

Phytophagous insects associated with endemic, macaronesian, and exotic plants in the Azores

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Abstract: A survey of *Myrica faya* Aiton (Myricaceae) natural enemies, was performed from 1991 to 1993, in order to find potential biocontrol agents for that plant, an ibero-macaronesian endemic, considered as a noxious weed in Hawaii. Samples were collected weekly at two sites in São Miguel, and complementary at São Jorge, Faial, Pico and Terceira islands (Azores). Since 1992, the survey was extended to include phytophagous insects associated with the other dominant trees at *Myrica faya* stands: *Erica scoparia* ssp. *azorica* (Hochstetter) (Ericaceae) an endemic, and *Pittosporum undulatum* Ventenat (Pittosporaceae) an exotic plant. Only 20 species of phytophagous insects were found: two Heteroptera, ten Homoptera, one Thysanoptera, two Coleoptera and five Lepidoptera. *M. faya* and *E. scoparia* ssp. *azorica* support the life-cycle of four endemic insects. *P. undulatum* is an occasional shelter for some insects. A correspondence analysis clearly separated the three plants, on the basis of their associated phytophagous insects.

Insectos fitófagos associados a plantas endémicas, macaronésicas e exóticas, nos Açores.

Resumo: Entre 1991 e 1992, realizou-se a prospecção dos inimigos naturais de *Myrica faya* Aiton (Myricaceae), um endemismo ibero-macaronésico, considerado como uma infestante nociva, no Hawaii. A amostragem foi semanal, em dois locais da ilha de São Miguel. Efectuaram-se amostras complementares nas ilhas de São Jorge, Faial, Pico e Terceira (Açores). A partir de 1992, estudaram-se igualmente os insectos fitófagos associados a duas plantas abundantes nos biótopos de *M. faya*: *Erica scoparia* ssp. *azorica* (Hochstetter) (Ericaceae) um endemismo, e *Pittosporum undulatum* Ventenat (Pittosporaceae) uma exótica. Encontraram-se 20 espécies de insectos fitófagos: dois Heteroptera, dez Homoptera, um Thysanoptera, dois Coleoptera, e cinco Lepidoptera. *M. faya* e *E. scoparia* ssp. *azorica* suportam o ciclo de vida de quatro insectos endémicos. *P. undulatum* funciona como abrigo ocasional para alguns insectos. Uma análise de correspondências separa as três plantas, com base nos insectos fitófagos associados a cada uma.

INTRODUCTION

Myrica faya Aiton (Myricaceae) is a small tree or shrub that is considered an ibero-macaronesian endemic (QUEIRÓS, 1987). The plant was introduced to

Hawaii by the end of the last century, and in the 1950's it was already considered a noxious weed, invading pastures, rangelands and the natural ecosystems of Hawaii (YAMAYOSHY, 1954; VITOUSEK *et al.*, 1987). On the other hand, in its natural habitat, namely in the Azores islands, *M. faya* distribution is decreasing, as a consequence of human activities and after the introduction of *Pittosporum undulatum* Ventenat (Pittosporaceae) (DROUET, 1866; SJÖGREN, 1984; QUEIRÓS, 1987).

A survey for the natural enemies of the plant was initiated in order to find potential, biocontrol agents (KRAUSS, 1964; HODGES & GARDNER, 1985; GARDNER *et al.* 1988; MARKIN, 1990; MARKIN *et al.*, in press). In 1991, a survey was started in the Azores, but since *Erica scoparia* ssp. *azorica* (Hochstetter) (Ericaceae), an endemic, and *P. undulatum*, were also dominating the vegetation in that area, we decided to extend our sampling program to those plants.

In the present work the phytophagous insects associated with each of those plants are compared, and those found in *Myrica faya* are evaluated as potential biological control agents. Consequences of a further spread of the exotic plant on the community of phytophagous insects are discussed.

METHODS

Sampling was performed weekly, at two places at São Miguel Island (Azores): Lombadas (550 m) and Pico das Camarinhas (150 m). Complementary, samples were taken at other locations in São Miguel island and at the islands of São Jorge, Faial, Pico and Terceira.

