercial fruit quality, it is a minor defect of little economic importance *(43)*.

Crosscuts

Crosscuts, which appear as clean breaks in the tissues of the lower part of fruitstalks on palms, may vary from a slight notch to complete breakage of the stalk. Fruits on strands in line with the break wither and fail to mature properly. Sayer is especially susceptible to this disorder. In the United States, up to one fourth of the crop may be lost; in 1934, about 1,000 fruit bunches were lost in a single planting in California because of crosscuts. Because of this disorder, Sayer is no longer propagated in Israel. Khadrawy is also susceptible to crosscuts, and the disorder is especially common in this variety in Israel *(44)*. Loss of fruit in Khadrawy may be substantial as a result of partial or complete damage to bunches by crosscuts. Bliss *(18)* concluded that crosscuts result from an anatomical defect in the fruitstalk, involving internal, sterile cavities or fractures that lead to mechanical breakage during elongation of the stalk. Crosscuts are most commonly found in varieties having crowded leaf bases and the incidence of crosscuts increases as the palms

age. Loss from crosscuts may be avoided by using nonsusceptible varieties, or by leaving a few extra fruitstalks per palm in susceptible varieties *(18)*. Similar crosscuts or V-cuts occur occasionally in leaves *(91)*.

Dry Bone

Dry bone is a minor disease of the date palm reported from Egypt and Tunisia *(90)* and from the United States *(91)*. Fawcett and Klotz *(91)* thought it might be caused by a bacterium. The principal symptoms on the leafstalks, midribs, and pinnae are whitish, irregular blotches and streaks that become sharply delimited and that may have reddish-brown margins. The lesions vary from one to several centimeters in the greatest diameter, but involve only the epidermis and a thin layer of subjacent tissue.

Black Scald

According to Nixon *(203)*, black scald is a minor date fruit disease of unknown cause occurring in the United States. Well-defined blackened areas appear on the tip and sides of the fruit, and affected tissues have a somewhat bitter taste. Black scald does not seem to be related to blacknose.

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APPENDIX

Glossary

The words in the Glossary are defined as they apply to the subject matter in the handbook. More detailed and different definitions of the same words may be found in standard dictionaries and glossaries of biological terms. Terms consisting of two or more words are listed under the most significant word.

The discipline to which a word in the text applies is indicated thus: *Agr.* = agriculture; *Biol.* = biology; *Bot.* = botany; *Chem.* = chemistry; *Ent.* = entomology; *Mycol.* = mycology. Plural endings other than "s" are given in parentheses.

Acaricide *Chem.* A chemical used primarily to control plant-feeding mites.

Adventitious root *Bot.* A root that develops directly from the trunk of the date palm, other than the primary root, which develops at seed germination.

