THE INSECT FAUNA ASSOCIATED WITH THE TREE *MYRICA FAYA* (MYRICACEAE) IN THE MACARONESIA ISLANDS AND ON MAINLAND PORTUGAL

By G. P. MARKIN [1], L. SILVA [2] & A. M. F. AGUIAR [3]

With 1 table

ABSTRACT. *Myrica faya* AITON, a plant native to the Macaronesia Islands, has been accidentally introduced to Hawaii where it has become a serious pest of our forests and other native ecosystems. Since the 1950's, an intensive survey of the insects associated with this plant has been conducted in those islands.

The goal was to identify those that may be potential biocontrol agents that could be released in Hawaii. While 36 insect species have been found feeding on this plant, the great majority are general feeders that were probably recently introduced by man. Only three species are thought to be specific to *M. faya*. A comparison of the insect fauna on the three island groups visited indicated a non-uniform distribution, with only two species found on all three and only half of the insects found on any two. A search for additional populations of *M. faya* was attempted in Europe and northwest Africa. The results indicated that relicts of a population if *M. faya* may have existed on the mainland until recent times, but may now be extinct. *M. faya* has recently been reintroduced by man to the north coast of Portugal, where a different complex of insects, all of them generalists, was found.

INTRODUCTION

In the Macaronesian Islands, the tree *Myrica faya* AITON is a major component of the native forests of the Azores, Madeira, and Canary Islands.

Here, it is widely distributed through a variety of climatic and altitude zones, but it is usually described as associated with the Laurelsilva and Fayal-Brezal vegetation zones (GONZALEZ-HENRIQUEZ *et al.* 1986; FERNANDEZ DE CORDOBA and MEDINA 1976). That the plant is also found commonly on the Hawaiian Islands in the Pacific, almost half a world away, would seem an anomaly until the history of the Hawaiian Islands is reviewed. In the

[1] USDA Forest Service, Institute of Pacific Islands Forestry, 1643 Kilauea Avenue, Hilo, Hawaii, USA 96720;

[2] Universidade dos Açores, Departamento de Biologia, 9502 Ponta Delgada, Açores, Portugal;

[3] Laboratorio Agricola da Madeira, 9139 Camacha, Madeira, Portugal.

 ISSN 0870-3876

1870's, the then independent country of Hawaii encouraged, and paid for, the immigration of several thousands families of Portuguese settlers from the Azores and Madeira Islands (CARVALHO 1980). These settlers probably brought with them the seeds of *M. faya*, and may have initially cultivated it as an ornamental, as a reminder of home. Unfortunately, with a seed-bearing fruit that was readily fed on and spread by local birds (WALKER 1990) and a lack of natural enemies, *M. faya* soon escaped cultivation and is now widely established throughout the islands (KIM 1969; WHITEAKER and GARDNER 1985).

In Hawaii's volcanic soils, so similar to those of *M. faya*'s home in the Macaronesian Islands, the ability of *M. faya* to fix nitrogen allowed it to outgrow and displace most of our native plants. Today, *M. faya* is considered to be one of the most aggressive weeds threatening Hawaii's remaining native forest ecosystems, particularly those found on newly formed soils in areas of recent volcanic activity (VITOUSEK et al. 1987). In areas such as these, it not only out competes native species of plants but interferes with the natural ecological succession by creating a nitrogen-rich soil, a habitat favorable to other introduced species of both arthropods and plants (APLET 1990, MATSON 1990, WALKER and VITOUSEK 1991) (For a more detailed account of this plant in Hawaii, see SMITH and LUTZOW-FELLING this Proceedings).

While originally considered a beneficial plant (at one time it was used for reforestation), *M. faya*'s aggressive nature was recognized by the early 1940's, when it was declared a noxious weed (LITTLE and SKOLMEN 1989).

Conventional methods of control such as chemicals and mechanical clearing have been used to eliminate it from higher valued agricultural land. Over most of the island where it has invaded large areas of native ecosystems, however, these methods are expensive and damaging to the native ecosystems which need protection.

