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SERIOUS ECONOMIC PESTS OF COFFEE THAT MAY ACCIDENTALLY BE INTRODUCED TO HAWAI'I

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Cover Photo: Dark brown to black lesions characterizing coffee berry anthracnose.

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SERIOUS ECONOMIC PESTS OF COFFEE THAT MAY ACCIDENTALLY BE INTRODUCED TO HAWAI'I

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INTRODUCTION

Most of the world's coffee production involves two species of coffee, *Coffea arabica* and *C. canephora*. About 75 percent of coffee exports is *C. arabica* grown in Central and South America. The remaining 25 percent is mostly *C. canephora* produced in Africa and Asia. There are several other minor coffee species, but these comprise a very small fraction of the world market.

Coffee was introduced to Hawai'i in the 19th century. Presently, coffee is grown on all of the major islands except Ni'ihau and Lāna'i. The hectareage in 1992 was 1093 (excluding Kaua'i).

Coffee pests in Hawai'i are few with insects being the most important. The green scale, *Coccus viridis* (Green), is the most serious insect threat throughout the year on Kaua'i and in the drier parts of Kona (Krauss 1931). There are several other insects that attack coffee plantings. These may be classed as occasional or minor pests unless conditions change, populations increase, and economic losses occur. The insects that attack coffee in Hawai'i are as follows:

Coleoptera (Beetles):
- Family: Anthribidae
  - *Araecerus fascicularis* (DeGeer), Coffee Bean Weevil
- Family: Scolytidae
  - *Xylosandrus compactus* (Eichhoff), Black Twig Borer
- Family: Curculionidae
  - *Asynonychus godmani* (Crotch), Fuller Rose Beetle

Diptera (Flies):
- Family: Tephritidae
  - *Ceratitis capitata* (Wiedemann), Mediterranean Fruit Fly

Homoptera (Scales, Mealybugs, Flatids):
- Family: Coccidae (Scales)
  - *Coccus viridis* (Green), Green Scale
  - *Pulvinaria psidii* (Maskell), Green Shield Scale
  - *Saissetia coffeae* (Walker), Hemispherical Scale
- Family: Pseudococcidae (Mealybugs)
  - *Dysmicoccus brevipes* (Cockerell), Pineapple Mealybug
  - *Geococcus coffeae* (Green), Coffee Root Mealybug
- Family: Flatidae (Flatids)
  - *Melormenis basalis* (Walker), West Indian Flatid

Hymenoptera (Bees, Wasps, Ants):
- Family: Formicidae (Ants)
  - *Anoplolepis longipes* (Jerdon), Longlegged Ant
  - *Pheidole megacephala* (Fabricius), Bigheaded Ant

Coffee is commercially produced in regions of Asia, Africa, Oceania, North America, Central America, and South America. Each of these areas has insect pests and diseases that play an important role in the production of coffee and the economy of the region (Barret 1966; Buyckx 1962; Sanchez-De Leon 1984; Waller 1988).

Of the many diseases and species of insects that attack coffee in other parts of the world, pathogens and insects that could be accidentally introduced into Hawai'i in infested coffee berries or beans are a source of great concern. Shipments of green coffee berries into Hawai'i are the most likely paths for introduction of these dreaded pests and diseases into the state. Currently, there are no serious diseases of coffee in Hawai'i. Therefore, Hawai'i agriculture regulations require a permit to import green coffee for roasting. The imported coffee must be fumigated and all emptied coffee bags must be destroyed.

Many species of nematodes are associated with coffee roots and some are very damaging to coffee. The only nematode of concern in the state is a newly described species of root-knot nematode, *Meloidogyne konaensis*, that is prevalent in Kona. Nematodes such as *Meloidogyne incognita* and *Rotylenchulus reniformis* have been reported as pests. However, these have been demonstrated to be of minor importance. In fact, most coffee cultivars are very poor hosts of these two nematode species.

M. konaensis has been found on four farms and at the Kona Branch Station. The nematode develops and survives best at approximately 24°C. Above this temperature, mortality increases rapidly. Coffee is considered to be a relatively poor host for this nematode because the juveniles require about 7 days to penetrate the roots and approximately 45 days to complete their life cycle, about twice the time required to develop in a good host. Coffee is a poor host, but is highly susceptible to damage because it delays the completion of the life cycle of the nematode. One nematode (effective inoculum) per plant in a 15.2-cm pot caused significant root necrosis and suppression of plant growth. Furthermore, the growth rate of coffee in the field is significantly reduced by this nematode.

The purpose of this publication is to provide information about serious diseases and pests of coffee not present in the Hawaiian Islands that can be accidentally introduced on or in coffee berries brought in for seed purposes. Particularly, we focus on those diseases and pests that could be a threat to coffee production in Hawai'i. The publication is designed to serve as a reference for growers, county agents, consultants, researchers, and quarantine personnel. It is the hope of the authors that this illustrated research-extension circular will enable users to identify these diseases and pests of coffee, to recognize and prevent their introduction, and to help manage possible serious outbreaks if they are accidentally introduced.

AMERICAN LEAF SPOT

This disease is known in the coffee regions of the Americas as *ojo de gallo*. Its literal translation is "rooster's eye." The pathogen *Mycena citricolor* (Berk. & Cur.) Sacc. has a wide host range on many perennial plants. The symptoms on the foliage are buff white or reddish brown and/or dark brown circular lesions measuring 15 to 18 mm in diameter. The fungus produces numerous fine stalks bearing sulfur-yellow gemmae resembling pin heads (Figure 1) on the surface of the necrotic lesions. These gemmae are removed from the lesions by splashing rain and are carried by wind. The fungus invades mostly the leaves causing severe defoliation and high yield losses (Sanchez-De Leon 1984). However, in severe epidemics, the fruit (Figure 2) and the stems of young flowering shoots are also affected.