Insects were collected by:

- beating in the foliage, and collecting the falling insects with an entomological net (beating in 100 branches, per plant species);
- cutting terminal shoots with flower, fruit or leaf damage (30 shoots per plant species).

Insects were mounted or preserved in 75% ethanol, and sent for identification. Species were sorted in categories, depending on their total abundance all around the year, namely: 0) absent; 1) $\log(\text{total number}) \leq 1$; 2) $\log(\text{total number}) \leq 2$; and 3) $\log(\text{total number}) > 2$.

Where possible, insect degree of host specificity was analysed, or checked in the literature.

A correspondence analysis was performed for the three plants at the two sites in São Miguel, using the abundances of the various species as variables.

RESULTS

Only twenty species of phytophagous insects were found (Table 1): two Heteroptera, ten Homoptera (one endemic), one Thysanoptera, two Coleoptera and five Lepidoptera (three endemic).

Table 1

Phytophagous insects associated with an exotic (*Pittosporum undulatum*), a macaronesian (*Myrica faya*) and an endemic plant (*Erica scoparia* ssp. *azorica*) at two sites in São Miguel Island, Azores: Lombadas (550 m) - L; and Pico das Camarinhas (150 m) - C. Data was collected from October 1992 until October 1993. Complementary, sampling was performed at other sites at São Miguel, São Jorge, Faial, Pico and Terceira Islands.

*Breeding population

Insect	Host Plant					
	<i>Erica scoparia</i> ssp. <i>azorica</i>		<i>Myrica</i> <i>faya</i>		<i>Pittosporum</i> <i>undulatum</i>	
	L	C	L	C	L	C
HETEROPTERA						
Miridae						
<i>Orthops</i> sp.	1	1	1	1	1	1
Lygaeidae						
<i>Kleydoceris truncatulus</i> (Walker)	2*	3*	2	2	1	2
HOMOPTERA						
Cercopidae						
<i>Philaenus spumarius</i> Linnaeus	1	1	1	1	1	1
Cixiidae						
<i>Cixius insularis</i> Lindberg	2	2	1	1	1	1
Flatidae						
<i>Cyphopterus</i> sp.	1	1	1	1	1	1
Aphididae						
<i>Aphis gossypii</i> Glover	0	0	Pico*		0	0
Psyllidae						
<i>Strophingia harteni</i> Hodkinson	1*	2*	0	0	0	0
<i>Trioza alacris</i> Flor	1	1	1	1	1	1
Coccidae						
<i>Ceroplastes sinensis</i> (Del Guercio)	0	0	Lagoa*		0	0
Diaspididae						
<i>Chrysomphalus</i> sp.	1	1	2	2	0	0
Margarodidae						
<i>Icerya purchasi</i> (Maskell)	1	1	1	1	0	0
Pseudococcidae						
<i>Pseudococcus</i> sp.	0	0	Lagoa, Terceira*		0	0

Insect	Host Plant					
	<i>Erica scoparia</i> ssp. <i>azorica</i>		<i>Myrica</i> <i>faya</i>		<i>Pittosporum</i> <i>undulatum</i>	
	L	C	L	C	L	C
THYSANOPTERA						
Thripidae						
<i>Heliothrips haemorrhoidalis</i> Bouche	1	2*	1	1	0	0
COLEOPTERA						
Nitidulidae						
<i>Meligethes aeneus</i> (Fabricius)	1	2	0	1	0	1
Anaspidae						
<i>Anaspis proteus</i> Wollaston	1	1	1	1	1	1
LEPIDOPTERA						
Yponomeutidae						
<i>Argyresthia atlanticella</i> Rebel	3*	3*	3*	3*	0	0
Gracillariidae						
<i>Caloptilia aurantiaca</i> (Wollaston)	0	0	0	2	0	0
Geometridae						
<i>Ascotis fortunata azorica</i> Pinker	2*	3*	3*	3*	1	1
<i>Gymnoscelis rufifasciata</i> (Haworth)	0	0	Lagoa*	0	0	
<i>Cyclophora azorensis</i> (Prout)	3*	3*	0	0	0	0

Species were sorted in categories, depending of their annual abundance, namely: 0) absent; 1) $\log(\text{total number}) \leq 1$; 2) $\log(\text{total number}) \leq 2$; and 3) $\log(\text{total number}) > 2$.

