First Survey for *Miconia calvescens* and Its Natural Enemies in Southern Mexico

Alec McClay[1], Benigno Gómez y Gómez[2], Carlos R. Beutelspacher[3], and Tracy Johnson[4]

[1]McClay Ecoscience , 15 Greenbriar Crescent, Sherwood Park, Alberta, Canada T8H 1H8, Email: alec.mcclay@shaw.ca;
[2]El Colegio de la Frontera Sur (ECOSUR), 29290 San Cristóbal de las Casas, Chiapas, Mexico;
[3]Universidad de Ciencias y Artes de Chiapas (UNICACH), Tuxtla Gutiérrez, Chiapas, Mexico;
[4]US Forest Service, Quarantine Laboratory, PO Box 236, Volcano, HI 96785, USA.

Abstract

The native range of *Miconia calvescens* extends into southern Mexico, but no surveys of its natural enemies had previously been done in Mexico. In August 2006 we conducted a 2-week survey of the state of Chiapas to locate populations of *Miconia calvescens* and to identify insect and other natural enemy species present on it that might have potential as biological control agents. *M. calvescens* was found to be present in Chiapas, although at very low population densities. Seven locations were found in two separate areas, one east of the Lagunas de Montebello National Park, and the other in the municipality of Ocosingo, near the Metzabok Natural Area. All locations of *M. calvescens* were in shaded secondary roadside vegetation between about 450 m and 1,100 m elevation. All plants were in the vegetative stage except for one that had flower buds. A number of insect species were collected, including larvae of Riodinidae, Geometridae, and Megalopygidae (Lepidoptera). A habitat analysis was conducted to identify further areas in the state of Chiapas that might be suitable habitat for *M. calvescens*. It is recommended that further surveys of areas identified as potential habitat for *M. calvescens* should be conducted at other times of year to locate additional populations and to further document its natural enemies. Planting cohorts of *M. calvescens* seedlings in areas where it occurs naturally could provide useful information on the role of natural enemies in its population dynamics, and assist in identifying suitable biological control agents.

Introduction

The native range of *M. calvescens* extends from Brazil to southern Mexico (Wurdack 1980). According to Meyer (1998), Mexico was the source of *M. calvescens* plants cultivated at the Peradeniya Botanic Gardens in Sri Lanka, from where they were introduced to Tahiti and probably to other Pacific islands. Thus, Mexican populations of *M. calvescens* may be the most closely matched to the invasive biotypes in the Pacific Islands, making them particularly suitable as a source of biocontrol agents. Although studies on potential biological control agents for *M. calvescens* were initiated in 1993 with surveys in Costa Rica, Brazil, Uruguay, Paraguay, Argentina, and Trinidad and Tobago, and currently the US Forest Service is coordinating studies of several potential biocontrol agents in Costa Rica and Brazil (Killgore *et al.* 1999; Santos-Seixas *et al.* 2002, 2004; Seixas *et al.* 2007; Burckhardt *et al.* 2005, Badenes-Perez and Johnson 2007a, b), no surveys had previously been conducted of the natural enemies of *M. calvescens* in Mexico.

The goal of this project, funded by the Hawai'i Invasive Species Council, was to locate sites of *M. calvescens* in southern Mexico and survey the insects, mites, nematodes and pathogens associated with it. The objectives were to determine:

1. Are there substantial populations of *M. calvescens* in southern Mexico that could harbour natural enemies?
2. Are *M. calvescens* populations in Mexico morphologically and genetically similar to the invasive populations present in Hawai'i and other Pacific islands?
3. Are there additional natural enemy species present in these populations that would expand the pool of potential biocontrol agents beyond that currently known from Brazil, Ecuador, and Costa Rica?
4. Are local collaborators and facilities available for further studies on potential biocontrol agents?
5. Would further studies on biological control agents for *M. calvescens* based in Mexico be warranted?