The disease is not severe in sun-exposed coffee, except in areas with overcast skies, light rains in the afternoon, and temperatures below 23°C (Figure 3). Shaded coffee is most severely affected by this pathogen during the rainy season. Therefore, shade trees are heavily pruned during this period to allow sunlight to dry the coffee leaves and improve ventilation of the canopy. Coffee trees may also require partial pruning. Copper fungicides at 3 to 6 kg/hectare are used in areas with high incidence of the disease. The fungicides are applied 15 days before the start of the rainy season with a second application made 30 days later.

KOLEROGA

Koleroga or web blight is caused by *Ceratobasidium koleroga* (Cke.) von Höhnel *sensu* Talbot. This pathogen is aggressive on shaded coffee during warm, humid weather (27 to 30°C and 100 percent relative humidity [RH]). The rhizomorphs of the fungus grow on the surface of young shoots bearing fruit and on the underside of leaves (Figure 4). Rhizomorphs feed on the host with microscopic root-like organs known as haustoria which penetrate the cells of young shoots, fruit, and leaves. The invaded organs wilt, become dark brown, and die. Abscised, dry, dead leaves remain hanging from dead tree branches attached to each other by the dark brown rhizomorphs of the fungus.

Adequate ventilation and sufficient pruning of shade and coffee trees is necessary for effective control of the disease with copper fungicides (Sanchez-De Leon 1984). This disease is not important in sun-exposed coffee. Fungicides not registered the United States for use on coffee, e.g., Benomyl (Benlate 50WP) at 100 g/200 l water and 125 ml of spreader-sticker, and captafol (Difolatan 80WP) at 1 kg/200 l water and 125 ml of spreader-sticker, are used to control this disease in Central America.

Figure 1. Symptoms of American leaf spot on coffee leaves. Typical buff to white, circular lesions (left leaf); reddish brown, irregular spots with buff centers (center leaf); and dark brown, circular lesions (right leaf).

Figure 2. Immature coffee berries infected by *Mycena citricolor*, showing brownish black, discolored lesions and sulfur-yellow gemmae on whitish fungal stalks.

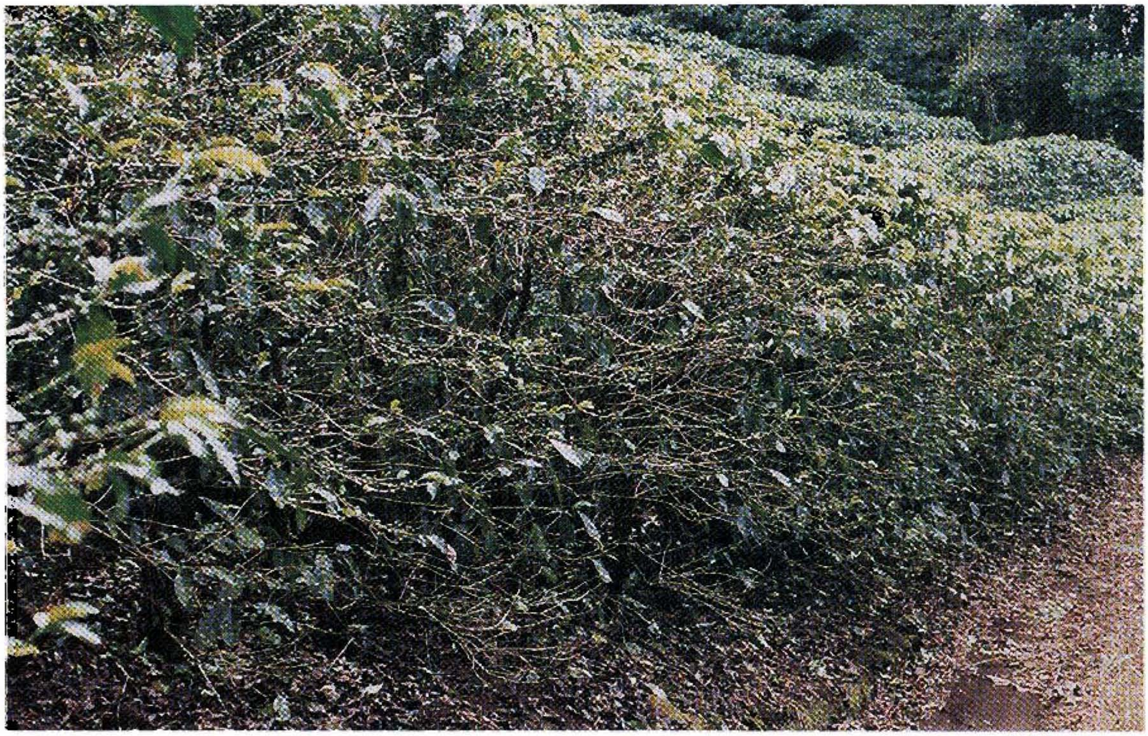

Figure 3. Severe defoliation caused by American leaf spot in a Costa Rican sun-exposed coffee plantation at 1450 m. This farm was frequently cloud covered, had light rains in the afternoon, and had daytime temperatures below 23°C.

Figure 4. The dark brown rhizomorph of *Ceratobasidium koleroga* on the surface of a young coffee branch. Note web-blight symptoms and dry leaves hanging from dead terminal branchlet.

CERCOSPORA LEAF SPOT

Mancha de hierro (iron spot) is the descriptive name for this disease in Central American coffee regions. The symptoms of the disease produced by *Cercospora coffeicola* Berk. & Cke. are circular, reddish brown leaf spots measuring up to 10 mm in diameter (Figure 5) and sunken, dark brown spots on green and ripening fruit measuring 1 to 4 mm in diameter (Figure 6). Observations made by the senior author in Guatemala, Costa Rica, and Panama in 1992 revealed two types of leaf spots caused by *Cercospora* spp.: the typical reddish brown circular leaf spot and a brown-black irregular leaf spot (Figure 5). High incidence of the disease causes severe defoliation, dropping of immature coffee berries, and damage to ripening berries (Figure 7). The infected pulp of ripening berries turns dark brown and leathery and becomes firmly attached to the parchment covering the green coffee bean (Figure 6). These mummified berries make processing difficult and lower the grade and quality of the product. The disease is severe in low-elevation Central American coffee farms (Sanchez-De Leon 1984) which have high daily average temperatures and relative humidity. The fungus sporulates abundantly on leaf lesions and on diseased berries during nocturnal periods of high humidity and temperatures of 25°C (Sanchez-De Leon 1984; Siddiqui 1970). When favorable environments for disease occur in Central America, farmers spray Difolatan and Ferbam at 1 kg/200 l and 100 ml of Triton B-1956 biweekly to control the disease.