Erica scoparia ssp. *azorica* supports the complete life-cycle of *Kleydoceris truncatulus* (Walker) (Heteroptera, Lygaeidae), *Strophingia harteni* Hodkinson (Homoptera, Psyllidae), *Argyresthia atlanticella* Rebel (Lepidoptera, Yponomeutidae), *Ascotis fortunata azorica* Pinker (Lepidoptera, Geometridae) and *Cyclophora azorensis* (Prout) (Lepidoptera, Geometridae). *Myrica faya* supports the life-cycles of *Ceroplastes sinensis* (Del Guercio) (Homoptera, Coccidae), *Heliothrips haemorrhoidalis* Bouche (Thysanoptera, Thripidae), *Argyresthia atlanticella*, *Caloptilia aurantiaca* (Wollaston) (Lepidoptera, Gracillariidae) and *Ascotis fortunata azorica*, but the first two insects as well as *Gymnoscelis rufifasciata* (Haworth) (Lepidoptera, Geometridae), are rarely found on that plant. Active populations of *Chrysomphalus* sp. (Homoptera, Diaspididae) and *Pseudococcus* sp. (Homoptera, Pseudococcidae) were also found on *M. faya*. The other insects were probably only using *Myrica* and *Erica* as shelter and not as a primary host.

As regards *P. undulatum*, we have found very reduced feeding damage caused by insects, and we suspect that this plant, in the Azores Islands, is only an occasional shelter for some insect species.

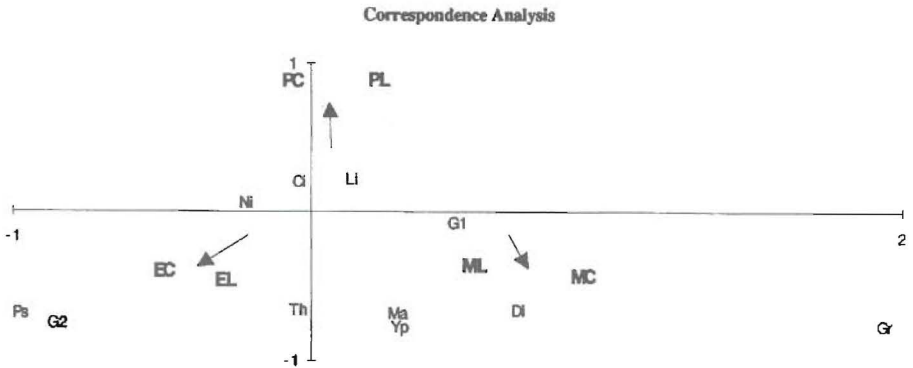


Figure 1. Correspondence analysis. Simultaneous projection of the variables (insects abundances) and objects (different plants at two different sites). Data based on the abundances of different species of phytophagous insects, over three plant species at two sites in São Miguel Island, Azores.

PC. *Pittosporum undulatum* at Pico das Camarinhas

PL. *Pittosporum undulatum* at Lombadas

EC. *Erica scoparia* ssp. *azorica* at Pico das Camarinhas

EL. *Erica scoparia* ssp. *azorica* at Lombadas

MC. *Myrica faya* at Pico das Camarinhas

ML. *Myrica faya* at Lombadas

Li - Lidgaeidae, Ci - Cixiidae, Ps - Psyllidae, Ma - Margarodidae, Di - Diaspididae, Ni - Nitidulidae, Th - Thripidae, G1 & G2 - Geometridae, Yp - Yponomeutidae, Gr - Gracillariidae.

A correspondence analysis on the data collected at two sites in São Miguel (Figure 1), clearly separated the three plants, on the basis of their associated phytophagous insects. The first axis, separates *M. faya* from *E. scoparia* ssp. *azorica*, and the second separates these two plants from *P. undulatum*. The main difference between *M. faya* and *E. scoparia* ssp. *azorica* is their association with *Caloptilia aurantiaca* and *Cyclophora azorensis*, respectively.

