



## Difficulties on the biological control of Macaronesian invaders

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### Abstract

*Myrica faya* is an Ibero-Macaronesian endemic which, after its introduction in Hawaii in the last century, invaded several islands in that archipelago. *Clethra arborea* is a tree endemic to Madeira island, naturalised in São Miguel (Açores) from the 1960s, where it invades high altitude native vegetation. From 1991 to 1994 a survey was undertaken to find *M. faya* natural enemies in Azores and Madeira. Although several insects and some pathogens were found, only two species of insects from Madeira might be potential biocontrol agents. One of which was released in Hawaii. Regarding *C. arborea* a similar survey initiated in 1997, but in this case no specific insects have been found. On the other hand, a fungus found in Madeira and São Miguel might be specific. A native insect, *Kleydoceris truncatulus*, feeds on the seeds. In general, the search for natural enemies with potential as biological control agents as not been very promising.

**Key words:** *Myrica faya*, *Clethra arborea*, invasion, biocontrol, tree.

Title: Dificuldades no controlo biológico de invasoras da Macaronésia

### Resumo

*Myrica faya* é uma árvore ibero-macaronésica que, após a sua introdução no Hawaii no final do século passado, invadiu várias ilhas deste arquipélago. *Clethra arborea* é uma árvore endémica da Madeira, naturalizada em São Miguel (Açores) desde os anos sessenta, onde invadiu a vegetação natural de altitude. Entre 1991 e 1994 decorreu a prospecção dos inimigos naturais de *M. faya* nos Açores e na Madeira. Embora vários insectos e alguns fitopatogéneos tenham sido encontrados, apenas dois insectos originários da Madeira teriam as condições necessárias para a sua utilização no Hawaii - serem específicos para o hospedeiro. Um deles foi introduzido no Hawaii. Para *C. arborea*, a prospecção dos inimigos naturais iniciou-se em 1997, mas neste caso, não têm sido encontrados fitófagos específicos. No entanto, encontrou-se um fungo fitopatogénico na Madeira e em São Miguel que poderá ser específico. Também se identificou um insecto fitófago autóctone, *Kleydoceris truncatulus*, que consome as sementes. De um modo geral, no entanto, a prospecção de inimigos naturais específicos e com potencial como controladores destas duas lenhosas macaronésicas não tem sido promissora.

**Palavras chave:** *Myrica faya*, *Clethra arborea*, invasão, biocontrol, árvore.

### Introduction

*Myrica faya* Aiton, 1789 (Myricaceae), a shrub or small tree that has been considered as an Ibero-Macaronesian endemic (Queirós, 1987), was introduced to Hawaii by the end of the 1800's, by Portuguese immigrants. In the 1950's *M. faya* was already considered a noxious weed, invading rangelands, pasturelands and the natural forests of Hawaii.

*Clethra arborea* Aiton (Clethraceae), a tree endemic to Madeira island invades native vegetation in São Miguel island (Azores). It is a relatively recent introduction that was found for the first time as naturalised in 1960 (Franco, 1984). Le Grand (1982) already cited the



invasion by *C. arborea*, of the native vegetation where the endemic bird *Pyrrhula murina* nests. Today, this tree invades several pockets of high altitude native vegetation in São Miguel, namely near Monte Escuro (Lagoa do Fogo Nature Reserve), Salto do Cavalo, Achada das Furnas, Tronqueira and Pico da Vara Nature Reserve, and at the area surrounding Achada forestry road. Only some tickets of high altitude native vegetation at the western part of the island (Sete Cidades) are free from the invader. Moreover, the seeds of *C. arborea* are used by *P. murina* during the winter (Ramos, 1994), which may cause some difficulties in the management decisions. In this paper we describe the difficulties found in the surveys of *M. faya* and *C. arborea* natural enemies.

In 1964 Krauss, resumed de insects found on *M. faya*. He found more than 30 species of insects, of which ten were sent for identification and propagation. Propagation problems occurred for most of the insects. *Strepsicrates smithiana* (Walsingham) (Lepidoptera, Tortricidae) was introduced in 1955 by the Hawaiian State Department of Agriculture, from Florida and Georgia (Weber, 1957). Its natural host is *Myrica cerifera*, and the insect established in Oahu in 1960 (Zimmerman, 1978), but was not effective against *M. faya*. In the 1980ís interest on biocontrol of *M. faya* was renewed. Hodges & Gardner (1985) reinitiated the research and found several insects and diseases. A synthesis of this research can be found in Markin (1989, 1990) and in Lutzouw-Felling *et al.* (1995). In 1991 the University of the Azores initiated a survey of *M. faya* associated insects in the Azores and Madeira.

