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Technical Report 75

Insect Survey of Potential Biological Control Agents of *Myrica faya* in the Azores and Madeira Islands, Portugal, 1988

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ABSTRACT

Myrica faya is an introduced shrub, or tree, recognized as one of the most potentially damaging and aggressive plants invading Hawaii's forests. In an effort to establish biological control of this plant, plant pathologists and entomologists visited the Azores and Madeira Islands of the North Atlantic where this plant is native, in the spring of 1984 and 1987, in a search for potential control agents. As a continuation of this survey, a fall visit to the Azores and Madeira was made by an entomologist in 1988. Results of this survey are discussed in this report.

Fall was a poor time for observing insect activity on *M. faya*. On the Azores Islands, two weeks were spent intensively sampling 14 representative sites, 12 on the island of Pico. The fruit feeding caterpillar *Carposina atlanticella* and an unidentified twig mining caterpillar, two promising insects identified in earlier visits to Madeira, are not present in the Azores. Also no evidence was found for any insects attacking roots, wood, or seeds of *M. faya.* A large number of sucking insects were found, and based on previous surveys a complex of insects that attack the male flowers exists, both of these complexes deserve further study. The most promising insect from the Azores is the leaf-rolling caterpillar *Phyllonorycter myricae*, and a new colony was collected and returned to quarantine in Hawaii where it is undergoing studies.

On Madeira both *C. atlanticella* and the twig mining caterpillar had been active earlier in the season, but by fall had begun winter diapause and could not be collected. A promising new insect, a leaf-mining caterpillar, was observed but attempts to collect and transport a colony to quarantine in Hawaii were unsuccessful.

A major outcome of this visit was locating several entomologists on both the Azores and Madeira that expressed an interest in cooperating in future studies of *Myrica faya* insects.

INTRODUCTION

The introduced plant *Myrica faya* Ait., known in Hawaii as firebush, faya tree, or firetree, is a native of the Azores, Madeira, and Canary Islands of the north Atlantic. Introduced to Hawaii before the turn of the century, probably by immigrant Portuguese (Kim 1969) as an ornamental, it was also used for a short period in the 1930's for reforestation (Neal 1965, Little and Skolmen 1989) before its aggressive nature was realized.

Myrica faya, like other members of the family Myricaceae, has nitrogen-fixing Actinomycete (*Frankia*) in nodules on its roots, which allow it to thrive and grow rapidly in nitrogen-poor soils (Turner and Vitousek 1987). Because birds feed on its small fruit and disperse its seeds, it also spreads rapidly. By 1954, it had become a serious economic problem on 8,200 acres of pastures and sugar cane lands on the Hamakua Coast on the island of Hawaii, and was declared a noxious weed (Yamayoshi 1954). Despite an almost continuous effort by the Hawaii Department of Agriculture's Chemical and Mechanical Control Branch to suppress this weed beginning in 1955, it has continued to expand its range, covering 21,375 acres in 1962 (Anonymous 1962), 54,000 acres in 1982 (Watanabe 1982), and an estimated total of 86,000 acres on the five major islands today (Whitaker and Gardner 1985).

The Hawaii Department of Agriculture's control program has effectively eliminated it as a problem to agriculture on sugar cane lands. However, *M. faya* high rate of dispersal and very rapid growth rate have made it a very aggressive invader of many of our native ecosystems, particularly those in Hawaii Volcanoes National Park (HAVO). In nitrogen poor areas, such as recent lava flows and cinder fields, it rapidly out grows and out competes native tree species such as ohia (*Metrosideros polymorpha* Gaud.). It also generally excludes other native species by creating an environment favorable to introduced plants (Vitousek, et al. 1987). Its rapid spread in HAVO and potential for large scale ecological modification have led to its being identified as one of the most serious threats to our native, dry forest ecosystems (Gardner and Davis 1982).

Along with the original efforts at mechanical and chemical control begun in the early 1950's, attempts were made to locate and identify potential biological control agents of *M. faya* in its homeland. Hawaii Sugar Planters Association entomologist Fred Bianchi (1955) traveled to the Atlantic islands in 1955, followed by Noel Krauss, an exploratory entomologist with the Hawaii Department of Agriculture in 1963 (Krauss 1964). Both scientists shipped potential biological control agents back to Hawaii, but in quarantine the insects could not be propagated or were found unsatisfactory.

A small moth, *Strepsicrates smithiane* Walsingham, that feeds on the foliage of the closely related species to *M. faya*, *M. cerifera*, in southeast United States was eventually tested, cleared, and released in Hawaii in hopes that it would switch its attack from *M. cerifera*, which has been also introduced to Hawaii, to *M. faya* (Krauss 1964). *Strepsicrates smithiane* is now established in Hawaii, but has not expanded its range to *M. faya*, remaining instead restricted to its original host *M. cerifera*.

Interest in biological control of *M. faya* resumed in the early 1980s as the plant's spread and impact on native ecosystems at HAVO became apparent. In 1984, a new survey of the three North Atlantic island groups for potential plant pathogens and insects was sponsored by the National Park Service (NPS) (Hodges and Gardner 1985). A second exploratory visit to the Madeira and Azores islands was conducted by NPS in 1987 (Gardner et al., 1988). As a continuation of present programs sponsored by NPS, a third visit was made to the Azores and Madeira Islands by an entomologist in the fall of 1988. General objectives of this visit included:

1. Survey for potential biological control agents that might be active only in fall; the previous two visits were conducted in spring. Particular emphasis was to be concentrated on *M. faya* seeds, which would be maturing at that time.
2. Learn more about the distribution and biology of the fruit feeding caterpillar *Carposina atlanticella* Rebel (Lepidoptera: Carposinidae), and a new twig mining

caterpillar and collect colonies of both for return to quarantine in Hawaii.

3. Obtain new colonies of the leaf rolling caterpillar *Phyllonorycter myricae* Deschka. This caterpillar was successfully established in quarantine in 1987, but after six generations was believed to have become too inbred for reliable further studies.
4. Identify local scientists who might be willing to cooperate in collecting or field testing additional potential biological control agents.

This report discusses observations and results of this trip as well as preliminary findings on studies of the insects returned to the HAVO quarantine facility.

Recorded Insect Fauna of *Myrica faya*

The results of the first two surveys for insect pests of *M. faya* on the Azores Islands by Krauss and Bianchi were poor (Krauss 1964). Seven insects were reported by Bianchi, but most were considered general feeders of no potential value for biological control or could not be propagated in quarantine. Krauss sent an unidentified looper (Lepidoptera: Geometridae) to Hawaii for further testing. Unfortunately, the insect could not be propagated in quarantine so no testing was conducted.

Collections on the Madeira Islands were more profitable. Bianchi (1955) sent five shipments of a small weevil and a caterpillar (all unidentified) that attacked *M. faya* male flowers to quarantine in Honolulu. Again, however, none could be propagated, and no tests were conducted. Bianchi also reported favorably on three additional species of insects: a leaf mining caterpillar, a leaf binding caterpillar, and a leaf feeding weevil.

Krauss (1964) concentrated his efforts primarily upon a new caterpillar not previously recorded by Bianchi: *Carposina atlanticella*, which feeds on *M. faya* green fruit. A total of 21 shipments of this caterpillar was made, but again the insects either died in shipment or could not be propagated in quarantine. Krauss also shipped a small looper, *Gymnoscelis pumilata insulariata* Stainton, that feeds on the male flowers and may be the same insect collected by Bianchi. He also shipped a leaf feeding looper, *Cleora fortunata*. Blanchies, and two species of a leaf mining caterpillar, *Gracilaria laurifoliella* Herin and *Lithocolletics* sp. Again, however, none of the insects were propagated or tested in Hawaii.

Hodges and Gardener (1985) reported no insects associated with *M. faya* in the Canary Islands. On the Azores, they encountered evidence of possible feeding by a twig miner during the previous year, but not other insects. This lack of insects was probably due to the time they conducted their survey: early April, which was too early in the season and cool for much insect activity (the Azores Islands are located at about 38 north lattitude or 1200 miles further north than Hawaii). They encountered the fruit feeding caterpillar *C. atlanticella*, collected by Krauss in 1962 on the Madeira Islands, and a new caterpillar that mines into the young twigs of *M. faya*.

The 1987 visit was made to only Madeira and Azores Islands, and was conducted later in the season (June). On the Azores, the most promising insect collected was the leaf rolling caterpillar *Phyllonorycter myracae*. Flowering at that time was well underway, particularly at higher elevations, and a small caterpillar (not a looper) feeding in the male flowers was also collected. This caterpillar is not believed to be the looper reported by Krauss (*G. pumilata insulariata*) from Madeira; however, it may be the same caterpillar collected and shipped by Bianchi in 1955. The third insect was a large looper that might be the same Krauss collected in Madeira (*Cleora fortunata*). Colonies of the leaf roller and the large leaf feeding looper were successfully returned to Hawaii and established in quarantine. While green fruit was common at lower elevations on the Azores Islands, the fruit feeding caterpillar *C. atlanticella* was not encountered in 1987, nor was the new shoot mining caterpillar.

The leaf roller *P. myricae* was again commonly encountered on the Madeira Island in 1987, and a colony was collected, shipped to Hawaii, and successfully established in quarantine. The large green looper *C. fortunata* was also present, but not

as abundantly as in the Azores. Flowering was complete in June on Madeira, so flower feeding insects were not collected, but plants had well-developed green or ripening berries. These attracted the fruit eating caterpillar *C. atlanticella*, but the insect appeared much less numerous than in 1984. The twig-mining caterpillar was also present but was quite rare and heavily parasitized. However, a new insect was found on Madeira: a leaf mining caterpillar of the same family (Gracilariidae) as *P. myricae*, possibly *Gracilaria laurifoliella* collected by Krauss.

MATERIALS AND METHODS

Azores Islands. During the previous visit to the Azores, efforts were concentrated on surveying as large an area as possible. This resulted in stays of usually less than three days on each island. While each island was thoroughly surveyed for stands of *M. faya*, time allotted for actual collecting and observing was usually limited to less than a half hour at any one location. Insects collected were usually limited to those easily located by their feeding damage or by beating branches over a drop cloth. The 1988 trip was organized to allow more concentrated sampling on a few of the most promising locations identified in 1987.