Survey Methods

Areas for survey were selected on the basis of known records for *M. calvescens* in southern Mexico. From online herbarium records at the California Academy of Sciences (CAS), *M. calvescens* sites had previously been identified in the municipalities of La Trinitaria, Ocosingo, and Palenque (state of Chiapas) and Santa María Chimalapa (state of Oaxaca). The REMIB database (Red Mundial de Información sobre Biodiversidad) at *www.remib.com* was searched for additional Mexican records. Immediately before starting this survey, I visited the Mexican National Herbarium (MEXU) in Mexico City to examine their miconia holdings for other sites of *M. calvescens*.

The survey was essentially a roadside survey, with some exploration on foot in areas where *M. calvescens* was found or had been reported. On the basis of the previously reported sites, a route was planned (Figure 1) starting in Tuxtla Gutiérrez, Chiapas, and proceeding southeast along Mexican Highways 190 and 307 to the Lagunas de Montebello National Park; following Highway 307, which loops around the eastern end of the state of Chiapas, to the Bonampak area; cross-country on back roads to Ocosingo; north on Highway 199 to Palenque; continuing north to Highway 186 and briefly entering the state of Tabasco before turning south again on Highway 195 through Teapa and back to Tuxtla Gutiérrez. For the last two days the area west of Tuxtla Gutiérrez from Ocozocoautla to Presa Nezahualcoyotl and Chicoasén was explored. We did not visit the reported site at Santa María Chimalapa, Oaxaca, due to security concerns in Oaxaca.

At all sites where *M. calvescens* was encountered, herbarium specimens were taken and shoot tip material was preserved dried in silica gel for DNA analysis. Any insects found associated with *M. calvescens* were collected. Adult insects were pinned or preserved in 95% ethanol, and larval stages were collected alive for rearing through to adults where possible. Some collections were also made on other *Miconia* species. All sites were documented by digital photography, and routes and collecting sites were located by GPS using a Garmin GPSmap 60CS receiver. After completion of the survey, all insect and plant material collected was shipped from ECOSUR to the University of Costa Rica, but unfortunately went astray and has not been recovered.

Results

Herbarium records

The National Herbarium in Mexico City was found to have relatively small holdings of *Miconia* species from Chiapas, although there is much material from other southern Mexican states such as Oaxaca and Veracruz. A specimen originally labelled as *Miconia impetiolaris* and later reidentified as *M. calvescens* was labelled "Cafetal Irlanda, Huixtla, Chis. 600 m. 26.XII.1968." This location is in southern Chiapas, near Tapachula, and was not on our survey route. Two records of *M. calvescens* from Santa María Chimalapa, Oaxaca, were duplicates of sites already known from the CAS database. One record dated October 7, 1992, in the REMIB database shows *M. calvescens* at Solosuchiapa, Chiapas, which was included on our survey route. The label information subsequently received from Dr. Jerzy Rzedowski (Instituto de Ecología del Bajío) indicates that this specimen was collected in "bosque tropical perennifolio" at an elevation of 430 m. A very old record (May 30, 1939) was also found in the REMIB database for Atoyac de Álvarez, in the state of Guerrero.

Miconia calvescens populations

In our survey we found *M. calvescens* in two areas of Chiapas, one east of the Lagunas de Montebello National Park, and the other near the Metzabok Natural Area, in the northern part of the municipality of Ocosingo. Two locations along Highway 307 just east of the Lagunas de Montebello National Park are probably close to those from which *M. calvescens* was collected by Breedlove in 1982 (specimens CAS 673154 and 674626). *M. calvescens* was found at another site about 32 km east of these sites along Highway 307, near Maravilla Tenejapa. Two plants were found about 2 km apart on unnamed roads just outside the boundaries of the Metzabok Natural Area. We were not able to confirm the records of *M. calvescens* from the Bonampak area (San Javier or Crucero Corozal), the Misol-Há waterfall (about 20 km south of Palenque) or Solosuchiapa. More recently, another location of *M. calvescens* was found at El Águila, municipality of Cacahoatán, about 22 km northeast of Tapachula. A full list of sites where *M. calvescens* was found, as well as other sites in southern Mexico from which it has been reported, is given in Table 1.