In the 1950's, a proposal was made to attempt biological control by returning to the islands of M. faya's origin in the Atlantic, finding its natural enemies, and introducing them into Hawaii. In Hawaii, biological control has long been used as a method of pest management for introduced insect pests. It has also been attempted on 22 species of introduced weeds, and in half of the cases successfully eliminated the weeds as pests (MARKIN et al. 1992). It was therefore expected that a similar successful program could be established against *M. faya*. The first visit by a Hawaiian entomologist to the Macaronesian Islands to search for *M. faya*'s natural enemies was made by the Hawaiian Sugar Planters' Association experiment station entomologist FRED BIANCHI in the 1950's (BIANCHI 1955). Further studies were made by Hawaii Department of Agriculture entomologist NOEL KRAUSS in the 1960's (KRAUSS 1964). While these early exploratory entomologists collected and identified a number of insects associated with *M. faya* and shipped many to a quarantine laboratory in

Hawaii for further studies, no suitable biological control agents from the Macaronesian Islands were identified and released in Hawaii.

The plant's spread continued unabated and in the early 1980's, the program was resurrected (HODGES and GARDNER 1985). Since then, seven trips by entomologists have been made through the Macaronesian Islands to continue the search for natural enemies of *M. faya*. Cooperative programs have also been established with entomologists at the Universidade dos Açores in Ponta Delgada, as well as with an entomologist on Madeira, to continue the search and study of the associated insects. This survey was not limited to just the insect enemies of *M. faya*, but included plant pathogens (see GARDNER this proceedings).

The primary object of this survey was not limited to the preparation of a list of all insects associated with *M. faya*, but to specifically identify those that utilize it as their sole food source. This is important because the only insects that can be introduced into Hawaii and released as biological control agents are those capable of feeding only on *M. faya*. They must present no threat to other species of plants. Therefore, on finding a new insect feeding on *M. faya*, the first response is to see if it is also feeding on adjacent plants. If not, a colony of the insect is established on a local laboratory or in a quarantine facility in Hawaii to evaluate its feeding behavior. Finally, for those insects that cannot be reared, the literature is used to try and obtain a clearer picture of their feeding behavior or at least that of closely related species.

RESULTS AND DISCUSSION

The results of the numerous visits by U.S. scientists and the searches and studies by local entomologists have produced a list of 36 insects which were found feeding on *M. faya* on the Azores, Madeira, and Canary Islands (Table 1).

A review of the results of this survey has produced some interesting information:

1. There is great disparity of the *M. faya* entofauna of the three island groups. Each island group has a distinctly different complex of insects associated with this plant. Only two insects were found on all three island groups, the looper *Ascotis fortunata* BLACHIER, and a small leaf mining moth (*Caloptilia sp.* probably near *schinella* WAISINGHAM). Only six insects have been found on any two of the island groups.

2. The relatively small size of the insect complex found with *M. faya* on any one island group was a surprise. In the search for biological control agents for other Hawaiian weeds (currently programs on six species are underway), it is routine in the original homeland of the plant to find as many as 100 associated insects. This indicates a long period of co-evolution between the plant and the insects. As an example, two weeds currently being

studied for biological control in Hawaii are the European shrub gorse, (Ulex europaeus L.) (HILL 1982), and a vine from the Andes Mountain of South America, Passiflora mollissima (PEMBERTON 1982, 1989). Each has been found to be associated with more than 100 insects. By contrast, to collect only 23 species of associated insects in Madeira, and for all three island groups, to find only 36 associates, seems low.

3. The third, and the most disappointing, discovery during this study was the very low number of insects that were exclusively associated with *M. faya*, *i.e.*, those that used it as their only source of food. It appears that only three of the species collected are specific feeders on *M. faya*. The remainder of the insects are all polyphagous, and many of them are general agricultural pests introduced from other parts of the world. Even those insects found which are considered to be endemic to the different island groups such as *Argyresthia atlanticella* REBEL, *Cyphopterum azoricum* LINDBERG, and *Gymnoscelis pumilata* STAINTON were found to be generalists which utilize plants other than *M. faya*. This very abbreviated list of insects after 40 years of searching was unexpected, and might be considered a result of the limited land mass and ecosystems available for an insect complex to evolve in on an island. However, when one considers the number of endemic insect species associated with endemic plants in other isolated island groups, this explanation does not seem entirely valid. For instance, in Hawaii, a group of volcanic islands strikingly similar in many ways to the Canaries, our two major forest trees, *Acacia koa* GRAY and *Metrosideros polymorpha* GAUD, have been found to contain complexes of almost 100 insects each. The majority of these are endemic, and many are highly specific feeders that attack only these host trees (GAGNE 1976, STEIN 1983).