In 1987 the island of Pico had the most extensive stands of *M. faya* in the Azores. Stands were distributed over a wide variety of habitats from fresh lava flows to well-formed soil and from sea level to 600 m in elevation. Most of the 1988 trip was therefore spent on this island. A small apartment was rented and set up as a temporary laboratory for rearing the insects collected. Pico also had access by ferry several times a day to the adjacent island of Faial, which has extensive stands of new *M. faya* on recent (1959) cinder fields around a volcano on its west end. An additional two days each were spent on the islands of Terceira and San Miguel, mostly to revisit 1987 collection sites to determine if any seasonal changes had occured in insect populations.

On Pico, 12 of the best stands of *M. faya* were selected for more in-depth sampling and collection (Fig. 1 and Table 1). Each site contained a variety of sizes of *M. faya* and was isolated enough that the destruction caused from intensive sampling would probably not be noticed by the local inhabitants (Fig. 2).

At each sampling site, five small shrubs (less than 2 m tall) were selected. These shrubs all contained the soft, large size leaves (greater than 5 cm) typical of young, vigorously growing plants (Fig. 3), which it was hoped would be most attractive to defoliating insects. These five shrubs were destructively sampled by cutting off each branch, examining it closely, then beating it over a drop cloth. The large branches and stems were split to locate boring or mining insects. Finally, the roots of each plant were dug out, or if the plant was too large, attached by a tow cable to a car and pulled up, so the root nodules could be examined. An additional five large, mature plants (characterized by small leaves less than 5 cm long with a thich, waxy texture (Fig. 3)) were also sampled. From each tree, ten 50-cm long branches were removed, examined, and beaten over a drop cloth. Stems and large branches of older plants were also examined for bark lesions or wounds that might indicate bark beetles or other insects.

Plants with fruits were closely examined for signs of the fruit feeding caterpillar *C. atlanticell.* At each sampling site, 100 green and 100 ripening berries were collected, placed in petri dishes, and held for at least two weeks so any insects present could be detected by their feeding damage. Ripe fruit, when found, was collected, dried and returned to quarantine in Hawaii to be examined for seed-feeding insects. Finally, if an insect seemed to be particularly abundant on *M. faya*, several adjacent species of shrubs or trees were examined and branches were beat over a drop cloth to see if the same insects could be found.

Larvae collected were returned to the apartment and reared on *M. faya* foliage in petri dishes or on small shoots of *M. faya* covered with perforated plastic sacks. Rearing was done to obtain adults that could be used for subsequent identification or to obtain pupae that could be cooled to halt development until they were shipped to quarantine in Hawaii.

Madeira. The insect population was much better known here since Krauss and Bianchi spent at least two months each collecting on the island. Also in 1987, three insects had been identified as the most promising potential biological control agents: the fruit feeding caterpillar, the new shoot mining moth, and a new small, leaf mining caterpillar. Only one week was spent on this island and efforts were concentrated on collecting colonies of these insects for shipment to quarantine in Hawaii.

Study sites were not set up on Madeira, however, the following five locations (Figure 4) were found to have plentiful *M. faya* with good collecting.

1. Highway 101-3 from Machico to Canical. At the highest point the road pierces a ridge by a highway tunnel, and on either side of the ridge scattered *M. faya* could be found. This was the driest location were *M. faya* was found on Madeira or the Azores.
2. Highway 101. Portela to Porto da Cruz. From Portela down to the edge of cultivation good stands of *M. faya* exist, often as an understory in pine plantations.
3. Highway 103, northside of the island, Ribeiro Frio down to edge of cultivated land. Trees were scattered along hillsides that had poor access due to steepness. This area however provided some of the best collecting both on recent trips and earlier by Bianchi and Krauss.
4. Junction Highway 101 and 103. Near Degolada. Poor access, but scattered plants on steep hillsides near this junction offered fair collecting at a low altitude, dry site on the north side of the island.
5. Highway 104. Between Ribeira Brava and S. Vicente. North of Serra da Agua, *M. faya* starts just a mile or two before reaching the pass. The best stand of the native *M. faya*-laurel forest on Madeira is located north of this pass down to the edge of cultivated land.

RESULTS OF SURVEY

Leaf Roller

Taxonomically this species fits the description of *Phyllonorycter myricae* given by Deshka (1976), who describes it as a new and undescribed species from the Azores and Madeira Islands. However, Deshka places it in the family Lithocolletidae, a family not recognized in North America but synonymous with the family of Gracilariidae (Brues *et al.* 1954). This caterpillar is probably the same collected and identified as *Lithocolletic* sp. by Krauss (1964). The family Gracilariidae is well represented in Hawaii; at least one species, *Cremastobombyeia lantanella* Busch, was introduced as a biological control agent for Lantana (Zimmermann 1978) and is now one of the most common agents helping suppress this weed. There also are approximately 30 species of native Gracilariidae in Hawaii.

The leaf roller *P. myricae* (Fig. 5) was commonly found in 1987 on both the Azores and Madeira Islands (Gardner *et al.* 1988). At that time, its biology was worked out and used to successfully establish two colonies of this insect (one from Azores, the other from Madeira) in quarantine in Hawaii. In 1988, it was found again on both island groups, and additional observations were made on its distribution, abundance, and biology in the field.

The leaf roller, despite intensive searching, was never found above 330 m in the Azores. At the two sites where it seemed to be most plentiful, several thousand leaves were examined. At site 1, it was found to have attacked 5.8% of the leaves and at site 3, 15% of the leaves. Survival from egg to pupa was estimated at only 4.1% at Site 2, and 17.9% at Site 3. Mortality factors included a disease (caused by a pathogenic fungus), a hymenoptera parasite, and a predator that chews open the rolled leaves to reach the larvae. The most common form of mortality appeared to be caused by a sucking predatory insect (probably Hemiptera) that locates the larvae inside the rolled leaf, then pierces the leaf to feed on the larvae.

The leaf roller was present at all sites examined on Madiera. It was less abundant than on the

Azores, attacking 2.1% of leaves at Site 2, but apparently was attacked by the same parasites and predators.

Host testing began once the colonies in Hawaii were large enough that surplus individuals were available, to determine on which plant species the females would oviposite and the larvae develop. Host testing showed that larvae could feed and develop to pupae only on *M. faya* and the related species *M. cerifera.* However, female moths would lay their eggs on a wide variety of other plants with leaves of the same size and texture as young *M. faya* leaves. Generally the larvae that hatched would not attempt to feed, but on a few species of plants first instar larvae entered the leaves and begin to form mines (later instar larvae leave the leaf to form the distinctive rolled-leaf shelter). However, these larvae did little or no feeding, and starved to death after forming a mine no more than 1 to 2 cm long. Examples of such tasting or attempted feeding by starving larvae is common in host testing and is normally not thought to detract from the value of potential biocontrol agents.

Unfortunately, in the case of *P. myricae,* one of the plants on which eggs were laid and newly hatched larvae attempted to attack was macadamia nut. The second season of testing (1988-1989) has confirmed that this insect cannot develop on any varieties of macadamia found in Hawaii. The damage that newly hatched larvae do before starving is minor and affects neither the growth nor the retention of the attacked leaves. We plan to petition for release of this insect in Hawaii sometime in 1990.

Leaf Miner

A leaf mining caterpillar (Fig. 6), also from the family Gracilariidae, was observed in 1987 on Madeira, but not in the Azores . It was so rare, however, that only two viable pupae were obtained and shipped back to Hawaii. In 1988, the leaf miner was found at all 5 sampling areas, but again was quite rare. However, at sampling area 2 between Porto da Cruz and Portela (Fig. 4), a population was encountered attacking up to 5% of the leaves. All stages of attack were present and by examining them, it was possible to construct the basic pattern of this insect's life cycle and biology.

While *P. myricae* lays its eggs and feeds on the soft, newly formed leaves at the growing tip of the *M. faya* shoot, the new leaf miner restricts its activity to older, harder leaves well back from the tip, often within the crown itself where there is plenty of shade. The moth lays its eggs singly on the under side of the leaf. Newly hatched larvae penetrate the leaf surface and form a 1 to 2 cm long serpentine mine just under the cuticle. After a few days of mining, a chamber is constructed at the end of the mine that eventually grows into a blotch approximately 1 1/2 to 2 cm long and 1/2 cm wide adjacent to the midrib of the leaf. When new, the blotch does not penetrate through the leaf and resembles a blister or an air bubble just under the cuticle. However as the larva continues to grow and feed within the blotch, it partially consumes the leaf content, leaving a frass-filled space between the two surfaces. At completion of feeding, the larve is 5 mm long, approximately half the size of the late instar larvae of *P. myricae,* and pupates within the blotch rather than exiting and spinning a cocoon on the leaf surface as does *P. myricae.* When ready to emerge, the pupa forces its sharp anterior end through the cuticle of the leaf until it half protrudes, at which time the adult emerges.

The moth is multivoltine, having many generations a year. In the 1988 visit, all stages of larval development from new mine to pupa could be found. It appears to be attacked by the same complex of parasites and predators that attacks *P. myricae,* but its mortality may even be greater. Of the 15 late blotches thought to contain pupae and returned to quarantine, no adults emerged. All had been killed by parasites or predators. Like *P. myricae,* its feeding does not directly kill the leaf, but only reduces its photo- synthetic area, increasing the leaf's susceptibility to pathogen attack and probably contributing to an early leaf drop. Despite the leaf miner and *P. myricae* both being leaf miners (at least as first instar larvae), the two insects do not appear to compete. If introduced and established in Hawaii, it is thought their feeding could complement each other since *P. myricae* would attack the newer leaves while the

leaf miner would restrict its attack to the older leaves.

This insect has not been positively identified due to a lack of sufficient adults. However, I suspect that it is the same insect, *Gracilaris laurifoliella,* collected by Krauss in 1962. It also may be the same leaf miner that Bianchi reported, since his leaf miner "pupated within the mine," which is a distinctly different behavior pattern than *P. myricae,* which exists its rolled leaf shelter to spin a silk cocoon attached to the undersurface of the leaf.