M. calvescens was found in shaded secondary roadside vegetation between about 450 m and 1,100 m elevation. It was never seen in open areas or under dense forest canopy. Population densities were extremely low. A total of seven sites were found, most consisting of single plants, ranging in height from 1 to 8 m. All plants were vegetative except for one, near Maravilla Tenejapa, that had immature flower buds. No seedlings of *M. calvescens* were seen at any site. All plants of *M. calvescens* seen in Chiapas had purple undersides to the leaves, and appeared visually very similar to the invasive populations in Hawai'i.

Insects and other potential agents found

Most insects found were foliage-feeding Lepidoptera. An adult *Euselasia* sp. (Riodinidae) (Figure 3) was reared out from a larva collected in the Lagunas de Montebello area. This belongs to a genus in which other members have already been studied as possible biological control agents for *M. calvescens*. A group of gregariously-feeding larvae (Figure 3) found at this site may have been of the same species, but stopped feeding before they could be reared through to adults.

A number of other foliage-feeding Lepidoptera larvae were found, including species of Megalopygidae (Figure 5), Geometridae (Figure 6), and other families (Figure 7, Figure 8).

Leaves with extensive feeding damage were sometimes found without any signs of what had caused the damage. Some leaves showed rasping damage similar to that caused by larvae of the sawfly *Atomacera* sp. (Badenes-Perez and Johnson 2007a). At one site dead petiole bases were seen on some stems, suggesting damage by some type of internally feeding insect. However, no larvae or definite signs of insect damage were seen in these petioles. Cottony filaments on shoot tips suggesting the possible presence of immature psyllids (Burckhardt *et al.* 2005) were collected at the Metzabok site.

At one site near Laguna Bélgica, northwest of Tuxtla Gutiérrez, a small *Miconia* species, possibly *M. chrysophylla*, was attacked by a number of species similar to others that have been found on *M. calvescens*. A possible lycaenid larva was similar to those collected on *M. calvescens* (Figure 8). Massive, spongy leaf galls closely resembled those caused by nematodes that have been found on *M. calvescens* in Costa Rica and Brazil. Larvae feeding on the leaf surface caused similar damage to that attributed to *Atomacera*. Cottony filaments emerging from shoot tips were similar to those produced by *Diclidophlebia lucens* on *M. calvescens* (Burckhardt *et al.* 2005). Another possible psyllid laid eggs in lines along the veins on the underside of leaves of the large miconia (possibly *M. elata*) found near Chajul.

Few obvious signs of disease were seen on *M. calvescens* but some leaf spots were observed on mature leaves on the plant near Maravilla Tenejapa.

Predicted habitats for Miconia calvescens

Based on the sites where *M. calvescens* was found during this survey in Chiapas, we developed a very simple model to predict other areas of the state where it would be likely to occur. GIS data on soils, vegetation and climate of the state of Chiapas were provided by the Laboratorio de Análisis de Información Geográfica y Estadística (LAIGE) at ECOSUR, and digital elevation data from the Seamless Shuttle Radar Topography Mission (SRTM) "Finished" 3 Arc Second dataset (90 m resolution approximately) were downloaded from the US Geological Survey at http://seamless.usgs.gov/index.php. Based on the data for confirmed and reported sites of *M. calvescens*, the following characteristics were selected as predictors of suitable habitat: elevation 450 – 1150 m; vegetation "Selva alta y mediana perennifolia" or "Selva alta y mediana perennifolia con vegetación secundaria arbustiva y herbacea," soil "Rendzina, Feozem, or Acrisol"; climate type (A)C(m), Am, or Af(m). Climate types used in this dataset are based on the Köppen system as modified for Mexico by García (1973). The sites at Metzabok were classified as "Pastizal cultivado" (cultivated pasture), but were within 1 km of areas classified as "Selva alta y mediana perennifolia con vegetación secundaria arbustiva y herbacea." Rather than including pasture as a habitat for *M. calvescens*, which is unrealistic on the basis of our field observations, a 1-km buffer was therefore added around all areas of the first two types of vegetation.