Regarding *Clethra arborea*, a survey of the natural enemies of this tree was initiated in 1997.

## Methods

From 1991 to 1993 weekly samples were taken at two *M. faya* stands in São Miguel, Lombadas (550 m) and Pico das Camarinhas (150 m). Sampling also extended to other parts of the island and to other islands: São Jorge, Faial, Pico, Terceira and Madeira island. Sampling included: beating in the foliage and collecting the insects with a net; direct observation of root nodules, shoots and leaves flowers and fruits. Insects were mounted or stored in alcohol and send for identification. Insects with potential as biocontrol agents were kept in the laboratory in order to develop, reproduce and to be tested for host range. Occurrence of diseases was also noted.

A similar work was initiated in 1997 for *C. arborea* in São Miguel, namely weekly at Monte Escuro (Lagoa do Fogo Nature Reserve), and Tronqueira, and more sporadically at Salto do Cavalo and Achada das Furnas. Several visits were also made to Madeira island, from where the most promising natural enemies were expected to come.

## Results

### *Myrica faya*

Insects collected in Madeira are reported in Table 1. *Carposina atlanticella* Rebel (Carposinidae), feeds on the stems, flowers and fruits (Aguiar, 1993), but it also feeds on other plants (Lutzouw-Felling *et al.*, 1995). *Phyllonorycter myricae* Deschka (Gracilariidae), *Caloptilia schinella* Walsingham (Gracilariidae), a leaf-miner and a leaf roller, and *Auletobius convexifrons* (Wollaston) (Atelabidae) which causes small perforation pits on the leaves, were the most promising insects.



In the Azores twenty species of phytophagous insects were found (Table 2): two Heteroptera, ten Homoptera (one endemic), one Thysanoptera, two Coleoptera and five Lepidoptera (three endemic).

**Table 1** - Phytophagous insects associated with *Myrica faya* in Madeira island. Collected by the author\* and by A.Aguiar (1993)†

Insect	Host spectrum	Affected plant organ
<b>HETEROPTERA</b>		
Lygaeidae		
<i>Kleidocerys truncatulus ericae</i> HORVATH	<i>Myrica faya</i> , <i>Erica arborea</i>	Flowers?, fruit? #
<b>HOMOPTERA</b>		
Cixiidae		
<i>Cixius verticalis</i> NOUALHIER	Polyphagous?	Stem #
Issidae		
<i>Issus maderensis</i> LINDBERG	Polyphagous	Leaves, stem #
Coccidae		
<i>Ceroplastes floridensis</i> COMSTOCK	Polyphagous	Stem #
Margarodidae		
<i>Icerya purchasi</i> MASKELL	Polyphagous	Stem *#
Diaspididae		
<i>Hemiberlesia rapax</i> COMSTOCK	Polyphagous	Stem #
<i>Chrysomphalus pinnulifer</i> MASKELL	Polyphagous	Leaves #
<b>THYSANOPTERA</b>		
Thripidae		
<i>Heliothrips haemorrhoidalis</i> BOUCHÉ	Polyphagous	Flowers *#
<b>COLEOPTERA</b>		
Curculionidae		
<i>Laparocerus noctivagans</i> WOLLASTON	Polyphagous	Leaves **
<i>Lixus angustatus</i> FABRICIUS	Polyphagous?	Leaves #
<i>Pantomurus cervinus</i> (BOHEMAN)	Polyphagous	Leaves **
<i>Apion urticarium</i> HERBST	Polyphagous	? #
<i>Apion saggitiferrum</i> WOLLASTON	Polyphagous?	Fruit? #
Attelabidae		
<i>Auletobius convexifrons</i> (WOLLASTON)	M. faya	Leaves **
Lathridiidae		
<i>Aridius nodifer</i> (WESTWOOD)	Polyphagous	?#
Chrysomelidae		
<i>Cryptocephalus crenatus</i> WOLLASTON	M. faya	Leaves **
<i>Ochrosis ventralis</i> ILLIGER	Polyphagous	?#
Phalacridae		
<i>Olibrus affinis</i> STURM.	COMPOSITAE?	Polen #
<b>LEPIDOPTERA</b>		
Geometridae		
<i>Cleora fortunata</i> BLACHIER	Polyphagous	Leaves **
<i>Gymnoscelis insulariata</i> (STAITON)	Polyphagous	Flowers *
Gracilariidae		
<i>Caloptilia schinella</i> WALSINGHAM	<i>M. faya</i> <i>Laurus azorica</i>	Leaves - mines **
<i>Phyllonorycter myricae</i> DESCHKA	M. faya	Leaves - mines **
Carposinidae		
<i>Carposina</i> sp. near <i>atlanticella</i> REBEL	Polyphagous	Flowers, stems, leaves **
Tortricidae		
<i>Clepsis new</i> sp. near <i>staintoni</i> OBRATZOV	Polyphagous	Leaves#