Anterior *Biol.* In front; placed in front.
Apical *Biol.* At the tip or apex of a part or organ.
Asexual *Biol.* Any type of reproduction not involving gametes, that is egg or sperm cells or their counterparts.
Axillary *Bot.* Refers to the point on a stem (axis) where a leaf arises; a bud is usually formed in the upper angle of leaf and stem.
Backcross (pl.-es) *Bot.* In date breeding, the mating of a first, or subsequent, generation male hybrid palm with the original female parent, with the object of accumulating in male progeny the genetic characteristics of the female parent.
Biological control *Ent.* Field control of insects and mites by the action of predatory and parasitic insects and mites that destroy the economic pest.
Calyx (pl. -es) *Bot.* The cluster of small, thick, overlapping scale leaves at the base of the date flower; the cup or disk to which the fruit is attached.
Chalcidoid *Ent.* Refers to the family of chalcid wasps (Chalcidoidea) that includes many species parasitic on other insects.
Chlamydospore *Mycol.* A thick-walled, asexual fungus spore derived from a hyphal cell; a resting spore.
Coleopterous *Ent.* Pertaining to beetles, family Coleoptera.
Conidium (pl. -ia) *Bot.* An asexual fungus spore usually produced on a specialized hypha or in a spore-bearing organ. Conidia are often thin-walled, short-lived, and capable of immediate germination.
Culture *Mycol.* Growth and maintenance of fungi and other micro-organisms, usually in a sterile environment, see Medium.
Dorsal *Ent.* Pertaining to the back or upper side of an insect.
Elytron (pl. -ra) *Ent.* Either of the pair of hardened forewings in beetles and certain other insects which act as protective covers for the rear wings.
Falcate *Biol.* Crescent- or sickle-shaped.
Frass *Ent.* The excrement of insects; that of larvae and boring insects is often conspicuous.
Frons (pl. -ntes) *Ent.* A facial area of an insect head between the mouthparts and the eyes.
Fruitstalk *Bot.* In the date, the heavy stalk supporting the flower and fruit-bearing strands.
Hectare *Agr.* A metric measure of land equaling 10,000 square meters; 2.47 acres; abbreviated: ha.
Histopathology *Biol.* Detailed study of the interaction of the host tissue and the pathogen.
Honeydew *Ent.* A sugary secretion of certain insects.
Host *Biol.* An organism that harbors and provides nourishment for a parasite.
Hyaline *Biol.* Colorless, or translucent; in fungi, hyaline bodies may appear to be white or pale.
Hypha *Mycol.* The threadlike, vegetative filaments forming the vegetative body of a fungus; see Mycelium.
Inflorescence *Bot.* In date palms, the complex flowering structure of either male or female palms.
Instar *Ent.* A developmental phase between molts in the growth of certain insects.
Intercalary *Mycol.* A cell, or spore, bounded by two or more adjacent cells; not apical or basal.
In vitro *Biol.* In an artificial environment outside the living organism; literally, in glass.
Isolate *Mycol.* A pure culture of a fungus or other micro-organism.
Khalal *Bot.* The first phase in maturation of date fruit after the full-grown green stage is reached. Fruit assumes a characteristic color from pale green through yellow to dark maroon. The khalal phase ends when the fruit begins to soften or dehydrate; see Rutab, Tamar.
Larva (pl. -ae) *Ent.* In insects with complete metamorphosis, an immature, worm- or grub-like stage between egg and pupa.
Lesion *Biol.* An abnormal change in the structure of an organ or part due to injury or disease.
Macroclimate *Biol.* The overall climate of an extensive region or larger geographic unit.
Macroconidium (pl. -ia) *Mycol.* In fungi with two conidial forms, the larger spore form.
Medium (pl. -ia) *Mycol.* A solid or liquid nutrient preparation on which fungi and other micro-organisms are grown.
Metamorphosis (pl. -ses) *Ent.* In insects, the series of stages in development from egg to adult.
Microenvironment *Biol.* A small, sometimes isolated, area and its physical and biological components; a microhabitat.
Microconidium (pl. -ia) *Mycol.* In fungi with two conidial forms, the smaller spore form; microconidia may be formed in, and move within, the vascular tissues of plants.
Microclimate *Biol.* The climate of a small, specific place, especially in relation to a given object or a group of associated objects.
Microhymenopterous *Ent.* Refers to minute and often parasitic insects, especially wasps, of the order Hymenoptera.
Molt *Ent.* A shedding of the outer covering (exoskeleton) of an immature insect as it progresses from stage to stage.
Mycelium (pl. -ia) *Mycol.* The vegetative part of a fungus, composed usually of a mass of branched hyphae; see Hypha.
Mycoplasma *Biol.* An essentially unicellular, microscopic organism without a true cell wall, reproducing by fission or budding, requiring sterols in its nutrition, and less organically developed than a bacterium.
Nymph *Ent.* An immature stage in insects with simple metamorphosis.

Offshoot *Bot.* In date palm, a shoot produced by development of an axillary bud, usually at the base of the parent tree. The only plant part adapted to asexual propagation of the date palm.

Oviposition *Ent.* Deposition of eggs by insects, in some species through a specialized, piercing ovipositor at the end of the abdomen.

Parasite *Biol.* An organism that is harbored on, derives its nourishment from, and damages another organism.

Parenchyma *Bot.* A living plant tissue composed of thin-walled, unspecialized cells.

Pathogen *Bot.* In plants, a usually microscopic organism that incites a diseased condition; common pathogens include nematodes, fungi, bacteria, mycoplasmas, and viruses.

Pathogenicity *Mycol.* A measure of the activity or aggressiveness of a pathogen in a host-pathogen relationship.

Pedicel *Bot.* The short stem that attaches the individual date flower to the strand.

Peridium (pl. -ia) *Mycol.* In many fungi, the outer wall or walls of a spore-bearing organ.

Perithecium (pl. -ia) *Mycol.* Simple or complex organs, frequently with a hardened outer wall and a spherical base, in which the sexual spores of certain fungi are produced.

Pinna (pl. -ae) *Bot.* A leaflet on a compound palm leaf.

Pollination *Bot.* In cultivated date palms, the manual or mechanical application of pollen to female flowers. In nature, the date palm is wind-pollinated.