ANTHRACNOSE

Coffee anthracnose is caused by *Colletotrichum gloeosporioides* Penz *sensu* von Ark (= *Colletotrichum coffeanum* Noack). Lesions on the leaves are angular, irregular in outline, dark brown, zonated, and large (Figure 8). On berries, lesions are superficial and are dark brown to black (Firman and Waller 1977). The fungus invades the whole pulp and the berry becomes black and dries. The dead pulp tissues stick firmly to the parchment and are difficult to remove during processing (Figure 9). Dark brown lesions are common on the surface of infected green beans. High incidence of anthracnose is common during prolonged wet periods with temperatures above 27°C. Under these conditions, the disease causes rapid defoliation of trees, kills

Figure 5. Coffee leaves showing symptoms of *Cercospora coffeicola*. Left, typical reddish brown lesion known as iron spot in Central America. Right, blackish brown, irregular leaf spot caused by *Cersospora* sp. in Central America.

Figure 6. Sunken, dark brown spots on green and ripening coffee berries caused by *Cercospora* sp.

Figure 7. Premature defoliation and dropping of fruit caused by *Cercospora* sp. on shaded coffee in Guatemala at intermediate elevations. The severity of this disease is high during prolonged periods of wetness, high humidity, and 25°C temperatures at night.

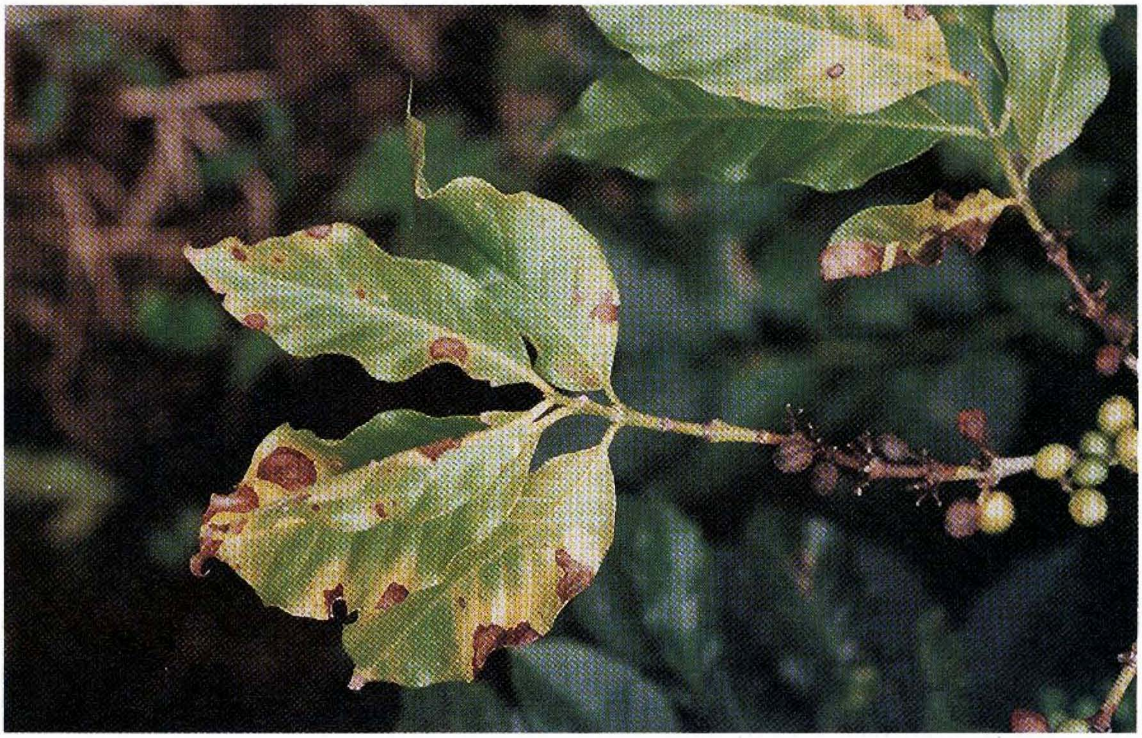

Figure 8. Anthracnose leaf symptoms caused by *Colletotrichum gloeosporioides* on shaded coffee in Guatemala. This disease occurs at 300 to 700 m elevation coffee farms during prolonged periods of wet weather and night temperatures of 27°C.

Figure 9. Coffee berry anthracnose is characterized by superficial, dark brown to black lesions. It causes mummification and blackening of the berry.

branches, and causes excessive damage to the fruit (Figure 10). The coffee berry disease in Africa is caused by a different biotype of the pathogen apparently not present in the Americas (Hocking 1966; Waller 1988; von Arx 1957). However, the disease on coffee berries observed in Guatemala resembles the descriptions of coffee berry disease from Africa in general symptomatology and aggressiveness.

PINK DISEASE

Corticium salmonicolor Berk. & Br. causes pink disease of coffee (Buyckx 1962; Sanchez-De Leon 1984). This fungal pathogen is visible on the surface of affected stems, branches, and fruit as a pink, powdery growth (Figure 11). Early infection of green berries is visible as a whitish, powdery, web-like surface growth (Figure 12). The affected berries first turn salmon pink in color, then black as they shrivel and dry. The disease is most serious on the apical portion of the coffee trees where defoliation and dieback are noticeable (Figure 13). The disease is prevalent in Costa Rica on sun-exposed coffee plantings at intermediate elevations from 900 to 1200 m during continuously wet periods and relatively mild temperatures from 20 to 25°C. The disease is controlled by pruning diseased branches and by spot applications of tribasic copper (Sanchez-De Leon 1984).