Areas predicted to be suitable for *M. calvescens* on the basis of this analysis are shown in purple in Figure 2. Three main areas of the state are shown as including potentially suitable habitat:

1. Eastern areas of the state from the Guatemalan border north to around the Metzabok Natural Area. Much of this area lies within the Montes Azules Biosphere Reserve, a largely pristine and roadless area where access would be difficult. Areas west of the Biosphere Reserve would be accessible by back roads from Comitán.

2. Scattered areas in the north-western part of the state, along the borders with Tabasco, Veracruz and Oaxaca. Much of this area is cleared for agriculture but suitable *M. calvescens* habitat may remain in forest remnants or in protected areas such as the Selva El Ocote Biosphere Reserve.

3. A relatively small area in the El Triunfo Biosphere Reserve in the southern part of the state. Much of this reserve is still in good ecological conditions and access by road and trails is good. The finding of *M. calvescens* at El Águila in 2008 suggests that suitable habitat for *M. calvescens* may be more widespread in southern Chiapas than this simple model suggests.

Conclusions and Recommendations

Miconia calvescens has been confirmed in this survey to occur in Chiapas, although at very low densities. Further searches in the vicinity of the sites identified on this survey, and in the areas of potentially suitable habitat identified in the GIS analysis (
Figure **2**) should lead to more locations of *M. calvescens*. The rarity of *M. calvescens* in Chiapas, in comparison with its high density and rapid spread in invaded Pacific islands, suggests that environmental factors, possibly including natural enemies such as insects and plant diseases, limit its populations in this area of its native range. On the basis of this short survey it is not possible to make a detailed comparison of the natural enemy fauna present on *M. calvescens* in Chiapas with that found in other areas where it has been studied in more detail.

ECOSUR (El Colegio de la Frontera Sur, *www.ecosur.mx*) is well placed to act as a cooperating agency for further studies on potential biological control agents for *M. calvescens* in southern Mexico. ECOSUR is a publicly funded, multidisciplinary institute for research and postgraduate education, focussing on the sustainable development of the southern regions of Mexico. Its headquarters is in Tapachula (Chiapas), and it has campuses in San Cristóbal de las Casas, Chetumal, Campeche, and Villahermosa. Its areas of research include biodiversity conservation, alternative production systems, agroecology, management of natural resources, and health and socioeconomic issues. The staff includes entomologists and botanists and the organization has an insect collection, herbarium and botanic garden, as well as libraries, internet access, and a range of laboratory facilities including GIS support. Much of their research is conducted at field sites in natural and managed ecosystems throughout southeastern Mexico, and they are able to obtain the required permits for field collection and research from appropriate authorities in Mexico. The San Cristóbal and Tapachula campuses are well located for access to areas where *M. calvescens* is expected to occur.

Our recommendations for further study of potential biological control agents for *M. calvescens* in Mexico are:

1. Further surveys should be conducted in the areas of Chiapas identified as potential habitat for *M. calvescens* in this report, to locate additional populations and further document the natural enemy complex associated with this species.

2. The current survey was conducted during the rainy season. Future surveys should include field work at other times of year to ensure that insect and other natural enemy species with varying phenologies are detected. In general the rainy season in Chiapas runs from approximately June to October.

3. Discussions should be held with ECOSUR on the possibility of initiating graduate student research projects on the ecology of *M. calvescens* and its natural enemies.

4. Field experiments using planted cohorts of *M. calvescens* seedlings in areas where it occurs naturally may be valuable in understanding its population dynamics in this part of its native range, as well as in recruiting populations of natural enemy species for further study.

5. Natural enemy complexes associated with other *Miconia* species occurring in Chiapas should be investigated to provide additional information on the host-specificity of potential biological control agents.