Working with this insect has been extremely difficult since a larva stops development and soon dies when its leaf is picked, even if the shoot the leaf is on is cut to make a bouquet. Therefore, early instar larvae cannot be reared, and collection for shipment to Hawaii depends on finding pupae. Once a sufficient number of viable pupae can be obtained in the field and shipped to Hawaii, establishment of a colony of this insect in quarantine should be fairly easy.

Myrica faya looper

One of the larger and more conspicuous insects found in both 1987 and 1988 was a light green or brown looper (Lepidoptera: Geometridae) approximately 1 inch in length. In the Azores it was not as abundant in 1988 as in 1987; only 12 specimens collected all at higher elevations between 330 and 570 m (study sites 5, 6, 7, and 9). Specimens collected in 1987 were successfully shipped to Hawaii where the insect's biology was determined and a colony established in quarantine. Host testing indicates this looper is not specific to *M. faya,* but is a general feeder that attacks a wide variety of other plants. This insect has, therefore, been dropped for consideration as potential biological control agent.

Fruit feeding moth

The caterpillar of this small moth, *Carposina atlanticella* Rebel, attacks the green fruit, eating through the hard flesh and shell to consume the developing seeds (fig. 7). Early biology of this moth (when the eggs are laid, when larvae hatch, where the early instar larvae feed, etc.) has not been observed in the field. Krauss (1964) reported finding this insect on Madeira from July to September. However, Gardener and Hodges (1985) found the insect active as half grown larvae in May. In our June 1987 visit, most larvae were full size and had begun to pupate by early July. Of the small colony returned to the quarantine in Hawaii in 1987, 10% of the pupae emerged by middle August, which might indicate that a second generation occurs in the fall. This would explain Krauss encountering this insect in September.

No *C. atlanticella* larvae were found in the Azores Islands in the spring surveys of 1987, but pollination was still occuring, and most fruit has not started developing. From the observations made in June, it was estimated that fruit would be fully developed by September, which should be the optimum time to search for this insect. One of the specific reasons for planning the 1988 visit in September was to coincide with fruit maturity in the Azores and to look for a second generation in Madeira.

No larvae or signs of past feeding damage were detected at the 14 study sites in the Azores, or at an additional 20+ locations where fruit was examined. The failure of both Bianchi and Krauss to report this insect from the Azores, plus the negative result of this survey, indicate that *C. atlanticella* is not established on this island group.

Fruit development was not only complete by October 1 on Madeira, but at least 99 % of the fruit had already fallen from the plants. The few plants retaining dried fruit, however, showed extensive evidence of feeding, indicating that earlier in the season this insect had been abundant. No evidence was found of a second flush of fruit. In all, only two plants were found to be out of synchronization with the phenology of the rest of the population and contained developing fruit. Both plants showed no sign of larvae.

The larve migrated to the nearest stem after feeding in quarantine, and spun a tightly attached, oval shaped cocoon of very dense silk, camouflaged with a covering of frass particles. Despite intensive searching for these cocoons in 1988, only three were found and all were parasitized. Therefore, no insects were successfully returned to quarantine in 1988.

A probable biology for the insect on Madeira can be constructed from these observations and information obtained in attempting to rear this insect in quarantine in 1987. It is presumed that the adults emerge from pupae in March or April, mate, and begin laying eggs, probably in synchronization with flowering of *M. faya.* The larvae hatch when fruit begins to develop in early May. Larval development continues actively through May and June and is completed by early July, when most fruit is mature. At this time the larvae spin cocoons and pupation occurs. The dense cocoons, well attached to the stem, appear adapted to protect the pupae for a long period, i.e., the remainder of the summer and the following winter. In quarantine, cocoons held at laboratory temperature (other than the 10% that emerged after four to six weeks) did not produce adults. However, cocoons placed in an environmental chamber at a 10C day and 5C night (12 hours daylight) and held for 4 months, then returned to room temperature, produced adults within 4 weeks. This indicates that this insect requires a winter diapause and uses warmer temperatures in spring to synchronize the emergence of adults with the phenology of the plant. The significance of the emergence of 10% of the adults in fall after only 4 to 6 weeks as pupae when no fruit would be available is unknown. Possibly a second crop of fruit is produced in some years.

The conclusions reached to date for this species include these:

1. The biology of this insect is tightly synchronized with the phenology of its host, indicating that it is highly specific to *M. faya* and a good candidate as a biological control agent.
2. The insect is currently not established in the Azores; therefore, further efforts to collect or study this insect should be restricted to Madeira. Neither Krauss (1964) nor Gardner and Hodges (1985) report encountering this insect in the Canary Islands, so it is unknown if the insect was not present or if they visited the island when it was in the pupal stage.
3. Future visits to collect colonies of these insects for shipment to Hawaii should take place in late June or early July. Larvae at this time are large enough that their feeding damage makes them easy to lacate, saving the tedious work of trying to rear larvae to pupae. Collections made later than early July will have to concentrate on finding cocoons, which are very well camouflaged.

Twig mining caterpillar

The larvae of this small, and as of yet, unidentified moth (Fig. 8) attack the new, soft growing tips of branches, mining down into the shoot as far as 10 to 15 cm. The larvae were found actively attacking the plant in May and June in visits to Madeira in 1984 and 1987. By late June, late instar larvae were preparing to pupate. The wilted tips and drying leaves at this time made it easy to identify trees that were being attacked. It is interesting that neither Bianchi nor Krauss report encountering this insect, for while it was not common, it was quite easy to find by locating trees containing dying branch tips.

In 1987, insects collected were heavily parasitized and only three adults emerged, not enough to form a series for identification. However if presumed that since *M. faya* has actively growing branch tips all year round, this moth would have more than one generation a year to utilize its host. I had expected to find this insect still active during the 1988 fall trip.

No insects were found in the Azores, nor was evidence of past feeding encountered. The remains of dead, mined stem would readily indicate that the insect had been present. On Madeira feeding damage indicated the insect had been active earlier in the season. No live larvae, or signs of recent feedings, and the growth of the side shoots to replace the dead tip indicatedthat feeding occurred at least 4 months earlier. From these observations, it was concluded that this insect has a single generation a year which is synchronized with the rapid plant growth that might occur in spring. As with the fruit feeder *C. atlanticella,* the optimum time to study the early stages of this insect would be in early spring: March or April. Collections to obtain insects for

shipment to Hawaii would probably be best made in June or early July. On Madeira, evidence of feeding was found at all collecting sites; however, the insects seemed to be most abundant in the area of Ribeiro Frio (collection Site 3).

Pollen feeding moth

Bianchi reported a caterpillar and several weevils, and Krauss reported a small looper attacking male flowers on Madeira. In our 1987 visit, none of these insects was encountered (pollination was well past), but in the Azores, a new, small caterpillar (Fig. 9) was found feeding on male flowers. Larvae were returned to quarantine in 1987, where they completed their development, pupated, and emerged as adults. Some of the adults remained alive and active for up to 3 months, but did not mate or lay eggs when offered new male flowers or buds. It is presumed this caterpillar overwinters as a diapausing adult. In the Azores during this trip, adults of what was thought to be the same moth were found when branches from trees containing the dried male flowers were beaten. In spring its life cycle may be spread over a long period, since larvae, pupae, and adults were enountered at the same time, often on the same bush.

An observation made in 1988 is of interest. During the visit, fruit development was nearly complete and trees contained 10 to 90 % ripe fruit. However, as shown in Fig. 10, the amount of fruit produced on trees in the Azores is generally less than that found on trees in Hawaii, where we are used to seeing the stem of a branch completely hidden by fruit. Is it possible that this pollen feeding moth, by attacking the male flowers, has reduced pollination of this plant in the Azores?

Seed feeding Mirid

The most exciting find in the Azores was the presence of a small true bug (Fig. 11) (Hemiptera: Miridae) at 6 of the 14 study sites. No specimens of this insect, however, were found on Madeira. In general it was rare (sites 6, 8, 13), although at two of the sites (7 and 14) it was common, and at one site (3) it was very abundant, averaging three adults for each 50 cm branch. The family Miridae (plant bugs) are all plant feeding insects with piercing mouth parts for feeding on plant juices. Many of them attack developing seed, sucking out the contents to leave an empty cavity. The insects found in the field were all inactive adults, usually hiding in clusters of 5 to 15 in protected places within the denser canopy. No immature stages were encountered, and no feedng damage or frass was seen on the leaves. Newly collected adults occasionally fed on the ripe outer layer of the fruit, but usually remained inactive in sheltered locations. It was presumed that the insects had entered diapause to overwinter. This insect might be a seed feeder that had emerged in spring; the nymphs developed on the growing fruit and now that the fruit was maturing, the adults had entered diapause to await next year's flowering.

Over 300 adults were collected and returned to quarantine in Hawaii for biological studies. Also extra fruits were collected from Site 3, where the insect was abundant, and Site 2, where it was not found. By opening and comparing the percentage of fruit with damaged or empty seeds from the two sites, I hoped to confirm that insects were seed feeders. In Hawaii, examination of 1000 seeds from each site failed to show any difference between Site 3, where the mirids were abundant (41.1 % of the seeds were empty), and Site 2, where the mirids were not present (51.1 % of the seeds were empty).

Still hoping that this insect might at least be a phytophagous feeder on *M. faya,* we attempted to break diapause. Subsamples of 25 adults were left at room temperatures or placed in environmental chambers (10°C day and 5-10°C night) for 3, 4, 5, and 6 months, then brought out and placed on small potted *M. faya,* plants. Adults at room temperature remained inactive, and died off slowly over the next 4 to 6 months. Those in the environmental chambers suffered little natural mortality, and when removed became quite active, indicating that they were out of diapause. However, no mating and feeding were observed, nor were eggs found on the plants. These observations led us to conclude that the insect is not associated with *M. faya,* but was just using the foliage of this plant for protection for overwintering.