DISCUSSION

Ascotis fortunata azorica, an endemic defoliator, is a polyphagous species (SILVA, 1992), feeding on *M. faya* and *E. scoparia* ssp. *azorica*, as well as on other plant species, namely: *Myrsine africana* L. (Myrsinaceae), *Viburnum tinus* spp. *subcordatum* (Trel.) Padre Silva (Caprifoliaceae) and *Ligustrum henryi* Hemsley (Oleaceae). First instars cause only light scarification on the leaves, but last instars originate large feeding damage during summer months. Larvae are also abundant over *E. scoparia* ssp. *azorica*.

Argyresthia atlanticella is a flower miner, feeding of *M. faya* male flowers

(GARDNER *et al.*, 1988), and green fruits, but also of *E. scoparia* ssp. *azorica* and *Vaccinium cylindraceum* Smathers in Rees (Ericaceae) flowers and leaves. Starvation tests showed that this insect is polyphagous (SILVA *et al.*, in prep.). In multiple choice oviposition tests, the insect preferred *E. scoparia* ssp. *azorica*, while *M. faya*, *Calluna vulgaris* (L.) (Ericaceae) and *Vaccinium cylindraceum*, were not so frequently selected as oviposition sites, and *Juniperus brevifolia* (Seubert) Antoine (Cupressaceae), *Polygonum capitatum* D. Don (Polygonaceae) and *Myrsine africana* were only rarely selected (SILVA, *et al.*, in prep.). First instar larvae developed to the adult stage feeding of *M. faya* flowers and green fruits, *E. scoparia* ssp. *azorica* flowers and leaves, *V. cylindraceum* flowers and leaves, and *P. capitatum* flowers. First instars search for a flower or a leaf to mine. Last instars feed from the outside. Larvae are found all around the year over *Erica scoparia* ssp. *azorica*, but also during *Myrica faya*, *Vaccinium cylindraceum* and *Calluna vulgaris* flowering periods.

Cyclophora azorensis first instar larvae were tested (unpublished data) using *Erica scoparia* spp. *azorica*, *Calluna vulgaris*, *Vaccinium cylindraceum*, *Myrica faya*, *Myrsine africana*, *Viburnum tinus* ssp. *subcordatum*, *Pittosporum undulatum*, *Laurus azorica* (Seub.) Franco (Lauraceae), and *Ilex perado* sp. *azorica* (Loes.) Tutin (Aquifoliaceae). Larvae only survived and developed on *Erica scoparia* ssp. *azorica*. The other tested plants did not allowed survival beyond three days, and larvae never reached second instar. Only *Erica scoparia* spp. *azorica* (Ericaceae) was a suitable host, supporting the life cycle of the insect. Larvae feed on flower buds and leaves, and are abundant all around the year. In oviposition tests, *Erica* was clearly preferred to *Myrica*, with a total of 279 and 13 eggs, respectively.

Caloptilia aurantiaca is a leaf-miner that was released in Hawaii (MARKIN, 1990). It was first erroneously identified as *Phyllonorycter myricae* Deschka (Lepidoptera, Gracillariidae). This insect was found associated with *Myrica faya* and *Hypericum foliosum* Aiton (Hypericaceae). First instars mine *M. faya* leaves, but similar mines were found on *Hypericum foliosum* in Terceira and São Miguel Islands. Last instar larvae leave the mine and roll the tip of the leaf, creating a chamber where they pupate. Two species are known for the Azores (CARVALHO, 1982), *Caloptilia aurantiaca* and *Caloptilia bistrigella* (Rebel). *Caloptilia schinella* Walsingham from Madeira (AGUIAR, 1993) is a polyphagous insect that also feeds on *Myrica faya*.

Gymnoscelis rufifasciata feeds on *Cynara cardunculus* L. (Asteraceae) flowers and is considered as a pest in Egypt (SADDIK & EL-MINIAWI, 1978). In the Azores this species was found on *Laurus azorica* and *Myrica faya* flowers. This species was considered as a pest of various crops (HARAKLY & ASSEM, 1978).