Predator *Ent.* An insect that feeds on another insect; predacious. See Biological Control.

Proboscis (pl. -ses) *Ent.* A sucking organ of insects that is often adapted also for piercing.

Pronotum (pl. -ta) *Ent.* The upper surface on an insect prothorax; the prothorax is the body region just behind the head.

Pupa (pl. -ae) *Ent.* An essentially immobile stage between larva and adult in insects with complete metamorphosis; frequently a resting stage.

Pycnidium (pl. -ia) *Mycol.* A simple or complex organ, frequently with a hardened outer wall and a spherical base, in which asexual spores are produced.

Rachis (pl. -ses) *Bot.* The main rib or axis that supports the pinnae (leaflets) of a palm leaf.

Resting spore *Mycol.* A thick-walled spore that remains dormant until conditions favor renewed growth.

Rhizosis *Mycol.* A name applied to rapid decline of the date palm when the pathogen was considered to be a root-(=rhizo) inhabiting fungus.

Rutab *Bot.* The second phase in fruit maturation in which the date begins to soften or dry into its typical condition.

Saprophyte *Mycol.* A fungus that grows on nonliving matter.

Sclerotium (pl. -ia) *Mycol.* A dense, frequently hardened, mass of fungus tissue that serves as a resting organ until conditions favor renewed growth.

Sorus (pl. -ri) *Mycol.* A spore-bearing organ which, in *Graphiola,* has a hard outer wall; see Peridium.

Spadix (pl. -ices) *Bot.* In palms, the flower-bearing structure; see Spathe.

Spathe *Bot.* The sheath enveloping a date inflorescence (spadix); the spathe is closed prior to flowering.

Spore *Mycol.* In fungi, the common reproductive body, corresponding to a seed in higher plants; a spore may be asexual or sexual in origin.

Sporulation *Biol.* The production and release of mature spores by fungi.

Strain *Mycol.* A line of individuals derived from a given plant or plant part.

Stylar *Bot.* Refers to the apex of the fruit, on which the styles are situated.

Tamar *Bot.* The third and final phase in fruit maturation, in which the date assumes its characteristic color, form, and texture.

Taxonomy *Biol.* The identification, naming, and classification of living organisms.

ULV spray *Chem.* In the United States, an ULV (ultra low volume) spray is one applied at the rate of 1 gallon or less of undiluted pesticide per acre (3.785 liters/ha).

Vascular *Bot.* Pertaining to the food and water conducting tissues in plants.

Vector *Biol.* An agent capable of transmitting a pathogen from one organism to another either mechanically or biologically; in the latter case, the vector may incubate and harbor the pathogen for a characteristic period of time.

Vertex (pl. -xes) *Ent.* In insects, the top of the head between the compound eyes.

Mites and Insects Discussed in Text[1,2,3]

Scientific Name	Common Name	Order-family
Anagasta kuehniella (Zeller)	Mediterranean flour moth	Lepidoptera-Pyralidae
Apate monachus Fabricius		Coleoptera-Bostrichidae

See footnotes at end of list.

Mites and Insects Discussed in Text [1,2,3]—Continued

Scientific Name	Common Name	Order-family
Arenipses sabella (Hampson)	greater date moth	Lepidoptera-Pyralidae
Asarcopus palmarum Horvath	*datebug	Homoptera-Issidae
Aspidiotus destructor Signoret	*coconut scale	Homoptera-Diaspididae
Asterolecanium phoenicis (Ramachandra Rao)	green scale	Homoptera-Asterolecaniidae
Batrachedra amydraula (Meyrick)	lesser date moth	Lepidoptera Cosmopterygidae
Bellicositermes spp.		Isoptera-Metatermitidae
Cadra calidella (Guenee)	currant moth	Lepidoptera-Pyralidae
C. cautella (Walker)	*almond moth	Do.
C. dowsoniella (Richard & Thompson)		Do.
C. figulilella (Gregson)	*raisin moth	Do.
Carpophilus dimidiatus (Fabricius)	*corn sap beetle	Coleoptera-Nitidulidae
C. hemipterus (Linnaeus)	*driedfruit beetle	Do.
Cocotrypes dactyliperda (Fabricius)	date stone beetle	Coleoptera-Scolytidae
Coptotermes spp.		Isoptera-Rhinotermitidae
Cotinis mutabilis Gary & Percheron	fig beetle	Coleoptera-Scarabaeidae
Cryptolestes ferrugineus (Stephens)	*rusty grain beetle	Coleoptera-Cucujidae
Diceroprocta apache (Davis)	Apache cicada	Homoptera-Cicadidae
Dinapate wrighti Horn	giant palm borer	Coleoptera-Bostrichidae
Ectomyelois ceratoniae (Zeller)		Lepidoptera-Pyralidae
Ephestia elutella (Hübner)	*tobacco moth	Do.
Haptoncus luteolus (Erichson)	yellowish nitidulid	Coleoptera-Nitidulidae
Ibostoma spp.		Isoptera-Termitidae
Microcerotermes diversus Silvestri		Do.
Myelois spp.		Lepidoptera-Pyralidae
Odontotermes sudanensis Sjöstedt		Isoptera-Termitidae
O. obesus (Rambur)		Do.
Oligonychus afrasiaticus (McGregor)	Old World date mite	Acarina-Tetranychidae
O. pratensis (Banks)	*Banks grass mite	Do.