COFFEE RUST

The coffee rust caused by *Hemileia vastatrix* Berk. & Br. is prevalent in the coffee-growing regions of the American tropics, Africa, and southeast Asia. The disease originated in Africa, the center of diversity of *Coffea* species (Rayner 1972; Rodigues, Bettencourt, and Rijo 1975; Waller 1988). Strict quarantine regulations have prevented this pathogen from being established in coffee-growing areas of many Pacific islands. The disease is characterized by yellow, circular spots on the upper surface of the leaf (Figure 14) and orange, powdery lesions on the underside of the leaf (Figure 15). Large areas of the leaf may be covered by the orange uredia which protrude through the stomata forming large, irregular patches. In warm, humid areas, hyperparasitic fungi such as *Darluca* sp. and *Verticillium* sp. frequently colonize rust lesions giving them a whitish cast. Extensive leaf infection causes premature defo-

Figure 10. Defoliation, branch dieback, and mummification of berries due to anthracnose disease on shaded coffee in Guatemala.

Figure 11. Pink, powdery growth on branches are signs of *Corticium salmonicolor* on sun-exposed coffee. The cracking bark on dead branches and black, mummified berries are characteristic symptoms of this disease.

Figure 12. Early signs of pathogen attack on immature coffee is the powdery, whitish, webby growth of *Corticium salmonicolor* on the surface of the berries.

Figure 13. The pink disease pathogen causes severe defoliation of the apical shoot and branches on sun-exposed coffee during prolonged wet periods and relatively mild night temperatures from 20 to 25°C on Costa Rican plantations located at intermediate elevations.

Figure 14. Coffee leaf rust on 'Bourbon' coffee from Guatemala. Characteristic orange rust pustules of *Hemileia vastatrix* are formed on the underside of infected coffee leaves.

Figure 15. Leaf of coffee cultivar 'Bourbon' from Guatemala showing yellow, circular to irregular spots which are symptoms of coffee leaf rust.

liation (Figure 16), reducing the photosynthetic capacity and yield of coffee trees.

The spores of this fungus germinate and infect coffee leaves when optimal temperatures of 21°C coincide with 6- to 8-hour periods of leaf wetness. Spore distribution is dependent on wind and rain (Becker and Kranze 1977). The rainy season of Central America extends from June through November with optimal conditions for infection prevailing at night in coffee-producing areas at elevations from 800 to 900 m. At elevations above 1000 to 1500 m the night temperatures are below 15°C and at elevations lower than 700 m they are above 28°C, too low or too high for germination of urediospores and infection of coffee leaves. Temperature alone appears to be responsible for mild epidemics of coffee rust disease at higher and lower elevations in the American tropics. Hawai'i coffee-growing areas located from 200 to 500 m have ideal temperature and periods of leaf wetness for infection during the winter. Therefore, one could predict that rust would be severe in Hawaiian coffee farms at these elevations if the pathogen were to be accidentally introduced. However, little or no rust would develop at elevations above 600 m where prevailing temperatures are below 15°C at night.

Chemical control is based on the application of fungicidal sprays during the rainy season. Basic copper at 4 kg/hectare, applied at 4 to 6 week intervals, is effective. In some areas, two sprays at the beginning of the rainy season are sufficient to control the disease. Coffee cultivars with resistance to rust derived from the 'Catimor' hybrids (Rodigues, Bettencourt, and Rijo 1975) are now in use in Colombia and Kenya.

Viability of urediospores of *H. vastatrix* was investigated to answer concerns of Hawai'i coffee growers on the possibility of the introduction of viable rust spores with shipments of green coffee beans from Central America to Hawai'i. Three collections of *H. vastatrix* spores made in Guatemala during the period of April 18 to 20, 1991, had a germination potential of 21.5 percent to 23.0 percent upon arrival in New York on 23 April 1991. Ten days after collection, no loss of viability was detected on spores kept in hermetically sealed glass vials stored at 25°C. Spore germination tests at 21°C done on 1 May 1991 averaged 21.23 percent, which is not in agreement with published spore

