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# 14 Biological Control in El Salvador

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**Abstract**
In the 1960s, natural control was shown to play an important role in the reduction of saturniid populations in *Spondias* fruit trees by dipteran and hymenopteran parasitoids and in the reduction of coconut weevil populations by a staphelinid. Later, other cases of high degrees of natural control were documented, such as that of the cotton leafworm by a native egg parasitoid and of the Mexican beetle by an ectoparasitic mite as well as by a pupal parasitoid. Classical biocontrol of citrus blackfly and purple scale in citrus was initiated in the 1970s, as well as augmentative biocontrol of lepidopteran pests with egg parasitoids. Another, very successful, augmentative biocontrol project during the 1970s concerned the killing of two mosquito species by an entomopathogenic nematode. Prospecting for nematophagous fungi in 1977 in El Salvador resulted in finding 18 species. Recently, several microbial control agents have been produced by the Escuela Agrícola Panamericana, Zamorano in Honduras for control of soil-borne diseases; nematodes and arthropod pests have been registered and are applied in El Salvador. *Tilipia* fish are used for biocontrol of *Aedes* mosquitoes, the vector of, among others, Zika, dengue and chikungunya viral diseases.

## 14.1 Introduction

El Salvador has an estimated population of more than 6 million (July 2017) and its agricultural activities concern coffee, sugar, maize, rice, beans, oilseed, cotton, sorghum, beef and dairy products (CIA, 2017).

## 14.2 History of Biological Control in El Salvador

The editors have not been able to find a contact in El Salvador who was able to write a chapter about biocontrol in this country. An extensive literature search resulted in a few interesting papers, which are summarized below.

### 14.2.1 Period 1880–1969

*Natural control of native pests*

The saturniid *Rothschildia aroma* Schaus is considered a pest of *Spondias* sp. (Anacardiacea), a fruit tree species of which several varieties are widely grown in backyards or along fences in the field in El Salvador. Quezada (1967) field-collected more than 1200 cocoons of the saturniid and found that 70% of these were parasitized: 91.3% by the tachinid *Belvosia nigrifrons* Aldrich and 6% by the tachinid *Lespesia* n. sp., 2.7% by the ichneumonid *Enicospilus americanus* Christ and a single individual of a hyperparasitoid of *B. nigrifrons*, the eulophid *Euplectrus comstockii* Howard. Another 19.5% of the cocoons died due to factors other than parasitism. Based on the fact that he never saw host plants heavily defoliated by the saturniid, Quezada (1967) concluded that the parasitoids might be responsible for a drastic reduction of the pest population.

When looking for natural enemies of the coconut weevil *Rhynchophorus palmarum* L., which, besides causing direct damage, is also a vector of red ring disease of palms, Quezada *et al*. (1969) observed that larvae and adults of the staphelinid *Xanthopygus cognatus* Sharp were eating eggs and larvae of the pest weevil. They mentioned that the staphelinid could be mass reared and prefererd to eat the coconut weevils, but could also survive on other prey.

### 14.2.2 Period 1970–2000

According to the BIOCAT database (Cock *et al*., 2016; and Chapter 32, this volume), three introductions for classical biocontrol programmes have been made into El Salvador: one in the 1970s, one in the 1990s and one undated.

*Classical biological control of citrus pests*

Citrus blackfly *Aleurocanthus woglumi* Ashby, native to Asia, invaded El Salvador in 1965 and dispersed to most citrus orchards in the country by 1972. Native natural enemies such as the predators *Delphastus* sp. and *Chrysopa* sp. and the pathogenic fungus *Aschersonia aleyrodis* Web. were unable to control the pest sufficiently (Quezada, 1974). Therefore, the parasitoid *Encarsia* (= *Prospaltella*) *opulenta* Silvestri was introduced from Mexico in 1971 and complete biocontrol of the blackfly was obtained.

Purple scale *Lepidosaphes beckii* Compere was brought under substantial-complete biocontrol by *Aphytis lepidosaphes* Compere (Laing and Hamai, 1976) and apparently the parasitoid had itself established fortuitously (Rosen and DeBach, 1979).