A complex of this size on *M. faya* was expected based on the presumed age and origin of the plant complex and the known geological age and degree of isolation of these three groups of Macaronesian Islands. For our particular purpose, that of finding phytophagous insects that would restrict their feeding to *M. faya* so they could be released as biological control agents, the survey has turned out to be a disappointment.

The three insects found, a flower feeding weevil, *Auletobius convexifrons* WOLLASTON, and two species of leaf mining Lepidoptera, *Caloptilia* sp. near *schinella* and *Phyllonorycter myricae* DESCHKA, are being studied as potential biological control agents. It is suspected that even if all three are successfully established in Hawaii, they will probably not impact *M. faya* enough to give the desired degree of control.

For this reason an additional source of insects was needed. This raised the question whether stands of *M. faya* still exist on the adjacent mainland and might represent relicts of the original population that provided colonies for the Macaronesian Islands. A few tentative references imply that *M. faya* may at one time have been found in northwestern Africa along the Atlantic coast of southern Morocco (QUEIRÓS 1987). The Atlas Mountains of Morocco would seem a logical location for the ancestral form of this plant. If *M. faya* moved south from Europe or the Mediterranean area during periods of glaciation in the Pliocene Epoch

(SUNDING 1979), populations in Morocco could have provided the colonies for the adjacent Canary and Madeira Islands. The African population then, might have migrated into the higher elevations of the Atlas Mountains as the climate subsequently warmed. However, our review of the literature and herbarium specimens and our contact with scientists familiar with this area have failed to locate a positive reference for the occurrence of this plant in the Atlas Mountains of Morocco. If *M. faya* at one time did occur there, it is now either exceedingly rare or extinct.

A search of the literature indicated that the only other reported distribution of *M. faya* was in mainland Portugal (CHEVALIER 1901). Several visits to this country confirmed that *M. faya* had a scattered distribution through much of the coastal area, although the largest and most continuous stand is found in a very narrow band less than 2 km wide, stretching for 100 km or more up the northern coast of Portugal. This population has created some controversy on whether the plants are native to this area or are recent introductions by man (QUEIRÓS 1987). An intensive survey for insects on *M. faya* in this area was even less productive than the one conducted on the Macaronesian Islands. The insect fauna found was very sparse and consisted only of polyphagous generalists that utilize *M. faya* only because it was available. We interpret this lack of a true complex of associated insects as supporting the theory that *M. faya* in northern Portugal is most likely the result of a relatively recent introduction by humans. In southern Portugal a more unusual population of *M. faya* may have existed. The Monchique Mountains, in the country's very southwestern most corner, are an isolated set of old granitic mountains reaching almost 1000 m above sea level and over 800 m above the surrounding countryside. The range is isolated by 100 km or more from the nearest significant mountains. *M. faya* herbarium specimens, some of which were collected as early as 1840 and are filed at museums around Europe, indicate these mountains at one time contained a population of this plant. This isolated group of mountains at first seems promising; their high elevation gave hope that they might harbor a relict population of plants remaining from some earlier geological period when the temperatures were cooler, perhaps even relict populations of the original ancestors of the Macaronesian *M. faya*. Unfortunately, the two visits to these mountains were exceedingly disappointing. The original plant complex has been totally exterminated and replaced by plantations of pines and eucalyptus. In visits in 1991 and 1993, only one *M. faya* plant was found. While it confirms the plants were found there in the past, we believe that the original forest and the *M. faya* it may have contained has now been basically exterminated.

ACKNOWLEDGMENTS

The majority of the funding for this study was provided by the State of Hawaii's Governor's Agricultural Coordinating Committee and administered by the National Park Service/Cooperative Parks Studies Unit. Special thanks are due to Dr. C. W. SMITH of the

CPSU, University of Hawaii at Manoa, and JOÃO TAVARES, Universidade dos Açores, for their help and coordination of this program. Additional thanks are due to Hawaii Department of Agriculture for allowing us access to their files and insect collection. We also wish to thank the taxonomist of the CAB International Institute of Entomology, London, for performing most of the identification.