See footnotes at end of list.

Mites and Insects Discussed in Text [1,2,3]—Continued

Scientific Name	Common Name	Order-family
Omatissus binotatus var. *lybicus* Bergevin	dubas bug	Homoptera-Tropiduchidae
Oryctes agamemnon Burmeister		Coleoptera-Scarabaeidae
O. boas (Fabricius)		Do.
O. elegans Prell	fruitstalk borer	Do.
O. monoceros (Olivier)		Do.
O. nasicornis prolixus (Wollaston)		Do.
O. rhinoceros (Linnaeus)		Do.
O. sahariensis De Mire		Do.
Oryzaephilus mercator (Fauvel)	*merchant grain beetle	Coleoptera-Cucujidae
O. surinamensis (Linnaeus)	*saw-toothed grain beetle	Do.
Parlatoria blanchardi (Targioni-Tozzetti)	*parlatoria date scale	Homoptera-Diaspididae
Phoenicococcus marlatti Cockerell	*red date scale	Do.
Phonopate frontalis Fahraeus	frond borer	Coleoptera-Bostrichidae
Phyllotetranychus aegyptiacus Sayed		Acarina-Tenuipalpidae
Plodia interpunctella (Hübner)	*Indian meal moth	Lepidoptera-Pyralidae
Psammotermes spp.		Isoptera-Rhinotermitidae
Pseudophilus testaceus Gahan		Coleoptera-Cerambycidae
Raoiella indica Hirst		Acarina-Tenuipalpidae
Rhynchophorus ferrugineus Olivier	Indian palm weevil	Coleoptera-Curculionidae
R. phoenicis Fabricius		Do.
Schistocerca americana gregaria (Forskal)	desert locust	Orthoptera-Acrididae
Stratigus julianus Burmeister	palm rhinoceros beetle	Coleoptera-Scarabaeidae
Urophorus humeralis (Fabricius)	pineapple beetle	Coleoptera-Nitidulidae
Vespa orientalis Fabricius		Hymenoptera-Vespidae

[1] Common names that have been accepted by the Committee on Common Names of Insects of the Entomological Society of America *(147)* are marked with an asterisk (*). The other common names are those widely used.

[2] Revised February 1976 by Marius S. Wasbauer, Systematic Entomologist and Curator, and Staff, Laboratory Services/Entomology, Division of Plant Industry, California Department of Food and Agriculture, Sacramento.

[3] Predatory and parasitic insects involved in biological control are not included.

Common and Chemical Names of Pesticides Mentioned in This Handbook [1]

[The superscript (D) indicates a common name officially designated by the U.S. Department of Agriculture]