*Auletobius convexifrons* from Madeira, is very abundant in spring on *M. faya* leaves. It might be specific, but the immature stages of this insect are unknown. *Phyllonorycter myricae* should be further studied, but its impact on the tree might not be effective. Regarding *Caloptilia schinella* it was released in Hawaii to date without appreciable effects on *M. faya* (Lutzouw-Felling *et al.*, 1995).

**Table 2** - Phytophagous insects associated with *Myrica faya* in the Azores

Insect	Host spectrum	affected plant organ
<b>HETEROPTERA</b>		
<i>Miridae</i>		
<i>Orthops</i> sp.	Polyphagous	Leaves
<i>Kleydoceris truncatulus</i> (WALKER)	Polyphagous	Fruits?
<b>HOMOPTERA</b>		
<i>Cercopidae</i>		
<i>Philaenus spumarius</i> LINNAEUS	Polyphagous	Leaves, stems
<i>Cixiidae</i>		
<i>Cixius insularis</i> LINDBERG	Polyphagous	Leaves
<i>Flatidae</i>		
<i>Cyphopterus</i> sp.	Polyphagous?	Leaves
<i>Aphididae</i>		
<i>Aphis gossypii</i> GLOVER	Polyphagous	Leaves
<i>Psyllidae</i>		
<i>Strophia harteni</i> HODKINSON	Polyphagous	Leaves, stems
<i>Trioza alacris</i> FLOR	Polyphagous	Leaves, stems
<i>Diaspididae</i>		
<i>Chrysonphalus</i> sp.	Polyphagous	Leaves, stems
<i>Margarodidae</i>		
<i>Icerya purchasi</i> (MASKELL)	Polyphagous	Leaves, stems
<i>Coccidae</i>		
<i>Ceroplastes sinensis</i> (DEL GUERCIO)	Polyphagous	Leaves, stems
<i>Pseudococcidae</i>		
<i>Pseudococcus</i> sp.	Polyphagous	Leaves, stems
<b>THYSANOPTERA</b>		
<i>Thripidae</i>		
<i>Heliothrips haemorrhoidalis</i> BOUCHE	Polyphagous	Leaves, stems
<b>COLEOPTERA</b>		
<i>Nitidulidae</i>		
<i>Meligethes aeneus</i> (FABRICIUS)	Polyphagous	Flowers?
<i>Anaspidae</i>		
<i>Anaspis proteus</i> WOLLASTON	Polyphagous	Flowers?
<b>LEPIDOPTERA</b>		
<i>Yponomeutidae</i>		
<i>Argyresthia atlanticela</i> REBEL	<i>M. faya</i> , <i>Erica azorica</i>	Leaves, stems
<i>Gracillariidae</i>		
<i>Caloptilia</i> sp.	<i>M. faya</i> <i>Hypericum foliosum?</i>	Leaves - leaf roller
<i>Geometridae</i>		
<i>Ascotis fortunata azorica</i> PINKER	Polyphagous	Leaves
<i>Gymnoscelis rufifasciata</i> (HAWORTH)	Polyphagous	Flowers
<i>Cyclophora azorensis</i> (PROUT)	<i>M. faya?</i> <i>Erica azorica</i>	Leaves



*Ascotis fortunata azorica* Pinker (Lep., Geometridae), is a defoliator found in the Azores. Although initially considered as promising, we latter found that several plants allowed the development of this insect namely, *M. faya*, *E. scoparia* ssp. *azorica*, *Myrsine africana* and *Viburnum tinus* ssp. *subcordatum*. Plants from different families, so the insect is polyphagous.