Kleidocerys truncatulus was collected at Lombadas and Pico das Camarinhas, specially in *Erica scoparia* ssp. *azorica*. It is largely established in the Eastern

Palaearctic region. In England it is associated with *Erica* sp.. It probably feeds on seeds or mature fruits. In the Azores many specimens were found in *Erica scoparia* ssp. *azorica*, but also in *Juniperus brevifolia* and *Pittosporum undulatum*. *Kleidocerys resedae* Panz. in France (VILLIERS, 1977) and *Kleidocerys truncatulus ericae* Horvarth in Madeira are found in *Erica* spp. (AGUIAR, 1993). This insect is not specific to *Myrica faya*.

Cixius insularis Lindberg (Homoptera, Cixiidae) an endemic, was found since March mainly in spring and summer, but also in *Erica scoparia* ssp. *azorica* and *Juniperus brevifolia*, including where no *M. faya* exists (Caldeira, Faial). Cixiidae nymphs are found in soil where they feed on the roots of the host. Adults feed on various host species. *Cixius nervosus* L. and *C. pilosus* Ol. are common in France where they have several hosts (VILLIERS, 1977). AGUIAR (1993) has found *Cyxius verticalis* Noualhier in *M. faya* on Madeira.

The remaining species (Table 1) are known to be polyphagous or pests.

The azorean entomofauna is relatively poor in number of species and endemics (OROMI, 1982; QUARTAU, 1982; MENDES, 1982; MACHADO, 1982; ILHARCO, 1982; BÁEZ, 1982; BORGES, 1990; VIEIRA & PINTUREAU, 1991). *Argyresthia atlanticella*, *Ascotis fortunata azorica* and *Cyclophora azorensis* are azorean endemics. On the other hand, *Pittosporum undulatum* is not a suitable host for these and other species of insects, present in *Myrica-Erica* stands. *Myrica-Erica* stands in the Azores islands are endangered by human activities and by the spread of exotic species, namely *Pittosporum undulatum* (DROUET, 1866; SJÖGREN, 1984; QUEIROS, 1987). Further spread of the exotic plant, an unsuitable host for several phytophagous insects supported by *Myrica faya* and *Erica scoparia* ssp. *azorica*, will affect not only the flora but also the entomofauna.

CONCLUSION

Of the lepidoptera found none is specific to *Myrica faya*. On the other hand, we can conclude that lepidoptera are important phytophagous in *Myrica-Erica* stands in the Azores Islands. No other species of insects specific to *Myrica faya* were found in the Azores, so that, no more species will be sent to Hawaii as biocontrol agents.

Since *Caloptilia aurantiaca* is not specific to *Myrica faya* no further introductions of this insect should be allowed in Hawaii.

If we are to preserve the natural ecosystems of the Azores, it does not suffice to preserve the native flora, but also the associated entomofauna, and the trophic relationships that characterize those ecosystems. To achieve that goal, weed control measures should be reinforced.

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REFERENCES

- AGUIAR, A. M. F. (1993): *Insect survey for Potential Biological Control Agents of Myrica faya in Madeira Island*. Unpublished Technical Report, Laboratório Agrícola da Madeira, Camacha, 15 pp.
- BÁEZ, M. (1982): Estudio Biogeográfico de la Superfamilia Muscoidea en la Macaronesia, con especial referencia a las islas Canarias (Insecta, Diptera). *Bolm Soc. port. Ent.* 7 (Supl. A): 257-273.
- BORGES, P. A. V. (1990): A checklist of the Coleoptera from the Azores with some systematic and biogeographic comments. *Bol. Mus. Mun. Funchal*, 42 (220): 87-136.
- CARVALHO, J. P. (1982): Acerca da inventariação dos Lepidópteros dos Açores. *Boletim Soc. port. Ent. Suplemento* 3(2): 169-198.
- DROUET, H. (1866): *Catalogue de la flore des iles des Açores*.
- GARDNER, D. E.; G. P. MARKIN & C. S. HODGES, Jr. (1988): Survey for potential biological control agents for *Myrica faya* in the Azores and Madeira. *Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa, Technical Report* 63.
- HARAKLY, F. A., & M. A. ASSEM (1979): Ecological studies on the truly pests of leguminous plants in Egypt. I Biting and chewing pests. *Proceedings of the Fourth Conference of Pest Control, Cairo, Egypt*, 233-236.
- HODGES, Jr., C. S., & D. E. GARDNER (1985): *Myrica faya*: Potential biological control agents. *Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa, Technical Report* 54.
- ILHARCO, F. A. (1982): Afidofauna Açoriana: comentários zoogeográficos (Homoptera, Aphidoidea). *Bolm Soc. port. Ent.* 7 (Supl. A): 275-285.
- KRAUSS, N. L. H., 1964. Insects associated with firebush (*Myrica faya* Aiton). *Proceedings, Hawaiian Entomological Society*, 18(3): 405-411.
- MACHADO, A. B. (1982): Acerca do estado actual do conhecimento das aranhas dos Açores (Araneae). *Bolm Soc. port. Ent.* 7(Supl. A): 137: 143.
- MARKIN, G. P., 1990. Insect survey of potential biological control agents of *Myrica faya*