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Longitude °W	Latitude °N	Elevation (m)	Date and time	Location	Herbarium data	Notes
91.5641	16.1108	1135	Aug 14 2006	Municipio La Trinitaria	CAS 674626, 10 km ENE of Dos Lagos above Santa Elena, Coll. Breedlove 1982	Confirmed in this survey
91.5601	16.1162	994	Aug 14 2006	Municipio La Trinitaria	CAS 673154, 15 km ENE of Dos Lagos above Santa Elena, Coll. Breedlove 1982	Confirmed in this survey
91.5600	16.1168	985	Aug 14 2006	Municipio La Trinitaria	CAS 673154, 15 km ENE of Dos Lagos above Santa Elena, Coll. Breedlove 1982	Confirmed in this survey
91.2609	16.1381	483	Aug 16 2006	near Maravilla Tenejapa	--	New record
91.6367	17.1031	577	Aug 19 2006	Metzabok Natural Area	--	New record
91.6474	17.0949	644	Aug 19 2006	Metzabok Natural Area	--	New record
92.185 approx.	15.093 approx.	unknown	2008	Ejido El Águila	--	New record
91.0939	16.8011	411	--	14 km NW Crucero Corozal	NYBG Specimen ID: 5212, coll. 1986	Reported, not found
91.9996	17.3919	247	--	Misol-Há waterfall	CAS 670513, Near Cascada Mizola, 25 km S of Palenque on road to Ocosingo	Reported, not found
93.0279 approx.	17.4257 approx.	430	--	Solosuchiapa (Coordinates are for the town of Solosuchiapa – the record may refer to the municipality, which covers a much larger area)	IEB 88959, Coll. 1992	Reported, not found
92.3333	15.1667	600	--	Cafetal Irlanda, Huixtla, Chiapas	MEXU, coll. 1968 ("Miconia cf. calvescens")	Not on the survey route

94.7333	16.8833	250 - 300	--	Santa Maria Chimalapa, Oaxaca	MEXU, coll. 1985	Not on the survey route
100.3747	17.3986	unknown	--	Plan del Carrizo, Atoyac de Álvarez, Guerrero	LL266723 coll. May 30, 1939	Not on the survey route

Table 1. Locations at which *Miconia calvescens* was found in Chiapas in the survey, and other locations in southern Mexico from which it has been reported.