Plant hopper

A brown plant hopper (Homoptera: Fulgoridae) (Fig. 12) 5 to 8 mm long, was found at 8 of the 14

sites in the Azores, generally at higher altitudes. The insect was usually found sitting on older stems, but nymphs were found feeding on the leaves. At several sites where the insect was abundant on *M. faya,* it could not be located on adjacent species of plants, indicating it preferred M. faya. Nymphs found on *M. faya* and reared in the apartment successfully completed their development on cut shoots. Since all species of this family feed on plant juices and many have fairly specific host ranges, this species may be specific to *M. faya.*

This insect was relatively abundant (sites 4, 7, 8), but its jumping habit made it quite difficult to collect without a sweep net. Only a small colony (8 individuals) was returned to Hawaii. The colony survived for a short period on a potted seedling, but when the plant died, the colony was lost before producing eggs or nymphs. Since nymphs and adults were found in the fall of 1988 and were also noted in the 1987 spring trip, it is suspected the insect has more than one generation per year. The insect was also found widely distributed on Madeira. The insect was given a low priority during this trip, but at some time in the future it should be investigated in more detail.

Other sucking insects

Several families of the order Homoptera were found in the Azores and Madeira during the recent survey. The most obvious species of sucking insects on *M. faya* was the cottony cushion scale *Icerya purchasi* Maskell. This insect is a widespread pest that originated in Australia and would be of no interest to biological control. A large (4 to 6 mm across) white wax scale (Fig. 13) (Homoptera: Coccidae) was found at 7 of the 14 sites in the Azores and was of some interst since at two locations (1 and 9) it was fairly common, but could not be found on any adjacent species of shrub. Since the immature stage of most scales (called crawlers) is exceedingly small, I did not think my quarantine was adequate to handle the insects, so no effort was made to return them to Hawaii. Another scale, possibly an armored scale (Homoptera: Diaspididae), was also found that was of some interest. While not common (it was found in only two sites: 1 and 4), this small scale-- 2 to 3 mm long, 2 mm wide, and 1 mm high-- was found on the brown wood of older branches. Its coloration was almost identical to the wood, making it very difficult to locate, and indicating that it may have evolved in association with this plant. Another sucking insect, a mealybug (Homoptera: Pseudococcidae) was found, generally in small clusters on green fruit. The same mealybug could be found on many adjacent plants, so it was presumed the species was not specific to *M. faya.*

Thrips

The most common insect found on *M. faya* in both the Azores and Madeira was a small thrips (1 1/2 mm long) (Fig. 14) found at all collection sites. Almost any place that two leaves touched to form a shelter, small colonies of these insects could be found, often causing enough feeding damage to discolor the leaves. However, in the apartment, specimens in a petri dish readily left a drying *M. faya* leaf and attached leaves of several other species of plants. For this reason I presumed the insect was a general feeder. Bianchi also reported finding a small general feeding thrips he believed to be *Hercothrips* sp. He also concluded that it was a general feeder not worth considering as a biological control agent.

Root feeding insects

Particular effort was made to survey the roots of *M. faya* in hope of finding insects that feed on the outside of the root (particularly weevils) or those that mine within the roots. Nitrogen fixing nodules on the roots of firetree in particular drew my interst. This good source of protein should be utilized by a complex of insects (Fig. 15); however, the survey for root insects was almost totally negative. The only evidence of feeding was small colonies of mealybugs just below ground level on the root crowns at Site 1 on Pico (Fig. 16). The mealybugs were attended by two species of ants and an examination of roots of other species of shrubs adjacent to infested firetree revealed the same three insects. Due to the short period of time, difficult terrain, and the lack of small plants, roots of *M. faya* on Madeira were not surveyed.

Seed feeding insects

From the 14 sites in the Azores and 5 sites on Madeira, approximately 4500 ripe, dried seeds

were returned to quarantine in Hawaii. Most were held for 6 months to see if any insects emerged, then opened and examined for pupae or signs of insect feeding. In general, the seeds were quite healthy, although up to 50% were empty or contained shriveled tissue that might indicate some type of external feeding. However close examination of the shell walls indicated no feeding puncture damage, leading to the conclusion that most of the seeds were empty because of a lack of pollination or other physiological reasons. Most plants have a complex of insects that develops within their seeds to utilize the rich oil and protein content. This was not hte case with *M. faya*; no insects were identified that fed on its mature seeds.

Wood boring insects

No wood-boring insects were found in either fresh or newly dead wood despite a search of over 50 bushes in the Azores. On very old, rotten wood, evidence of wood-feeding insects was found, but it was suspected that these attacks occurred well after the plant had died. On Madeira, evidence was found of attack by the twig mining Lepidoptera (mentioned above), but no other sign of attack on either fresh or recently dead wood was observed.

Leaf feeding beetles

One of the more common insects found both on Madeira and in the Azores was a 10 mm long, heavy bodied weevil (Fig. 17) that fed on the edges of the leaves, leaving a distinctly scalloped appearance. Since the weevil was found on adjacent shrubs and readily fed on other leaves placed with them in a petri dish, I concluded that this was a general feeder that would not be of interest to our program. Bianchi and Krauss both mentioned finding small weevils that feed on the leaves, giving them a small shot-hole effect. Shot-hole feeding damage was observed at only one location on Madeira (collection Site 1), and only two specimens of a small beetle (not a weevil) were collected (Fig. 18). No specimens of a small weevil reported by Bianchi and Krauss were recovered, although a very large (15 mm in length) weevil (Fig. 19) was found feeding on the new foliage at collection Site 1 on Madeira.

Diseases

While visiting the island of Sao Miguel (Azores), I was accompanied by Duarto Furtado, an ecologist on the faculty of the University of the Azores at Ponta Delagada. On the north side of the island, we drove southeast from the town of Ribeira Grande through the small community of Lambadas toward Caldeiras on the road to the Lake Lagoa do Fogo. Here, we visited a *M. faya* stand that had been extensively decimated by an outbreak of a pathogen approximately 5 years earlier. The area was near the crest on the north side of the mountain chain that runs the length of the island. The area appeared to be a 10-plus-year-old clear cut, 50 to 100 ha in size, in an otherwise solid planting of Japanese cypress (*Cryptomeria japonica* D. Don), an introduced tree. Dr. Furtado estimated that most of the *M. faya* was killed in a two-year period by a disease that first wilted the branch tips then moved down the branches, eventually killing the entire bush.

During our visit, the area was covered with an almost pure stand of *M. faya* 2 m high, with the skeletons of many of the dead plants protruding above the new canopy. The new growth was from resprouting from the lower one third of the original stems or from the root crowns. The original plants, therefore, had not been killed by the disease, just severely set back.

The new growth, however, showed one of the highest incidence of disease observed in this trip to the Azores Islands. Almost every plant had one or more branch tips killed, twisted, and often covered by white fruiting bodies that may have been the fungus *Ramularia destructiva* Phillips and Plowright reported previously as widespread in the Azores and Madeira (Hodges and Gardner 1985).

While this disease was encountered frequently in the Azores and Madeira during this visit, at most sites it attacked only a few scattered plants in any one area. At this site, however, the attack was totally unexpected in its size and intensity, and even 4 or 5 years afterward its impact was readily visible and impressive.

Potential Cooperators

During the visits to Madeira and the Azores, efforts were made to locate potential cooperators

who could work with us in locating, screening, and testing potential biological control agents before shipping them to Hawaii.

At the University of Azores in Ponta Delagada, I found a small, but well-equipped biology department already involved in biological control of several introduced insect pests in the Azores. The department had a cooperative program underway with the USDA to control the Japanese beetle on the Island of Terceira, so researchers there were familiar with the procedures of cooperating with a US agency. The head of this biology department, Dr. Antonio Manuel de Frias Martins, a US-trained biologist, assured me that they would be interested in a cooperative *M. faya* program. We discussed several possible arrangements, but the one we both liked was that his department would soon be hiring a new entomologist. After spending a 6-month period in training and orientation with the department in the Azores, this researcher would visit Hawaii for 3 months. Here the researcher would work in quarantine facilities on our various biological control programs to obtain on-the-job experience. After the 3 months training in Hawaii, the entomologist would return to the University of Azores and set up our biological control studies for *M. faya.* The researcher would concentrate on this project for approximately 3 years, during which time the University of Azores would pay his salary and provide facilities and space. Hawaii would only provide his direct operating expenses, primarily travel, supplies and cost of shipping insects.

On Madeira the local university, located in Funchal, had a science department with one biologist, who was mostly involved in teaching. The department did not seem overly anxious or capable of cooperating with our program. I also visited the "Laboratorio Agricola de Madeira," at the Jardin Botanic a large, relatively well-equipped plant experiment and breeding station in Funchal. They don't employ an entomologist, but they do have two plant pathologists, one of whom I talked with, Dr. Adelaide Fernandes, a young, apparently well-trained plant virologist. The second pathologist was in Lisbon at the time for additional training. While the staff seemed very involved in its own programs, it appears there might be a possibility of a Hawaii pathologist using these facilities.

At the local, natural history museum in Funchal, I found a staff consisting of two full-time scientists, both ichthyologists. The head of the museum, Manuel Biscoito, explained that the museum has a steady stream of visitors who use its facilities. He offered me the same opportunity but said that currently the staff would be able to contribute little to our program. Within a year or two however he hopes to hire an entomologist to add to his staff. He has tentatively selected Denato Caires, a local from Madeira who is currently obtaining his entomology degree in Portugal. If the museum fills this position, it is likely its staff will be more interested in cooperating with us.

In addition, Dr. Biscuito introduced me to another local entomologist, Antonio Miguel F. Aguiar, who is an "enginero agronomy"--a position equal to that of our bachelor of science. He had just been hired by their local department of agriculture and in the future will be in charge of handling control programs for several agricultural pests, including fruit flies. Aguiar said that after he is settled in his new position, he could work for us on his own for the *M. faya* studies, but that he would be more interested in a cooperative program exchanging information on *M. faya* insects for information and possibly biological control agents of fruit flies from Hawaii. After returning to Hawaii, I contacted the USDA Fruit Fly Laboratory at Manoa, and it appears that Hawaii has considerable information and several parasites we could provide them.

The Azores and Madeira Islands are small, poor provinces of Portugal, itself a very poor country. However, the scientists I met seem relatively well trained (mostly from universities in Portugal) and familiar with biological control. Since both island groups are dependent on agriculture for their main exports (dairy products in the Azores, bananas in Madeira) they seem interested in the contributions that biological control could make to their islands. I believe that with sufficient funds and more work, we can set up some very profitable mutual cooperative programs between Hawaii and these islands.