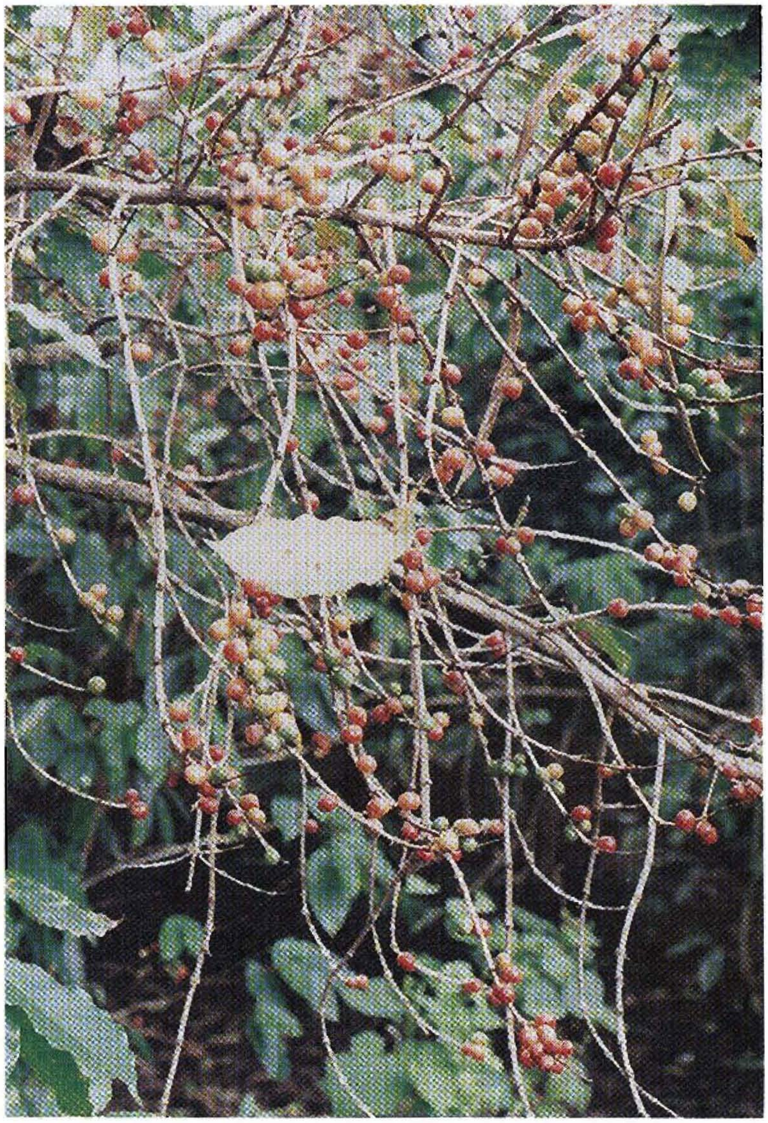

Figure 16. Severe defoliation caused by coffee leaf rust in Guatemala at elevations from 800 to 900 m where optimal conditions for infection and sporulation of *Hemileia vastatrix* prevail during the wet season.

viability data indicating that *H. vastatrix* urediospore viability decreases rapidly with storage time (Becker and Kranze 1977). However, the same urediospore collection mixed in Guatemala with green coffee beans at 10 to 12 percent moisture lost almost all viability in the same period. Urediospores with a 21.5 percent germination (Figure 17a), when mixed with green coffee beans at 10 to 12 percent moisture on the day of collection, showed 0.2 percent germination after separation from coffee beans on 1 May 1991. These urediospores were separated from coffee beans by washing beans with water on a 18 to 22 μ screen. Three germination tests conducted with spores collected on the 18 to 22 μ screen resulted in 3 of 1460, 3 of 1580, and 4 of 2370 germinated spores, after incubation for 24 hr on water agar covered slides at 21°C and 100 percent RH (Figure 17b). Urediospores, received from Costa Rica as contaminants of green coffee beans, did not germinate. Apparently, *H. vastatrix* urediospores do not survive long on the surface of green coffee beans at 10 to 12 percent moisture. Furthermore, the opportunity for urediospores of the coffee leaf rust to land on green coffee beans is minimal. In addition, coffee is generally dried in the sun as