Citrus snow scale *Unaspis citri* Comstock was the most severe armoured scale pest of citrus in El Salvador, but attempts to introduce the ladybeetle *Telsimia* sp. from Fiji to control it failed (Quezada *et al.*, 1973).

#### *Natural and classical biological control of pests in cotton, maize and bean*

In cotton, high percentages of the eggs of cotton leafworm *Alabama argillaceae* Hubner were parasitized by the native egg parasitoid *Trichogramma semifumatum* Perkins (Catareda *et al.*, 1976).

In 1977, the Ministry of Agriculture's National Center for Agricultural Technology (Centro Nacional de Tecnologia Agropecuaria) (CENTA) imported the egg parasitoid *Telenomus remus* Nixon from Trinidad for classical biocontrol of the fall armyworm *Spodoptera frugiperda* (Smith) in maize and other crops, but results are unknown (Quezada, 1989).

The Mexican bean beetle *Epilachna varivestris* Mulsant (Coleoptera: Coccinellidae) is a common pest in lima bean *Phaseolus lunatus* Linnaeus in El Savador. During field observations, up to 75% of the beetle pupae appeared to be parasitized by *Tetrastichus* sp. Beetles were also often infected by the ectoparasitic mite *Coccipolipus epilachnae* Smiley, resulting in the beetle's drastically reduced oviposition and increased mortality (MAD, 1984).

#### *Augmentative biological control of lepidopteran pests*

Smith and Bellotti (1996) mentioned that Colombian laboratories were producing *Trichogramma* spp. as well as one of its hosts, eggs of *Sitotroga cerealella* Oliver, for exportation to El Salvador and other countries for control of lepidopteran pests.

#### *Augmentative biological control of mosquitoes*

Petersen *et al.* (1978) reported about biocontrol of two mosquito species, *Anopheles albimanus* C.R.G. Wiedemann and *An. pseudopunctipennis* Theobald, in lakes in El Salvador by treating the water with the entomopathogenic nematode *Romanomermis culicivorax* Ross & Smith. This resulted in high rates of mosquito infection and the *Anopheles* populations had decreased by 94% at the end of the release period.

#### *Classical biological control of weeds*

Two species of curculionids, *Neochetina bruchi* Hustache and *Neochetina eichhorniae* Warner, were imported into Honduras by Escuela Agrícola Panamericana, Zamorano (see Chapter 19: Honduras) from Florida in 1990 for control of *Eichhornia crassipes* (Martius) Solms-Laubac, a water weed originating from the Amazon. Later, curculionids were field collected and released in several other Central American countries. They were introduced into El Salvador in 1994, but results of this introduction are unknown (Cave *et al.*, 2011).

#### *Nematophagous fungi present in El Salvador*

As a result of sampling at 38 locations in 1977 all over El Salvador, Búcaro (1983) found 18 species of nematophagous fungi, 11 species were predators and seven were parasites. *Stylopage hadra* Drechsler was the dominant species and might be an interesting candidate for biocontrol of nematodes, due to its aggressiveness. It was established for the first time that *Helicosporina veronae* Rambeli was able to kill nematodes.

## 14.3 Current Situation of Biological Control in El Salvador

### 14.3.1 Microbial control of pests and diseases

In Honduras, the Escuela Agrícola Panamericana, Zamorano, started a large project on production of microbial agents for pest and disease control (see Chapter 19: Honduras). One of the spin-offs of this project was the introduction into El Salvador and registration of several microbial agents, such as: (i) the fungi *Trichoderma harzianum* Rifai for control of soil diseases and *Beauveria bassiana* (Bals.-Criv.) Vuill. for control of lepidopteran and