CONCLUSIONS AND RECOMMENDATIONS

The result of this survey, combined with earlier surveys of Bianchi and Krauss, indicate that we have a fairly complete idea of the insects associated with *M. faya* in the Azores. It is doubtful that future surveys will turn up any new insects. At present the most promising insect from the Azores is the leaf roller *P. myricae,* colonies of which have already been established in quarantine in Hawaii. The three other most promising insects--the new leaf mining caterpillar, the fruit feeding *C. atlanticella*, and the new twig mining caterpillar--are not established in the Azores.

The complex of insects that attacks the male flower, reported by Bianchi and seen by myself in 1987, definitely needs further study. Also, the relatively large complex of sucking insects (aphids, leaf hoppers, plant bugs, and scale insects) deserves further study. The study of these two complexes, I believe, would best be contracted using a local entomologist through a cooperative program with the University of the Azores in Ponta Delagada.

On Madeira, the two most promising insects, the fruit feeder and twig miner, were not collected on this trip due to poor timing. Both apparently have a single generation a year and the optimum time for collection is in late June or early July. It is recommended that a new trip be planned, specifically to collect these insects. The third promising insect, the new leaf miner, is present all year around, but is generally rare and would require several weeks of concentrated effort to collect the number of pupae necessary to start new colonies in Hawaii.

Most of this visit and the previous visits to Madeira concentrated on investigating *M. faya* stands along the northside of the island--an area of relatively high rainfall. Only a short visit was made to one unusual stand of *M. faya* (collecting Site 1, Fig. 4) located between the communities of Machico and Canical on the east end of the island. This stand, located on a high spur of land penetrated by a highway tunnel, was in a very dry environment. Two insects, a large weevil, and a small flea beetle seen nowhere else were encountered here, indicating there may be a different complex of insects in drier areas. Unfortunately, this is the only remnant of a dry forest I could find. In further work in Madeira, I would recommend conducting extended studies, similar to those run in Azores, in this dry stand near Machico, as well as in the wet forest in the vicinity of Portela (Area 2) and Ribeiro Frio (Area 3), and in the fairly extensive *M. faya* stands between Serra de Agua and S. Vicente in the central portion of the island (Area 5).

On Madeira, much of the area with good *M. faya* lies adjacent to small agricultural plots. It should be possible to rent small areas of these plots to raise Hawaiian plants which would then be monitored for any natural spread of these agents from the nearby *M. faya* (field host testing).

Further searching for *M. faya* insects could also be extended to the Canary Islands and possibly to mainland Portugal. In Krauss's earlier report (1964), he states that *M. faya* is not native to Portugal but was introduced. Botanists and biologists in the Azores and Madeira, however, questioned this statement, saying that to their knowledge *M. faya* is a native of Portugal. Neither Bianchi nor Krauss surveyed Portugal for insects of *M. faya*, and the National Park Service hasn't yet sponsored any visits. There also was an unverifiable report that *M. faya* is, or at one time was, established at higher elevations in the Atlas Mountains of Morocco, the African country closest to Madeira. Future visits to survey for *M. faya* should include Portugal, and inquiry should be made as to the existence of this plant in Morocco.

ACKNOWLEDGEMENTS

I am grateful for the cooperation and generosity of the staff of the Department of Biology of the University of Azores at Ponta Delgada, in particular to Dr. Duarte Furtado for accompanying me on my survey of his island and providing me with the invaluable information about its ecology and natural history. I am also grateful to Dr. Martins and the rest of his staff for the cooperation they showed me during my stay. I also wish to thank Hollis Summers, acting United States Counsel, and Abigail Freedman, present

Table 1. *Myrica faya* study sites on the Azores Islands, 1988.

No.	Island	Location	Elevation m (ft)	Description of sites	Associated flora[1]
1	Pico N. side	East Beach Road, edge of Madalena	10 (33)	Abandoned building site Crushed, flattened lava	Predominantly M. fay. >>>> P. und.
2	Pico N. side	Beach Road 1 Km West Junction Airport Rd.	30 (100)	Abandoned vineyard on recent pahoehoe lava flow	M.fay. = P. und. >> E. azo>> >> J. bre.
3	Pico N. side	Directly across from Motel "Residencial Pico" Madalena	100 (330)	Abandoned vineyard with vigorous regrowth of *M. faya*	M. fay. = P. und.
4	Pico N. side	Paved forest road running inland from Arcos	200 (660)	Disturbed forest site with vigorous growth of exotic shrub	Introduced shrubs >> M. fay. >> A. mel
5	Pico N. side	Paved forest road running inland from Arcos	330 (1000)	Native laurel-Myrica forest	L. azo. >> M. fay. >> P. und.
6	Pico N. side	Paved forest road running inland from Arcos	480 (1600)	Relatively undisturbed native forest	L. azo. >> M. fay. >> E. azo.
7	Pico N. side	Paved forest road running inland from Arcos	570 (1900)	Abandoned pasture at transition from forest land to open pasture land.	M. fay. >> L. azo. >> E. azo. >> J. bre.
8	Pico E. end	Below highway east of Terra Alta trail to farm lots	210 (700)	Understory in open, old pine forest	P. pin. >> P. und. >> M. fay.

No.	Island	Location	Elevation m (ft)	Description of sites	Associated flora
9	Pico E. end	Above highway east of Terra Alta Trail to pasture lands	510 (1700)	Abandoned pastures and older trees in pasture	L. azo. >> M. fay. >> E. azo. + misc. exotics
10	Pico S. side	1 km west of Lajos do Pico	100 (300)	Steep hillside above highway dense, old stand of *M. faya*	Mostly older M. fay.
11	Pico S. side	Between Sao Caetuno and Sao Mateus	10-30 (33 -66)	Dense stand of *M. faya* below highway lower edge of stand killed by salt spray at coast	Almost pure M. fay.
12	Pico S. side	Sao Mateus west of Lajos do Pico	180 (330)	Recent aa lava flow planted to pines, now 10-15 m high	P. pin. >>>> M. fay.
13	Fial W. end	Near abandoned light house, west end of island in cinder field from 1959 volcano eruption	200 (660)	Trees scattered in draw/rest of area heavy stand of cane	A. don. >>>> M. fay.
14	Terceira S. side	Monte Brazil, Peninsula old cinder cone/south of Angra do Heroismo	300 (1000)	Municipal park and military reserve	M. fay. >> L. azo. >> E. azo. >> P. pin. = P. und.

[1]/ Abbrevations used of most commonly encountered shrubs or trees, scientific names from Sjoogren 1984

A. don = *Arund donax* L. (common cane), Introduced
A. mel. = *Acacia melanoxylon* R. Br., Introduced
E. azo. = *Erica azorica* Hochst., Native
J. bre. = *Juniperus brevifolia* (Seub) Antoine, Native
L. azo. = *Laurus azorica* (seub) J. Franco, Native
M. fay. = *Myrica faya* Aiton, Native
P. pin. = *Pinus pinaster* Aiton, Introduced
P. und. = *Pittosporum undulatum* Vent., Introduced

American Counsel to the Azores, for providing information on funding and coordinating studies between Portugal and the United States. In Madeira, I am very grateful for Dr. Manuel Biscoito of the Municipal Museum at Funchal, Adelaide Fernandez of the Jardin Botanic, and other members of these two facilities for their friendliness and cooperation.

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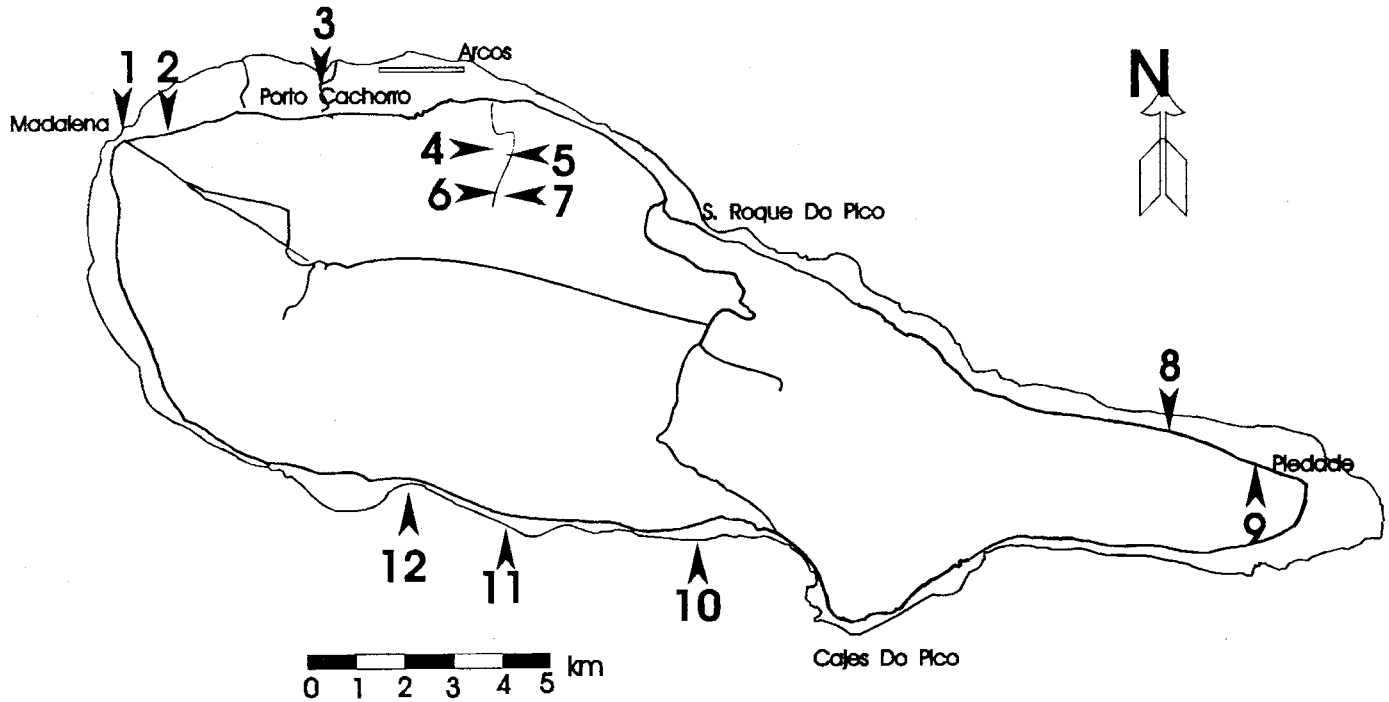

Figure 1. Map of the island of Pico (Azores Islands, Portugal) showing location of 12 sample sites where most collections were made.