REFERENCES

APLET, G. H.:
1990. Alteration of earthworm community biomass by the alien *Myrica faya* in Hawaii, *Oecologia*, **82**: 414-416.

BIANCHI, F. A.:
1955. Unpublished correspondence to Alan Thistle, June 1955. On file, Hawaii Dept. of Agriculture, Honolulu, HI.

CARVALHO, E. W.:
1980. The Portuguese. In: People and Cultures of Hawaii, A psychocultural profile. John A. Burns School of Medicine and the University Press of Hawaii. pp. 100-110.

CHEVALIER, A.:
1901. Monographie des Myricacees. Mem. Soc. Nat. Scienc, *Nature*, Cherbourg XXXII, pp. 85-340.

FERNANDEZ DE CORDOBA, L. C. & MEDINA, F. O.:
1976. Estudio sobre la vegetacion y flora forestal de las canarias occidentales. Excmo Cabildo Insular, Santa Cruz de Tenerife. pp. 259-313.

GAGNE, W. C.:
1976. Canopy-associated arthropods in *Acacia koa* and *Metrosideros* tree communities along the Mauna Loa transect. Island Ecosystems Integrated Research Program, U.S. International Biological Program. Tech. Rep. 77: 1-37.

GONZALEZ-HENRIQUEZ, M. N.; ROGRIGO PEREZ, J. D.; RODRIGUEZ, C. S.:
1986. Flora Y Vegetacion Del Archipielago Canario, *Gran Biblioteca Caneria*, CEDIRCA S.L. (publisher), 355 p.

HILL, R. L.:
1982. The phytophagous fauna of Gorse (*Ulex europeaus* L.) and host plant quality. Unpublished manuscript submitted for Doctoral Degree at University of London, Dept. of Pure and Applied Biology. 268 p.

HODGES, C. S., JR. & GARDNER, D. E.:
1985. *Myrica faya*: Potential biological control agents. Tech. Rep. 54. Cooperative National Park Resources Studies Unit, Manoa, Hawaii: University of Hawaii, 37 p.

KIM, J. Y.:
1969. *Myrica faya* control in Hawaii, *Down to Earth*, **25**: 23-25.

KRAUSS, N. L. H.:
1964. Insects associated with firebush (*Myrica faya* AITON). In: Proceedings of the Hawaiian Entomological Society, **18**(3): 405-411.

LITTLE, E. L., JR. & SKOLMEN, R. G.:
1989. Common forest trees of Hawaii (native and introduced). USDA Forest Service, Agriculture Handbook 679, 321 p.

MARKIN, G. P.; LAI, P. Y.; FUNASAKI, G. Y.:
1992. Status of biological control of weeds in Hawaii and implications for managing native ecosystems. In: Alien plant invasions in native ecosystems of Hawaii, Management and Research. C. P. STONE, C. W. SMITH, and J. T. TUNISON; eds., Cooperative National Park Resources Studies Unit, University of Hawaii, pp. 466-482.

MATSON, P.:
1990. Plant-soil interactions in primary succession at Hawaii Volcanoes National Park, *Oecologia*, **85**: 241-246.

PEMBERTON, R. W.:
1982. Exploration for natural enemies of *Passiflora mollissima* in the Andes. Unpublished paper, USDA Biological Control of Weeds Laboratory, Albany, CA.

PEMBERTON, R. W.:
1989. Insects attacking *Passiflora mollissima* and other *Passiflora* species; field survey in the Andes. In: Proceedings of the Hawaiian Entomological Society, **29**: 71-84.

QUEIRÓS, M.:
1987. Tab. LV *Myrica faya* (Myricaceae). In: Fernandes, A. and Fernandes, R. B., eds., Iconographia Selecta Florae Azoricae, **1**(2):17-24, Secretaria Regional da Educação e Cultura da Região Autónoma dos Açores.

STEIN, J. D.:
1983. Insects infesting *Acacia koa* (Leguminosae) and *Metrosideros polymorpha* (Myrtaceae) in Hawaii: Annotated List. In: Proceedings, Hawaiian Entomological Society, **24**: 305-316.