Common Name	Chemical Name
Aldrin[D]	1,2,3,4,10,10-hexachloro-1,4,4*a*,5,8,8*a*-hexahydro-1,4-*endo*-5,8-dimethanonaphthalene.
Aluminum Phosphide	Aluminum phosphide, *See* Hydrogen phosphide; Phostoxin.
Areginal	*See* Ethyl formate.
Azinphosmethyl	*See* Guthion.
Baytex	O, O-dimethyl O-[3-methyl-4-(methylthio) phenyl] phosphorothioate. *See* Fenthion.
Benomyl	Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate.
Benzene hexachloride[D]	*See* BHC.
BHC	1, 2,3,4,5,6-hexachlorocyclohexane.
Bordeaux mixture	Hydrated lime and copper sulphate.
Calcium polysulfides	*See* Lime sulfur.
Carbaryl	1-naphthyl *N*-methylcarbamate. *See* Sevin.
Carbon disulfide[D]	Same; also named Carbon bisulfide.
Chlordane[D]	1,2,4,5,6,7,8,8-octachloro-2, 3, 3*a*,4, 7, 7*a*-tetrahexahydro-4,7-methanoindane.
Copper oxychloride	Basic cupric chloride. *See* Cupravit.
Copper sulfate-lime	*See* Bordeaux mixture.
Cupravit	*See* Copper oxychloride.
Cygon	*See* Dimethoate.
DDT[D]	1,1,1-trichloro-2,2-*bis*(*p*-chlorophenyl) ethane.
DDVP	2,2-dichlorovinyl dimethyl phosphate. *See* Dichlorvos.
Diazinon	*0,0*-diethyl *0*-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate.
Dichlone[D]	*See* Phygon.
Dichlorvos	*See* DDVP.
Dieldrin[D]	Hexachloro-epoxy-octahydro-*endo, exo*-dimethanonaphthalene.
Dimethoate[D]	0,0-dimethyl *S*-(*N*-methylcarbamoylmethyl) phosphorodithioate. *See* Cygon.
Dipterex	*See* Dylox; Trichlorfon.
Du-Ter	Triphenyltin hydroxide. *See* Fentin hydroxide.
Dylox	Dimethyl (2,2,2-trichloro-1-hydroxyethyl)phosphonate. *See* Dipterex; Trichlorfon.

Common and Chemical Names of Pesticides Mentioned in This Handbook [1] — Continued

Common Name	Chemical Name
Endrin	Hexachloroepoxyoctahydro-*endo, endo*-dimethanonaphthalene.
Ethylene oxide	1,2-epoxyethane.
Ethyl formate	Same; *see* Areginal.
Fenthion[D]	*See* Baytex.
Fentin Hydroxide	*See* Du-Ter.
Ferbam[D]	Ferric dimethyldithiocarbamate.
Guthion	*O,O*-dimethyl *S*-[(4-oxo-1,2,3-benzotriazin-3(4*H*)-y1) methyl] phosphorodithioate. *See* Azin phosmethyl.
Heptachlor	1,4,5,6,7,8,8-heptachloro-3*a*.4.7. 7*a*-tetrahydro-4,7-methanoindene.
Hydrocyanic acid	Hydrogen cyanide
Hydrogen cyanide	*See* Hydrocyanic acid.
Hydrogen phosphide	*See* Aluminum phosphide; Phostoxin.
Lime sulfur	*See* Calcium polysulfides.
Lindane[D]	Gamma isomer of 1,2,3,4,5,6-hexachlorocyclohexane.
Malathion[D]	*0,0*-dimethyl *S*-(1,2-dicarbethoxyethyl) phosphorodithioate; or *0,0*-dimethyl-phosphorodithioate of diethylmercaptosuccinate.
Methyl bromide	Bromomethane.
Oxytetracycline	4-(dimethylamino)-1,4,4a,5,5a,6,11,12a-octahydro-3,5,6,10,12,12a-hexahydroxy-6-methyl-l,11-dioxo-2-naphthacenecarboxamide. *See* Terramycin.
Para-dichlorobenzene	1,4-dichlorobenzene.
Parathion[D]	*0,0*-diethyl *0*-*p*-nitrophenyl phosphorothioate.
Phostoxin	*See* Aluminum phosphide.
Sevin	*See* Carbaryl.
Sulfur	Same.
Tedion [V 18]	*S*-*p*-chlorophenyl 2,4,5-trichlorophenyl sulfone; 2,4,5,4'-tetrachlorodiphenyl sulfone. *See* Tetradifon.
Terramycin	*See* Oxytetracycline.
Tetradifon[D]	*See* Tedion.
Thionazin	*See* Zinophos.

Common and Chemical Names of Pesticides Mentioned in This Handbook [1] — Continued

Common Name	Chemical Name
Thiram[D]	Bis (dimethylthio-carbamoy1)disulfide; or tetramethyl-thiuram disulfide.
Trichlorfon[D]	*See* Dipterex, Dylox.
Tuzet	*See* Urbacid.
Urbacid	Bis(dimethylthio-carbamoylthio)methyl-arsine. *See* Tuzet.
Zinophos	*0,0*-diethyl *0*-2-pyrazinyl phosphorothioate. *See* Thionazin.

[1] The information in this list was abstracted from: SHEPARD, H. [consulting editor]. 1977 FARM CHEMICALS HANDBOOK. Meister Publishing Co., Willoughby, Ohio. [Paged sectionally.] 1977.

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