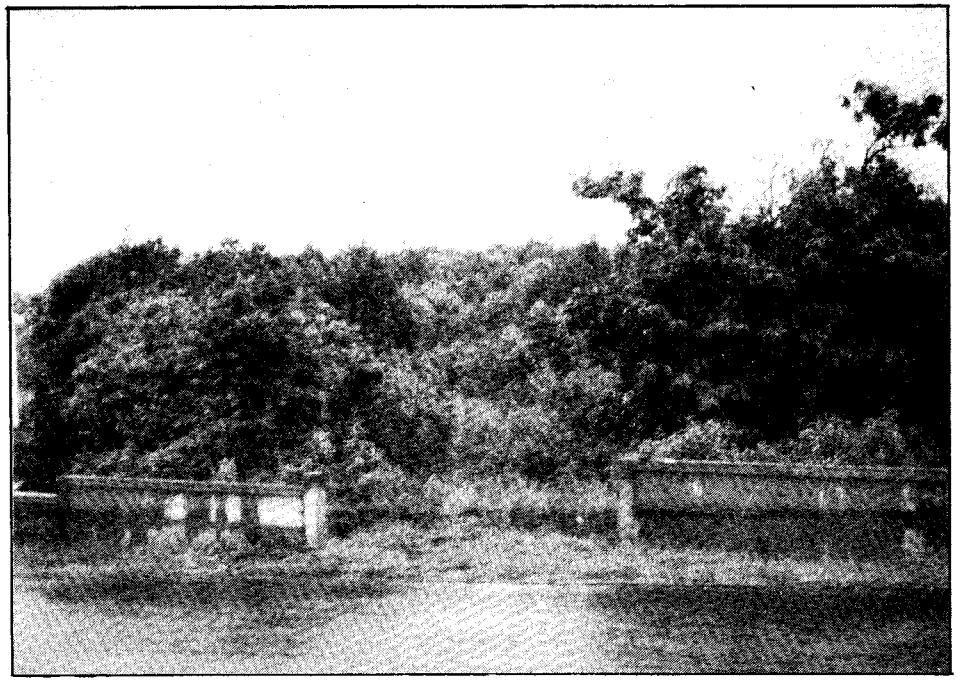

Figure 2. Site 2, an abandoned vineyard across from the island's one motel (Residencial Pico), typifies the collecting sites on Pico.

Figure 3. Two types of foliage of *Myrica faya*. Large, soft leaves on lower shoot are typical of seedlings and regeneration from cut stems. The small, darker leaves of the top shoot are harder and waxier and are typical of those found on older mature plants.

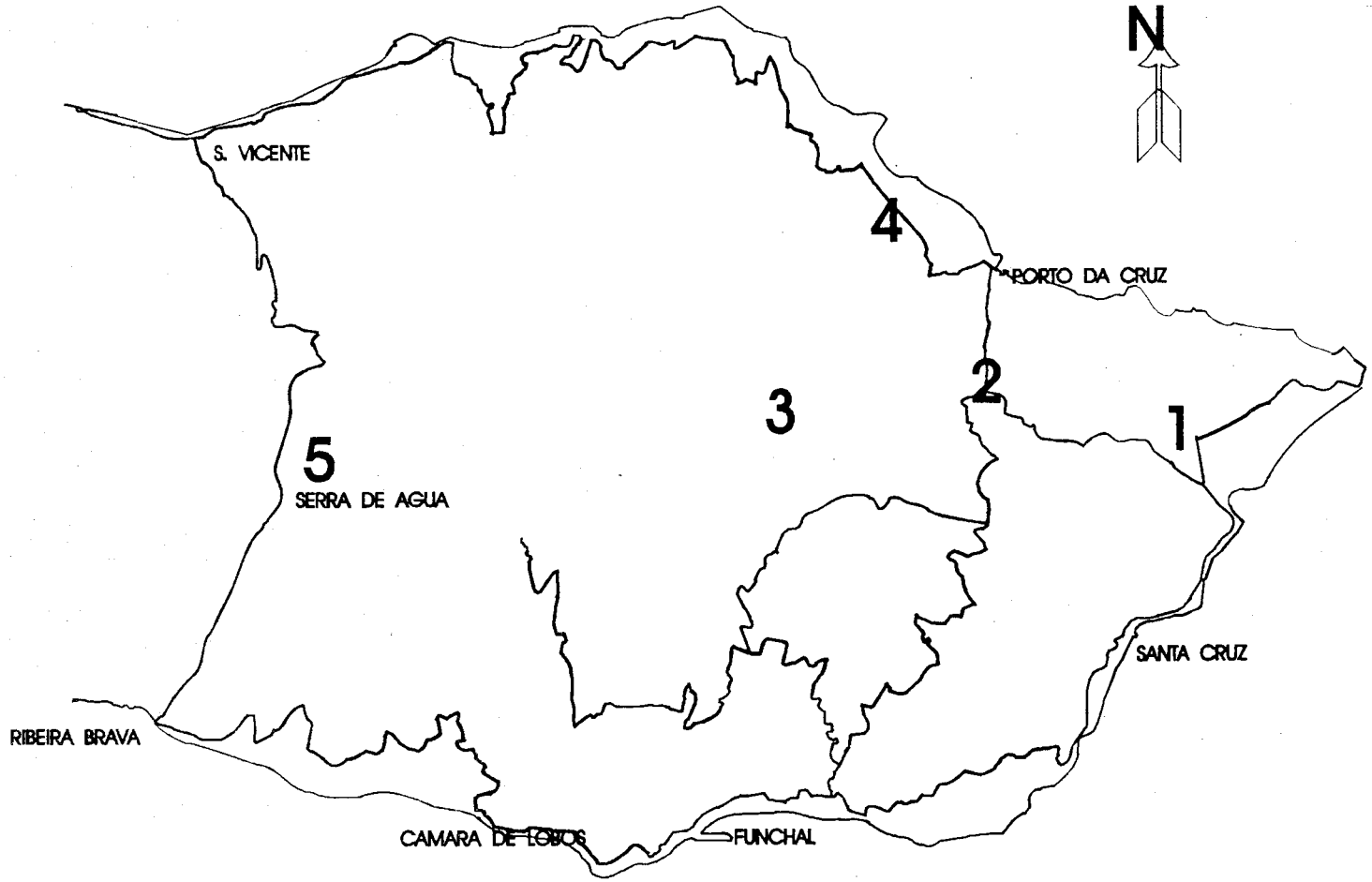

Figure 4. Map of the island of Madeira (Portugal) showing the five areas where most collecting was done in 1987 and 1988.

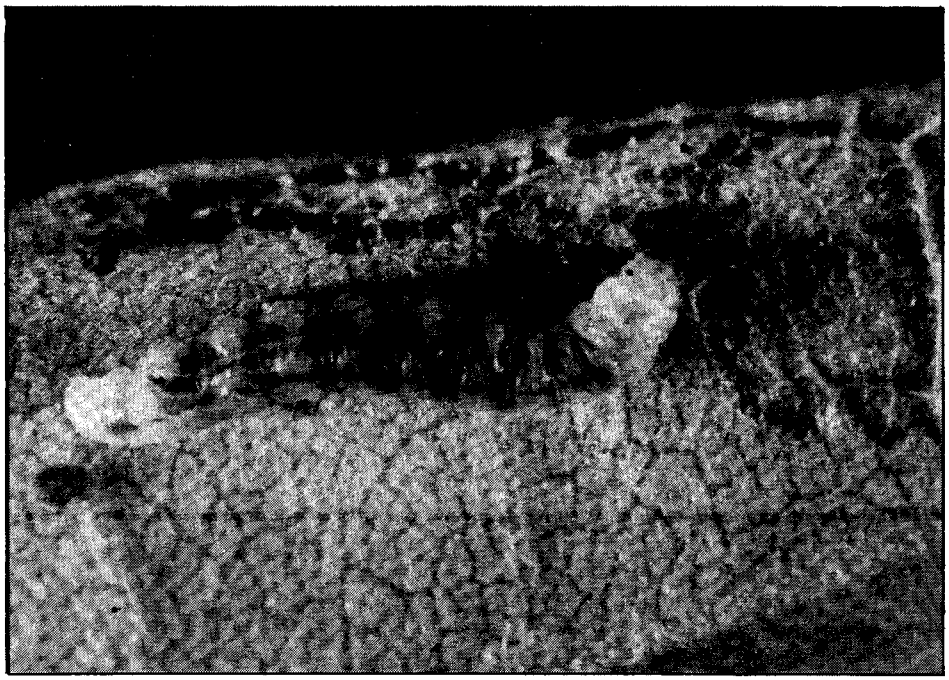

Figure 5. Larva of the leaf rolling caterpillar, *Phylonorycter myricae*, the most promising insect found to date as a potential biological control insect for *Myrica faya* (length 8mm).