**Table 14.1.** Overview of major biocontrol activities in El Salvador.

| Biocontrol agent / exotic (ex), native (na) | Pest / crop | Type of biocontrol[a] / since | Area under biocontrol[b] | Reference |
|---|---|---|---|---|
| *Belvosia nigrifrons* / na | Saturniid *Rothschildia aroma*, fruit trees | NC | Control / ? | Quezada, 1967 |
| *Lespesia* n. sp / na | | NC | Control / ? | |
| *Enicospilus americanus* / na | | NC | Control / ? | |
| *Xanthopygus cognatus* / na | Coconut weevil, coconut | NC | Partial control / 250 ha | Quezada *et al*., 1969 |
| *Delphastus* sp. / na | Citrus blackfly, citrus | NC | Insufficient control / ? | Quezada, 1974 |
| *Chrysopa* sp. / na | | NC | insufficient control / ? | |
| *Aschersonia aleyrodis* / na | | NC | Insufficient control / ? | |
| *Encarsia opulenta* / ex | | CBC / 1971 | Complete control / 1,500 ha | |
| *Aphytis lepidosaphes* / ex | Purple scale, citrus | FBC / 1975s | Substantial control / 1,500 ha | Laing and Hamai ,1976 |
| *Telsimia* sp. / ex | Citrus snow scale, citrus | CBC / 1970s | No control / not established | Quezada *et al*., 1973 |
| *Trichogramma semifumatum* / na | Cotton leafworm, cotton | NC | Partial control / 325 ha | Catareda *et al*., 1976 |
| *Telenomus remus* / ex | Fall armyworm, corn | CBC / 1977 | ? / ? | Quezada 1989 |
| *Tetrastichus* sp. / na | Mexican bean beetle, lima bean | NC | Substantial control / 180 ha | MAD, 1984 |
| *Coccipolipus epilachnae* / na | | NC | Substantial control / 180 ha | |
| *Romanomermis culicivorax* / na | Mosquitoes, lakes | ABC | Substantial control / ? | Petersen *et al*., 1978 |
| *Neochetina bruchi* / ex | *Eichhornia crassipes* weed, lakes | CBC / 1994 | ? / ? | Cave *et al*., 2011 |
| *N. eichhorniae* / ex | | CBC / 1994 | ? / ? | |
| *Trichoderma harzianum* / ex | Soil diseases various crops | ABC / 2008 | Control / ? | Cave *et al*., 2011 |
| *Beauveria bassiana* / ex | Lepidopterans and coleopterans, various crops | ABC / 2008 | Control / ? | |
| *Metarhizium anisopliae* / ex | Leafhoppers, cotton | ABC / 2008 | Control / ? | |
| *Purpureocillium lilacinum* / ex | Nematodes, horticulture and fruit | ABC / 2008 | Control / ? | |
| *Tilapia* sp. / ex | Mosquitoes, lakes | ABC / 2018 | ? / ? | PLANUSA 2018 |

[a]Type of biocontrol: ABC = augmentative biocontrol, CBC = classical biocontrol, ConsBC = conservation biocontrol, FBC = fortuitous biocontrol; NC = natural control
[b]Area of crop harvested in 2016 according to FAO (http://www.fao.org/faostat/en/#data/qc)

coleopteran pests in various crops in 2008; (ii) *Metarhizium anisopliae* (Metchnikoff) Sorokin, among others, for leafhopper control in sugarcane; and (iii) *Purpureocillium lilacinum* (Thom) Luangsaard, Houbraken, Hywel-Jones and Samson for nematode control in horticulture and fruit (Cave *et al*., 2011)

### 14.3.2 Biological control of mosquitoes

Plan International USA (PLANUSA) is a non-governmental organization (NGO) working in more than 50 developing countries to end the cycle of poverty. In El Salvador they use small tilapia fish to control *Aedes aegyti* L. mosquitoes that spread viral diseases like Zika, dengue and chikungunya, by introducing the fish into water barrels, ponds and drinking-water tanks in homes.

In conclusion, natural enemies that were introduced, released and did establish in previous periods for classical biocontrol of pests in El Salvador are still supposed to be present, and particular successes in citrus have been obtained. Recently, microbial control agents are being used in various crops. Very limited quantitative data are available about areas under control (Table 14.1). Classical biocontrol is used on about 1,500 ha of citrus and natural control on more than 750 ha.

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