- in the Azores and Madeira Islands. *Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa, Technical Report 75*.
- MARKIN, G. P.; L. SILVA & F. AGUIAR (in prep.). Insect fauna associated with the plant *Myrica faya* in the Atlantic Islands and in mainland Portugal. *Bol. Mus. Mun. Funchal*.
- MENDES, L. F. (1982): Notas taxonómicas e zoogeográficas sobre os tisanuros (Microcoryphia e Zygentoma: Apterigota) macaronésicos. *Bolm Soc. port. Ent.* 7(Supl. A): 151-167.
- OROMI, P. (1982): Distribución de los Tenebrionidae (Coleoptera) en las islas atlánticas. *Bolm Soc. port. Ent.* 7(Supl. A): 215-231.
- QUARTAU, J. A. (1982): A preliminary faunistic analysis of the Cicadellidae (Homoptera, Auchenorrhyncha) of the Azores. *Bolm Soc. port. Ento.* 7(Supl. A): 145-149.
- QUEIRÓS, M. (1987): *Myrica faya*. in Fernandes, A. & R. B. Fernandes (ed.), *Iconographia Selecta Florae Azoricae*, 2(1): 17-24. Secretaria Regional da Cultura da Região Autónoma dos Açores, Coimbra.
- SADDIK, A., & EL-MINIAMI, S. F. (1979): A study on infestation of artichoke *Cynara cardunculus* V. *scaberrimus* L. by looper caterpillars and other pests. *Proceedings of the Fourth Conference of Pest Control, Cairo, Egypt*, 179-187.
- SILVA, L. (1992): Contribuição para o estudo da bioecologia de *Ascotis fortunata azorica* Pinker (Lep., Geometridae). *Bolm. Soc. port. Ent.*, 2(Supl. 3): 337-346.
- SILVA, L.; G. MARKIN & J. TAVARES (in prep.). *Argyresthia atlanticella* REBEL (Lep., Yponomeuidae) an excluded agent for *Myrica faya* (Myricaceae) Biocontrol. Presented at the "5th International Congress of Entomology, York, 29 August-3 September 1994".
- SJÖGREN, E. (1984): *Açores Flores*. Direcção Regional de Turismo, Horta, 90 lam.
- VIEIRA, V., & B. PINTUREAU (1991): Comparative diversity of Lepidoptera (Insecta) in the islands of the Azores. *Arquipélago - Life and Earth Sciences*, 9: 25-35.
- VILLIERS, A., 1977. *Atlas des Hémiptères*. Société Nouvelle des Éditions Boubée & Cie, Paris, 301 pp.
- VITOUSEK, P. M.; L. R. WALKER, L. D. WHITEAKER, D. MUELLER-DOMBOIS & P. A. MATSON. (1987): Biological invasion by *Myrica faya* alters ecosystem development in Hawaii. *Science*, 238: 802-804.
- YAMAYOSHI, H. T. (1954): *Myrica faya* Survey. Territory of Hawaii Board of Commissioners of Agriculture and Forestry, Honolulu.