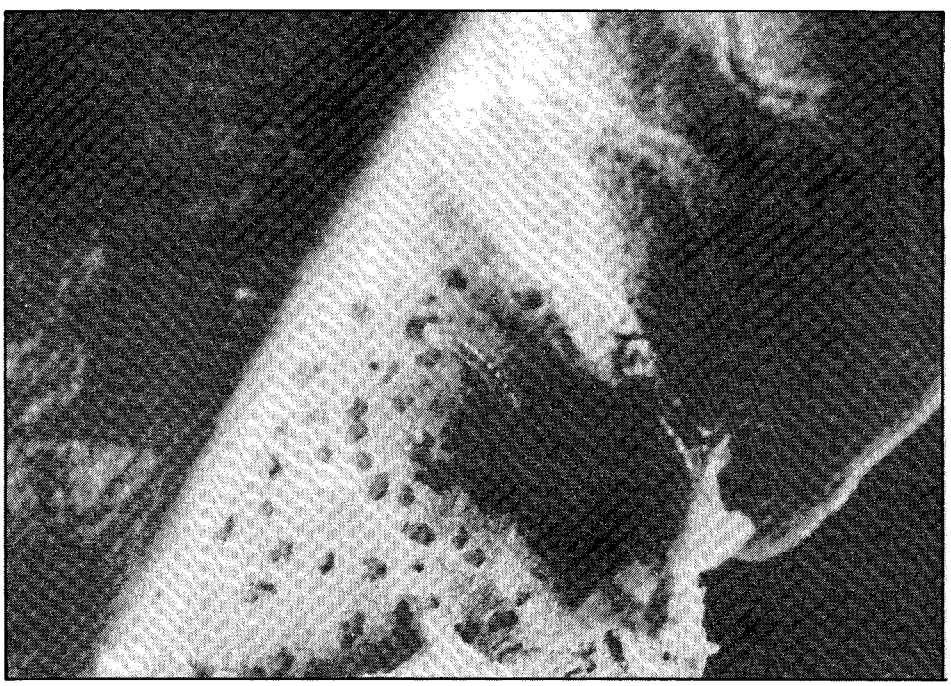

Figure 6. Early blotch on a leaf of *Myrica faya* opened to show the larva of a new leaf mining Gracillarid caterpillar (length 3mm).

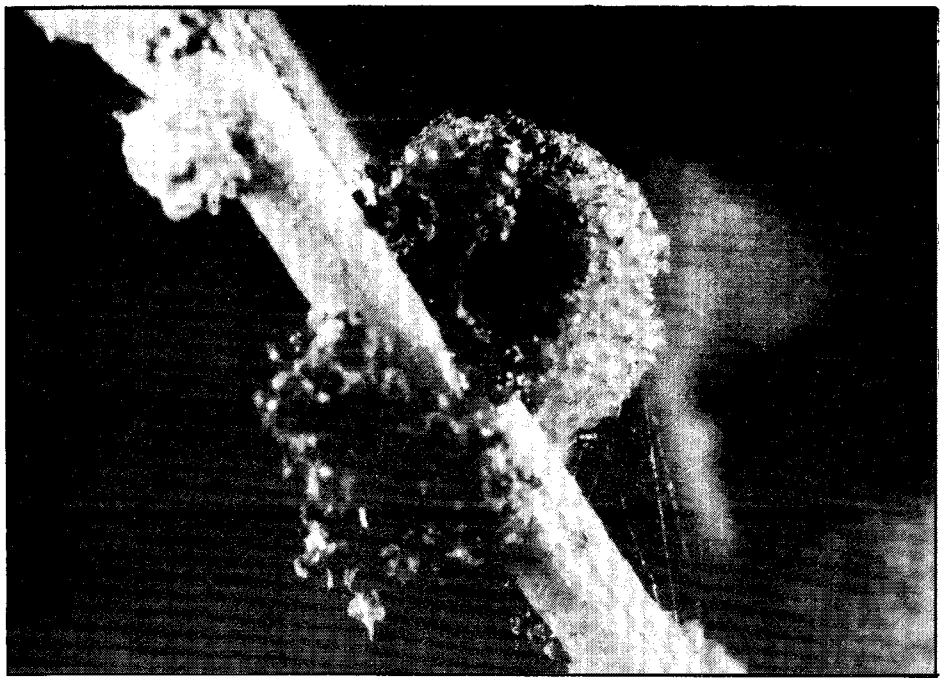

Figure 7. Damage caused by the fruit feeding moth *Carposina atlanticella*. A larva has eaten through the flesh and shell of the fruit to reach the seed inside. Damage was done earlier when the fruit was green.

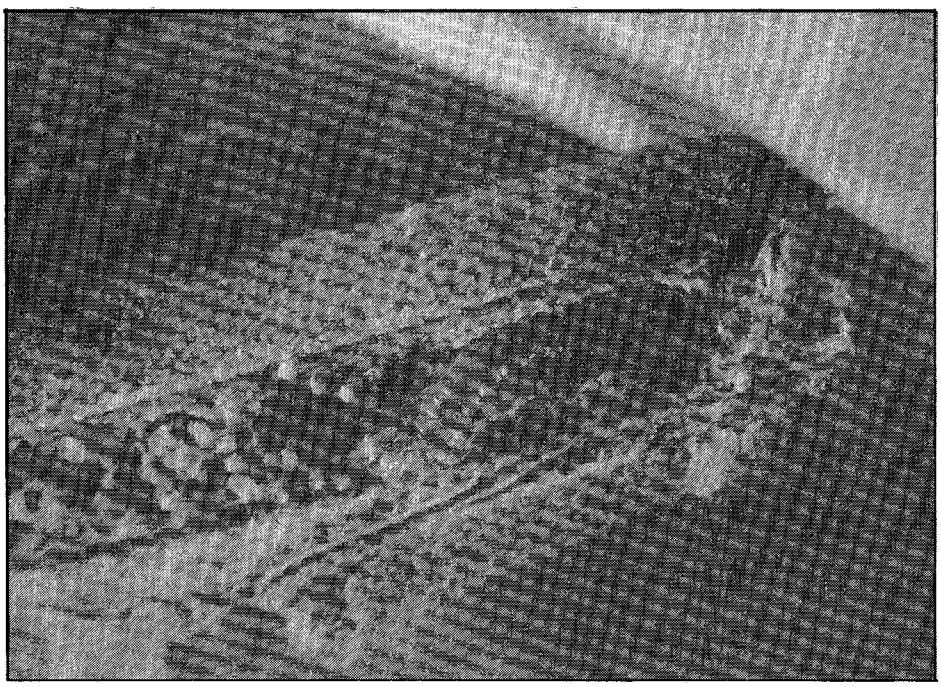

Figure 8. Shoot of *Myrica faya* opened to show a twig mining caterpillar and its feeding damage (length 8 mm).

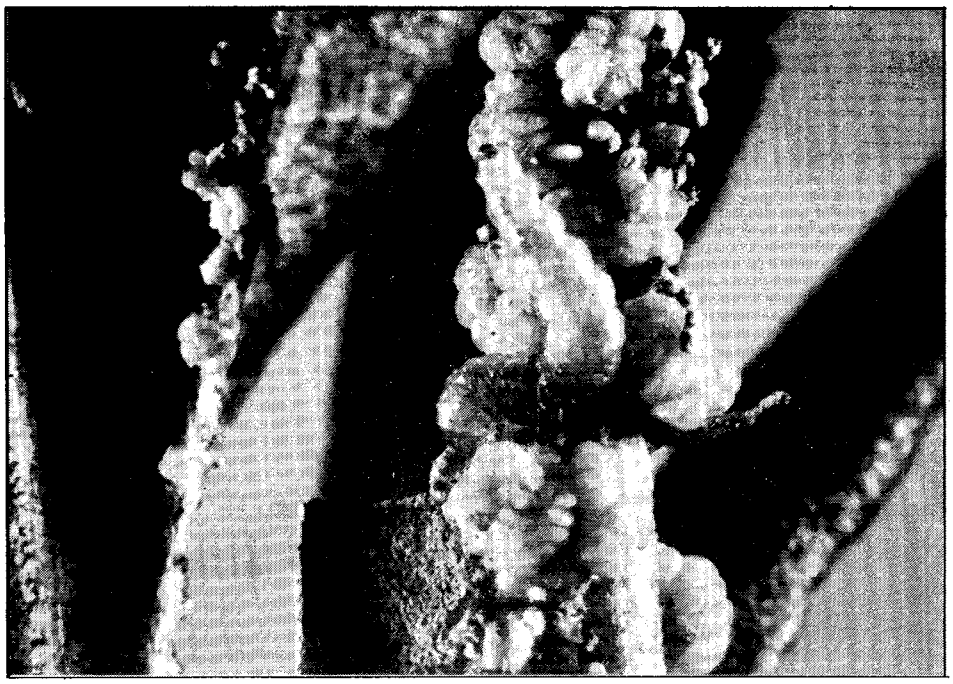

Figure 9. Larva of a pollen-feeding moth on male flowers of *Myrica faya* (length 3 mm).

Figure 10. Typical fruit load of *Myrica faya* on the Azores Islands.

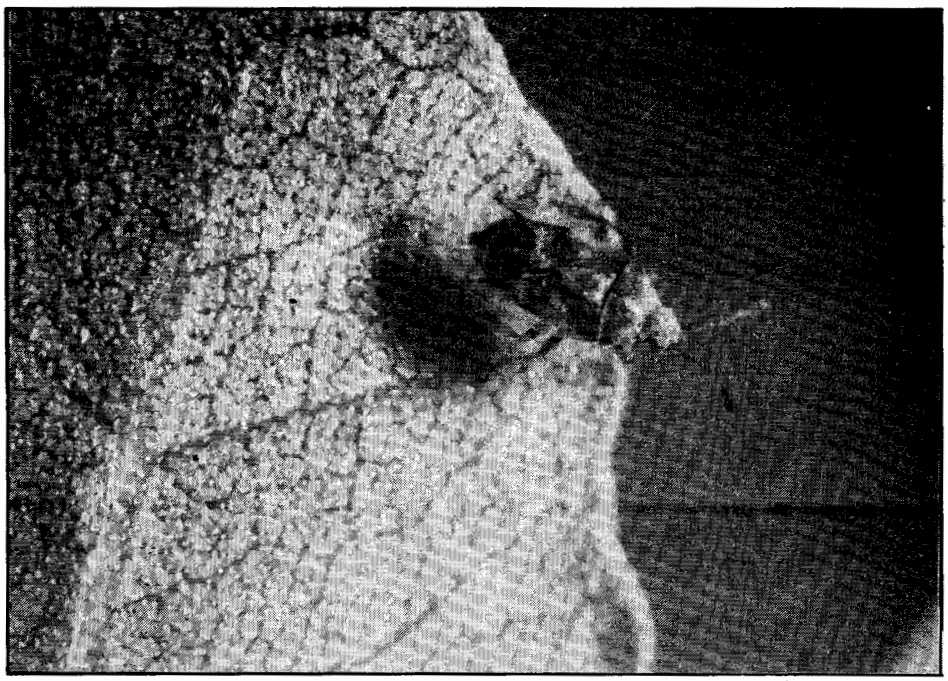

Figure 11. Small (3-4 mm) Mirid (plant bug, Hemiptera). Originally suspected of being a seed feeder.