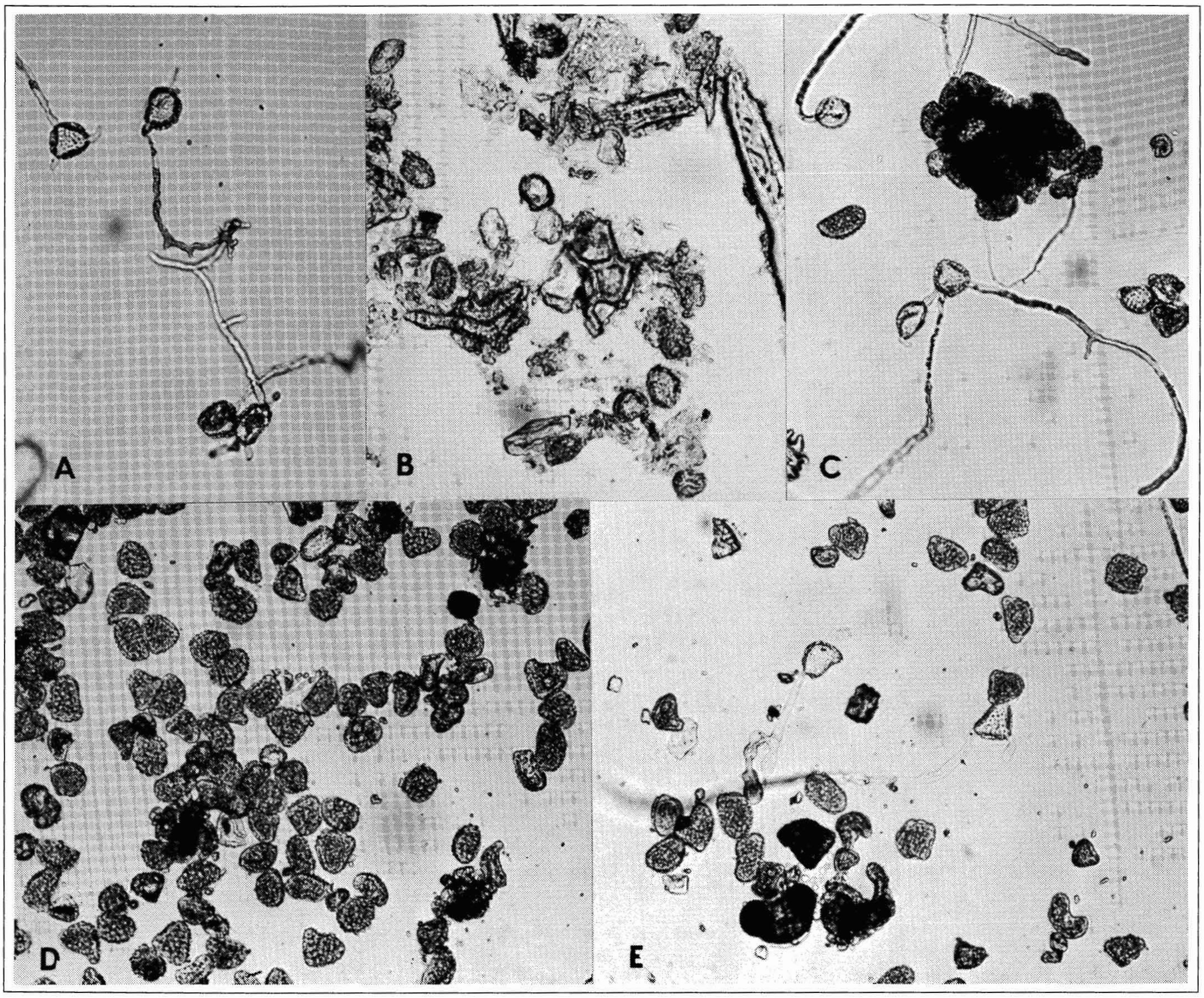

Figure 17. Viability of urediospores of *Hemileia vastatrix*. a. Guatemalan urediospores germinated 3 days after collection on glass slides covered with 2 percent water agar film incubated at 21°C. Approximately one of five urediospores germinated resulting in 21.3 percent viability. Note length of the germ tube and protoplasm translocation to the tip of the germ tube. b. Urediospores of coffee leaf rust from Guatemala mixed with green coffee beans at 10 to 12 percent moisture the day of collection and germinated after 10 days storage at room temperature. Note lack of spore viability. c. Urediospores showing 40 percent germination. The two-fold increase in germination over the control was due to the moist heat treatment at 65°C for 30 seconds. d. A 3-minute treatment with moist heat at 65°C for 30 seconds. d. A 3-minute treatment with moist heat at 65°C killed all the urediospores. e. Urediospores after treatment at 65°C for 1.5 minutes with moist heat showing less than 4 percent germination.

parchment coffee and stored in the parchment. Prior to shipment, the parchment is removed by machinery which polishes the beans; the beans are electronically graded on the basis of color; and damaged beans are removed. Export-grade coffee is bagged in new bags which are stored in containers for final shipment. We have attempted to recover urediospores of *H. vastatrix* from imported coffee in many occasions by washing the samples with water and collecting the spores on a 18 to 22 μ sieve. In every occasion, we were unable to detect spores.

Moist air heated to 65 and 67°C killed the urediospores of the coffee leaf rust pathogen *H. vastatrix* (Figure 18). In the first 30 seconds of treatment at these temperatures, there was a two-fold increase in germination over the control (Figure 17c and 18). At treatment times longer than 1 minute, germination of the urediospores decreased significantly from the control (Figures 17e and 18). All spores were killed after 3-minute exposures to the above temperatures in a moist atmosphere (Figure 17d and 18).

The viability of urediospores of *H. vastatrix* was less affected by dry heat. Urediospores treated with dry heat at 65°C decreased 75 percent in the first 30 minutes of treatment. As treatment time increased to 6 hours, viability decreased slowly until all urediospores

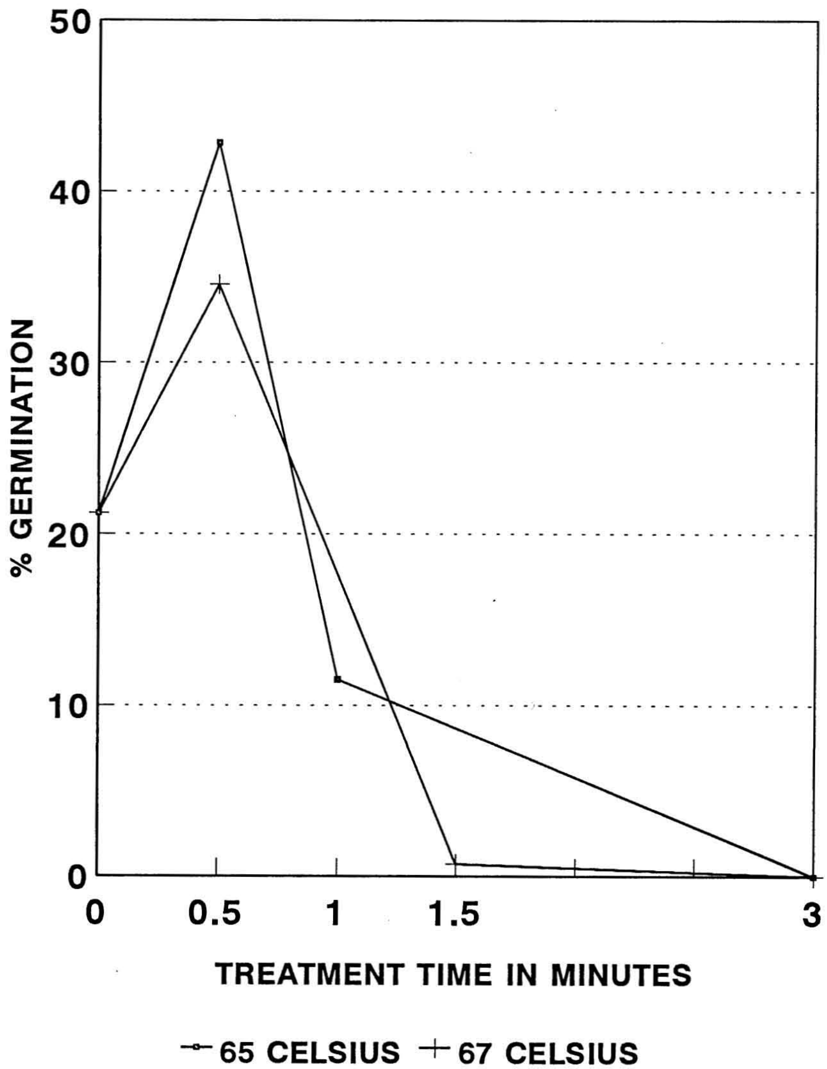

Figure 18. Viability of urediospores of coffee leaf rust treated with moist heat. Each data point represents average urediospore germination counts in ten 100× microscope fields of three replicates per treatment and is expressed as percent germination.

were killed (Figures 17e and 19).

MC-2 (methyl bromide, 98 percent and chloropicrin, 2 percent) fumigation at 1132 g/1000 ft^3 for 3 hours killed urediospores of *H. vastatrix*, whether free or on the surface of green coffee beans. Controls showed a 23 percent germination, whereas MC-2 treated urediospores failed to germinate.

THE COFFEE BERRY BORER

Adult

The coffee berry borer is one of the most serious insect pests of coffee in the world. It is a small beetle named *Hypothenemus hampei* (Ferris) of the family Scolytidae. Members of the family are generally called bark beetles or engraver beetles. There is a closely related species in Hawai'i, *Hypothenemus obscurus* (Fabricius), the tropical nut borer, which is a pest of macadamia nuts.