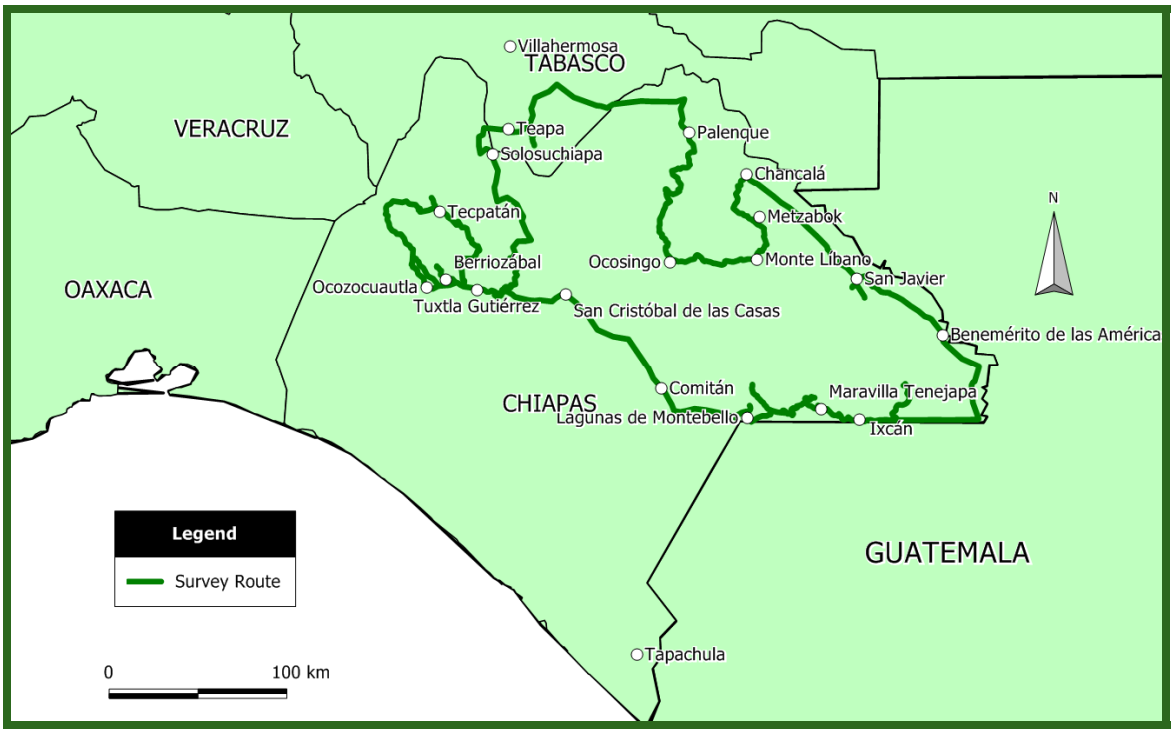

Figure 1. Survey route in Chiapas, August 2006.

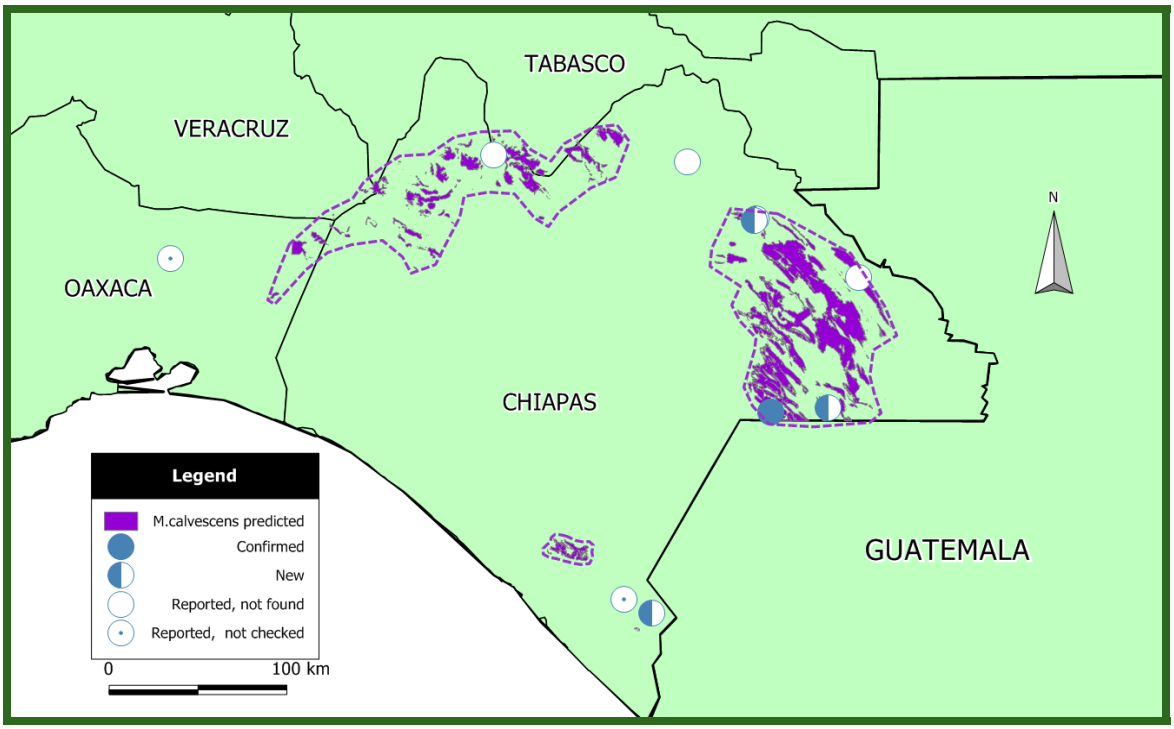

Figure 2. Locations of *M. calvescens* in Chiapas, and areas predicted to be suitable habitat by a simple GIS model.

Figure 3. Adult *Euselasia* sp. reared from larva on *M. calvescens*

Figure 4. Gregarious larvae, probably also *Euselasia* sp.

Figure 5. Larva of Megalopygidae sp. feeding on *M. calvescens*

Figure 6. Larva of Geometridae feeding on *M. calvescens*

Figure 7. Unidentified Lepidoptera larva feeding on *M. calvescens*

Figure 8. Larva and pupa of Lycaenidae feeding on *M. calvescens*