SUNDING, P.:
1979. Origins of the Macaronesian flora. In: Plants and Islands, Academic Press Inc. Ltd., London, pp. 13-40.

VITOUSEK, P. M.; WALKER, L. R.; WHITEAKER, L. D.; MUELLER-DOMBOIS, D.; MATSON, P. A.:
1987. Biological invasion of *Myrica faya* alters ecosystem development in Hawaii, *Science*, **238**: 802-804.

WALKER, L. R.:
1990. Germination of an invading tree species (*Myrica faya*) in Hawaii, *Biotropica*, **22**(2): 140-145.

WALKER, L. R. & VITOUSEK, P. M.:
1991. An invader alters germination and growth of a native dominant tree in Hawaii, *Ecology*, **72**(4): 1449-1455.

WHITEAKER, L. D. & GARDNER, D. E.:
1985. The distribution of *Myrica faya* AITON in the state of Hawaii. Tech. Rep. 55, Cooperative National Park Resources Studies Unit, Honolulu, Hawaii: University of Hawaii, 36 p.

TABLE 1 - Insects Found Feeding on *Myrica faya*

Order **Family**	Species	Collection Location
Coleoptera		
Apionidae	*Apion sagittiferum* WOLLASTON	Madeira & Canaries
	Apion urticarium (HERBST)	Madeira
Attelabidae	*Autetobius convexifrons* (WOLLASTON)	Madeira & Canaries
Chrysomelidae	*Cassida hemisphacrica* HBGT.	Canaries
	Cryptocephalus crenatus WOLLASTON	Madeira
	C. near signatiellis SAFF.	Canaries
	Ochrosis ventralis (ILLIGER)	Madeira
Curculionidae	*Brachyrhinus* sp.	Madeira & Canaries
	Otiorhynchus sp.	Madeira
	Laparocerus noctivagans (WOLLASTON)	Madeira
	L. angustatus (WOLLASTON)	Madeira
	Pantomorus cervinus (BOHEMAN)	Madeira
	Lixus angustatus (FABRICIUS)	Madeira
Phalacridae	*Olibrus affinis* (STURM)	Madeira
	Brachyderus lusitanicus (FABRICIUS)	Portugal
	Cneorhinus (=Tretinus?) heydeni grandis (STIERLIN)	Portugal
Hemiptera		
Miridae	*Lygus insularis* REUTER	Canaries
	Kleidocerys truncatulus (HORVATH)	Azores & Madeira
	Taphropeltus nervosus (FIEBER)	Madeira
	Othotylus viburni LINBERG	Canaries
Rhopalidae	*Liorhyssas hyalinus* (FABRICIUS)	Azores
Homoptera		
Cicadellidae	*Penthimia irrorata* HORRATH	Canaries

Cixiidae	*Cixius insularis* LINDBERG	Azores
Coccidae	*Ceroplastes floridensis* COMSTOCK	Madeira
Diaspididae	*Hemiberlesia rapax* COMSTOCK	Madeira
	Chrysomphalus pinnulifer MASKELL	Madeira
Flatidae	*Cyphopterum azoricum* LINDBERG	Azores
Issidae	*Issus canariensis* MELICHAR	Canaries
	I. miaderensis LINDBERG	Madeira
Margarodidae	*Icerya purchasi* MASKELL	Madeira & Portugal
Thysanoptera		
Phlaoethripidae	*Haplothrips* sp.	Azores
Thripidae	*Heliothrips haemorrhoidalis* BOUCHE	Azores & Madeira
Lepidoptera		
Carposinidae	*Carposina* sp. near *atlanticella* REBEL	Madeira
Geometridae	*Ascotis fortunata* BLACHIER	Azores, Madeira, & Canaries
	Gymnoscelis pumilata sp. insulariata STAINTON	Madeira
Tortricidae	*Clepsis* sp. near *stantoni* OBRATZOV	Madeira
Gracilariidae	*Caloptilia* sp. near *Schinella* (WALSINGHAM)	Azores, Madeira, & Canaries
	Phyllonorycter myricae DESCHKA	Madeira & Azores
Noctuidae	*Xestia c-nigrum* (LINNAEUS)	Azores
Yponomeutidae	*Argyresthia atlanticella* REBEL	Azores