The adult coffee berry borer is brown to black and about 1.7 mm long with a cylindrical punctate and striated body (Figure 20). The insect has elbowed antennae ending in a distinct club (Buyckx 1962). The beetle originated from tropical Africa. At the beginning of the 20th century, the insect was carried in seed to Java, Sumatra, and Brazil. It has spread to Central

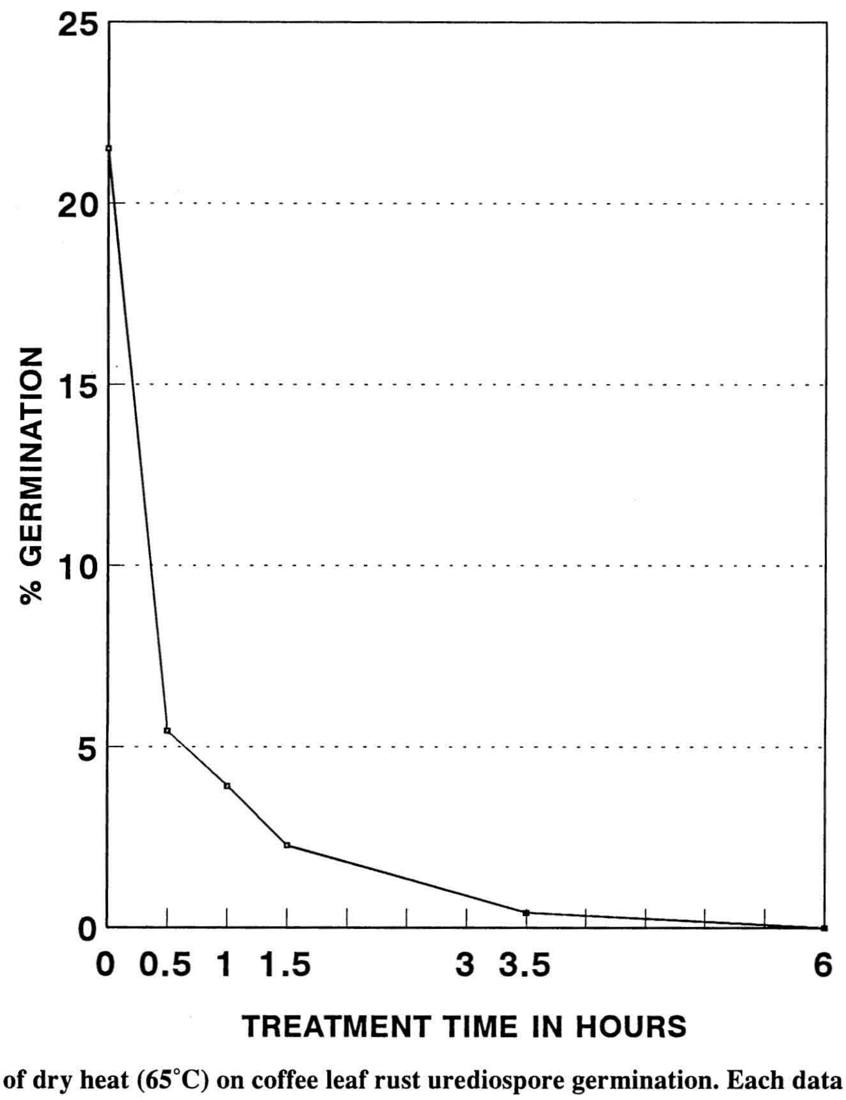

Figure 19. Effect of dry heat (65°C) on coffee leaf rust urediospore germination. Each data point represents average spore germination counts in ten 100× microscope fields of three replicates per treatment and is expressed as percent germination.

Figure 20. Adult stage of the coffee berry borer, *Hypothenemus hampei*, on the surface of a green coffee bean.

America. The adults attack the developing coffee berries on the tree.

Injury

Examination of an infested cherry will show one or more holes about 0.5 mm in diameter at the end of the fruit within the area where the calyx of the flower was attached (Figure 21). A small amount of rust-colored dust may accumulate at the border of the tunnel. Upon dissecting the cherry, a thickset adult female beetle may be found at the end of each of several galleries. In mature green cherries, a number of small grubs may be found feeding on the beans. Although the fruit may not be suitable for egg laying, the beetles may tunnel into a cherry and hollow out a gallery with the object of feeding, although the fruit may not be suitable for egg laying.

Life Cycle

All the development of the beetle occurs in the coffee berry. The females tunnel into the cherry within the mark left by the calyx of the flower. They lay their eggs inside the tunnels where they eventually hatch (Figure 22). The eggs are typically globose, slightly elliptical, and milky white in color. Later they become hyaline and turgid. The eggs are 0.45 to 0.83 mm in length. In about a week, depending upon temperature, small, yellowish white grubs emerge from the eggs and begin feeding on the bean. Larval development takes from 15 to 19 days (Figure 23). The larvae pupate within the cherries. The pupal stage lasts about 7 days. Newly emerged adult beetles eventually emerge from the tunnels. Male beetles are smaller than females and usually stay within the tunnels where they fertilize the females. The life cycle varies between 19 to 36 days depending upon the temperature and elevation of the coffee plantings. A female may attack numerous berries. An average of 30 eggs is deposited by a single female. The coffee berry borer can produce 7 to 8 overlapping generations per year (Bergamin 1943,

Figure 21. Green coffee berries with perforations at the blossom end made by *Hypothenemus hampei.*

Figure 22. Egg and larva of the coffee berry borer in an exposed gallery of a damaged green coffee berry.

Figure 23. Fully developed larval stage of the coffee berry borer on the surface of a damaged green coffee bean.

Figure 24. Dried green coffee beans from Guatemala damaged by the coffee berry borer.