*Argyresthia atlanticella* Rebel (Lepidoptera, Yponomeutidae), from Azores feeds on male flowers and green fruits. Also initially considered as promising. The larvae were found to develop on different plants to adult stage. First instar larvae developed on *Erica scoparia* ssp. *azorica*, *Myrica faya* and *Poligonum capitatum*. In multiple choice oviposition tests the insect prefers *E. scoparia* ssp. *azorica* for oviposition, following *M. faya*, *Calluna vulgaris* and *Vaccinium cylindraceum*. In winter, adults and larvae are regularly found on *Erica scoparia* ssp. *azorica*. It was also found on *Vaccinium cylindraceum* flowers.

In Madeira and Azores several trees were found with cankers caused by *Nectria galligena* Bres (Gardner & Hodges, 1990). The disease is common in the Azores, but it is not specific to *M. faya*. Another disease, caused by *Ramularia destructiva* Phillips, & Plowright, is commonly found at Lombadas. The introduction of an exotic pathogen demands a large number of tests to prove specificity to the host. At Lombadas many *M. faya* leaves present brown spots surrounded by a lighter halo. Similar signs were found in other species of *Myrica* in North Carolina and Venezuela, probably caused by a species of *Septoria*. At Lombadas, many leaves seem to be lost due to a pathogenic activity. Further studies should be performed with the latter pathogens. For more detailed results see Silva (1992), Silva & Tavares (1995), Silva *et al.* (1995) and Markin *et al.* (1995).

### *Clethra arborea*

In S.,o Miguel a relatively poor entomofauna was found. Only some feeding damage on the leaves due to *Ascotis fortunata azorica* and the presence of some scale insects (Homoptera: Diaspididae), trips (Thysanoptera) and mites (Acarinae). *Kleydoceris truncatulus* was found feeding on the seeds inside the fruits, but only at low altitude. Since seeds in fruit are more abundant in winter, the insect is not an efficient control agent, because by that time temperature at high altitude is limiting for insect development. The most interesting enemy found to date is a fungus, causing dark spots on the basal leaves. Probably the same species that was found in Madeira. According to Spooner (Kew Royal Botanical Gardens) it might be a species of *Gnignardia*, an Ascomycete. The spots are present only in the basal leaves, not in the upper, more exposed leaves. This fungus was probably introduced with the host when *C. arborea* was brought to S.,o Miguel. In autumn and winter the number of affected leaves seems to increase (unpublished observations). In the more exposed leaves, red spots develop, especially beginning in autumn and during winter. The more affected leaves become almost completely reddish. The causal agent, biotic, or abiotic is still not known.

In Madeira two important defoliators were found. A moth, of which the larvae apparently also feeds on *Vaccinium padifolium*, and that is heavily parasitised by several parasitoids (Tachinidae and several Hymenoptera). The behaviour of the larvae resembles that of *Carposina atlanticella*. A weevil (Coleoptera: Curculionidae) was found which causes a typical feeding damage, perpendicular to the leaf margin, and forming more or less complicated patterns, which are also found on leaves of other species. Other less promising insects include



*Issus maderensis* with large numbers of adults and nymphs on the leaves, but also present on other hosts (*Laurus*, *Myrica*, etc. ). Interestingly, no insects were found feeding on flowers or young fruits, despite the enormous amounts available. The exception to this was the larvae of a geometrid moth, found when it was trying to feed on a young fruit. Regarding fungi, leaf spots were found on Madeira, and we suppose that they are caused by the same fungi found in São Miguel.

## Discussion

Work for the biocontrol of *M. faya* has extended for several years focusing on classical biocontrol. The work with *C. arborea* is now beginning. For the latter, a different strategy is in place, namely to study the pathogens already found in place. If a combination of foliar pathogens is put to work, the competitive ability of *C. arborea* might be reduced. Localised chemical control of mature trees, and uprooting of saplings might complement the control methods. Reduced rates of herbicide applied to cut stumps are already known to be efficacious in *C. arborea* control. Other invaders in the Azores are also future targets of biological control namely *Hedychium gardnerianum*, for which a pathogen causing a rot is now being searched for. Although for *M. faya* a classical strategy was predominant - the search for host specific natural enemies in the region of origin - for *C. arborea*, natural enemies already in the place of introduction are now being studied.

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