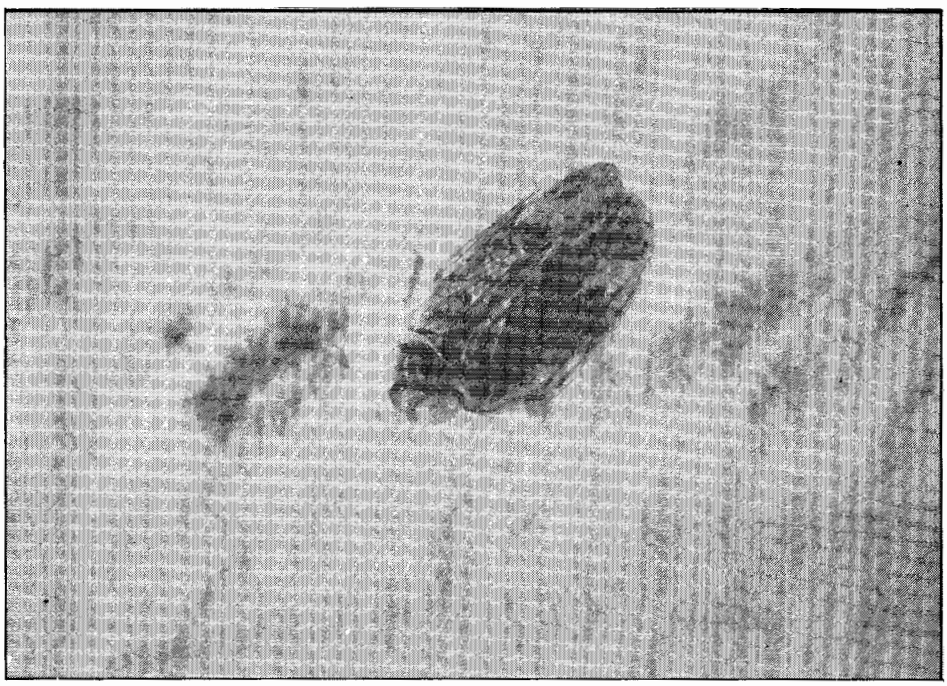

Figure 12. Plant hopper (Homoptera: Fulgoridae). Widely distributed at higher altitudes on *Myrica faya* on the Azores and Madeira (length 7 mm).

Figure 13. A large, wax scale (4-6 mm in diameter) widely distributed on *Myrica faya* on the Azores Islands.

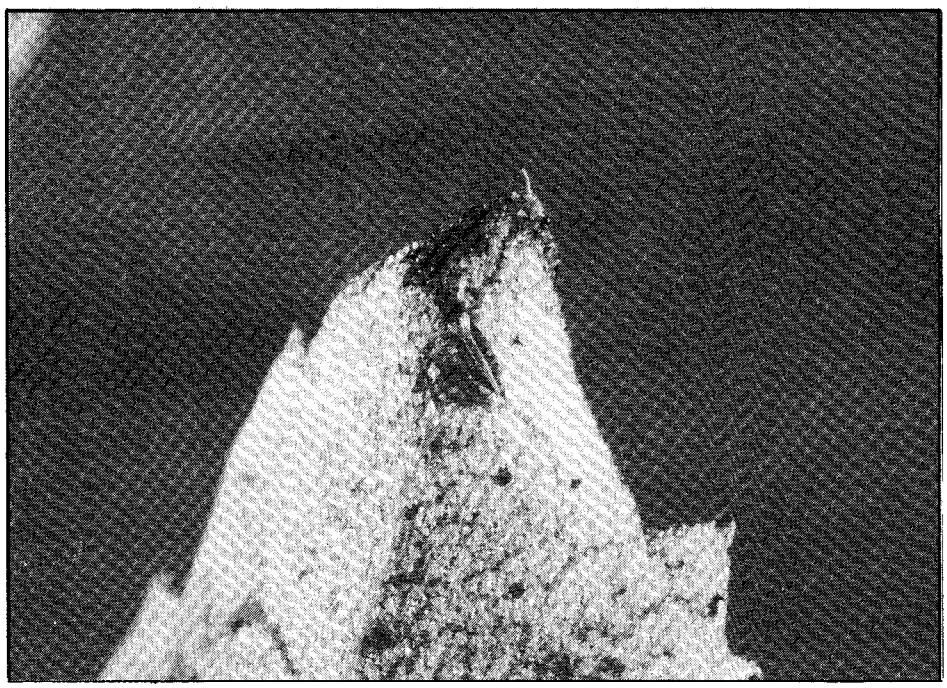

Figure 14. Thrips such as this one were found at all collecting sites. They are suspected of being general feeders of no use in biological control (length 2 mm).

Figure 15. Nitrogen fixing nodules on roots of *Myrica faya*. Surveys for insects that attacked these nodules on the Azores were negative.

Figure 16. Mealybugs just below soil level on root collar of *Myrica faya*. Small colonies of this insect, always attended by ants, were the only root-feeding insect found.

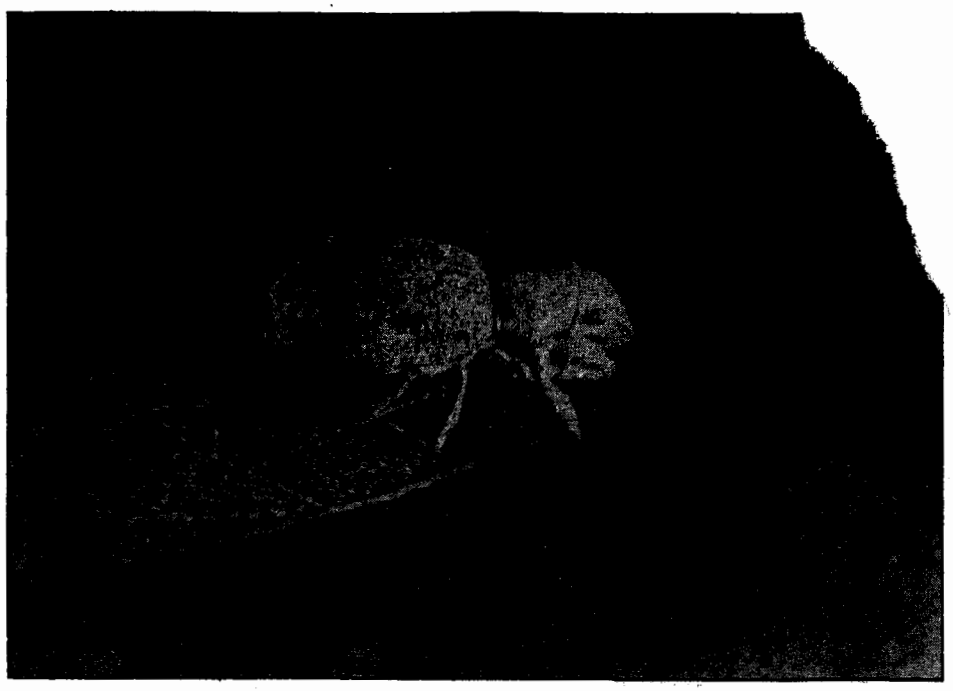

Figure 17. Large weevil commonly found feeding on *Myrica faya* leaves on both Azores and Madeira. It is a general feeder (length 10 mm).

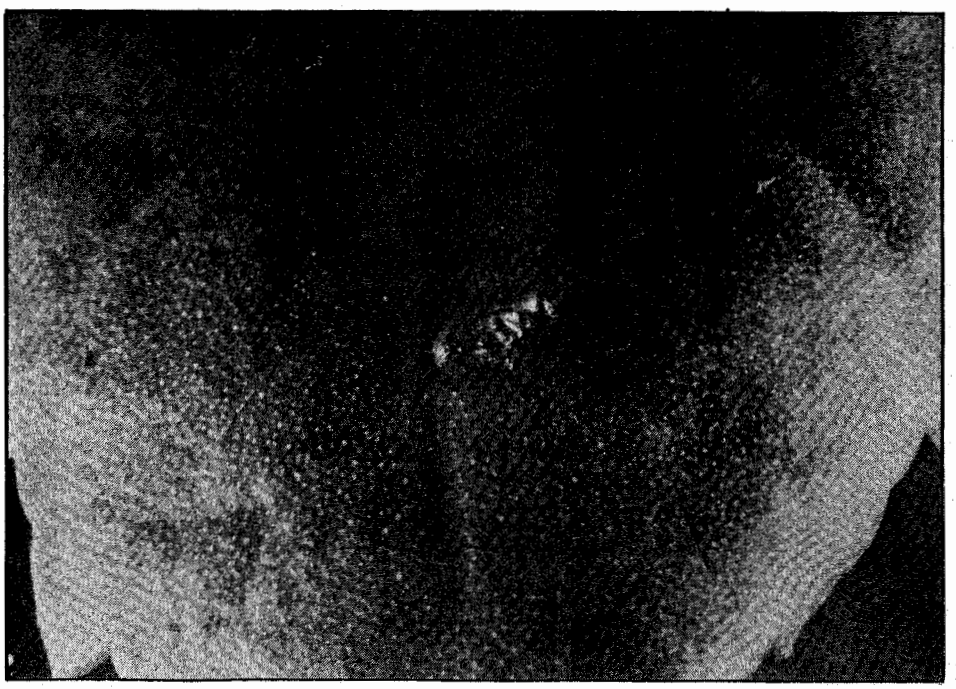

Figure 18. Small (3 mm) beetle observed making "shot holes" type feeding on *Myrica faya* leaves at one site on Madeira.

Figure 19. Large (length 15 mm) tip-feeding weevil collected on Madeira.

Figure 20. Shoots of *Myrica faya* killed by a disease believed to be *Ramularia destructiva*.