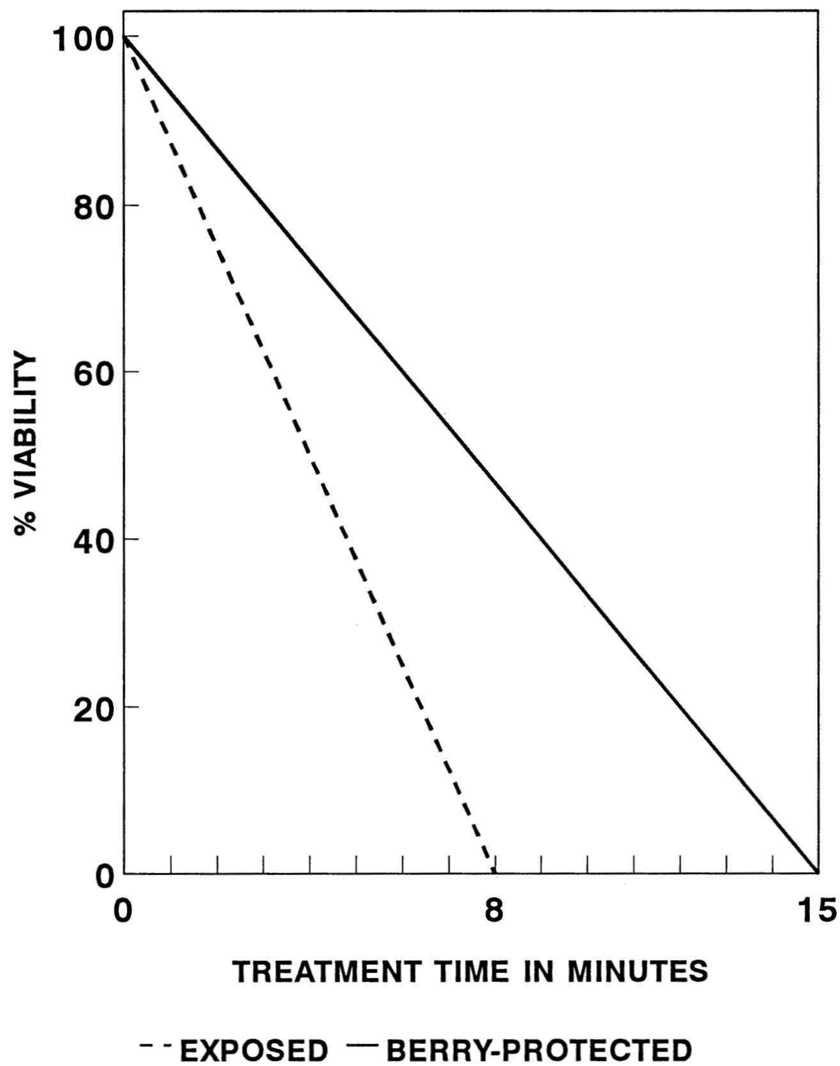

Figure 25. Mortality of the coffee berry borer, *Hypothenemus hampei*, treated with moist heat at 65°C. Each data point of berry-protected graph represents percent mortality in 4 sets of 10 green coffee berries infected with *H. hampei* treated at 65°C for 0, 8, and 15 minutes. Twenty adult insects were used to determine thermal death point of the coffee berry borer when directly exposed to the treatment.

1944; Hernandez-Paz and Sanchez-De Leon 1972; Le Pelly 1968). The borer is capable of infesting parchment and dry, green bean coffee (Figure 24). Adult beetles may live for 3 months or longer.

Economic Importance

Apart from the major loss caused by the falling and mummified cherries in the field, there are losses due to the reduction in market value of the infested coffee's chewed and tunneled beans. A water bath floatation process separates borer-infested coffee cherries from uninfested berries. The infested cherries are light. They float and are screened off, while the uninfested cherries sink to the bottom and are collected. There are varietal differences in susceptibility to attack by the borer. Arabica and robusta varieties of coffee are preferred hosts.

Controls

Cultural controls are practiced in many coffee-growing areas (Barret 1966; Hernandez-Paz and Sanchez-De Leon 1972). Stripping the bushes of all green berries for one season has been effective. Plantings at higher elevations have achieved control of the borer by frequent and thorough picking; removal and destruction of all dried and mummified berries; elimination of untended plantings; and destruction of the "floaters" to destroy the insect. Destroy old refuse berries and beans that tend to accumulate around the processing plant.

The scolytid has few natural enemies. Two hymenopterous parasitic wasps, a braconid, *Heterospilus coffeicola* Schmeid. and a bethyliid, *Prorops nasuta* Waterst., have been reported from the Congo. These wasps attack the immature forms.

A fungus, *Beauvaria bassiana* (Balssamo) Vuillemin, has been reported to attack adult borers within the tunnel. The adult is marked on the abdomen and becomes covered with a whitish fungus mat. It surrounds the insect's body and is easily seen around the opening to the tunnel in the berry. Mortality from the fungus varies greatly from year to year because appropriate conditions of temperature and humidity are necessary.

Insecticidal sprays of Thiodan 35 percent EC to control the borer have been used successively in Central and South America. Many of the insecticides utilized in coffee production in the foreign countries are banned in the United States. There are no insecticides registered in the United States for pests of coffee.

Heat treatment to eradicate the coffee berry borer in infested green cherries was investigated at the New York Agricultural Experiment Station, Cornell University, Geneva, New York. In these studies, adults, eggs, and larvae of the coffee berry borer were killed when infested cherries were exposed in moist 65°C air for 8 and 15 minutes. Adult beetles exposed to direct moist heat treatment were killed in 8 minutes (Figure 25). Research conducted by ANACAFE in Guatemala (Hernandez-Paz and Sanchez-De Leon 1972) has shown that heat is an effective treatment for control of the coffee berry borer during sun drying and machine drying of coffee. The insect cannot survive more than a week in coffee that is dried to 10 to 12 percent moisture. The borer cannot feed on dry beans. Dry coffee beans reduce the chances of survival of the borer. Quarantine regulations in Central America require export coffee to be fumigated before leaving the farm.

The borer requires at least 30 percent moisture in the beans to survive. Coffee beans kept at more than 30 percent moisture to maintain seed viability are common carriers of this pest from country to country.

CONCLUSION

When traveling to coffee-producing countries, Hawai'i residents must abide by state and federal quarantine regulations and should refrain from illegal introduction of coffee cherries into Hawai'i.

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