15 Biological Control in French Guiana, Guadeloupe and Martinique

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Abstract

Several biological control agents have been introduced successfully in Guyana, and / or Guadeloupe and Martinique: three tachinid dipterans and one hymenopteran for control of sugarcane borers, a ladybird and a hymenopteran parasitoid against the pink hibiscus mealybug, a hymenopteran parasitoid to control Asian citrus psyllid, another hymenopteran parasitoid against citrus blackfly, and a hymenopteran parasitoid for control of fruit flies. Mass rearings of a lacewing and a *Trichogramma* egg parasitoid are being implemented in Martinique for augmentative biocontrol. Use of native natural enemies in conservation biocontrol projects is being initiated in several crops, after a period of intensive prospecting for natural enemies. A recently started project in French Guiana aims at control of the mango mealybug by introducing two exotic parasitoids.

15.1 Introduction

French Guiana has an estimated population of about 290,160 (estimate 2018, UN World Population Prospects) and its main agricultural products are rice, vegetables, perennial fruit trees, pineapple, manioc, sugarcane, cocoa, bananas, flowers, cattle, pigs, poultry, goats, shrimps and forestry products (https://en.wikipedia.org/wiki/Economy_of_French_Guiana).

Guadeloupe has an estimated population of almost 450,000 (estimate 2018, UN World Population Prospects) and its main agricultural products are sugarcane, bananas, fruits, vegetables, pineapple, root crops, coffee, flowers, cattle, goats, pigs, poultry and fish (https://en.wikipedia.org/wiki/Economy_of_Guadeloupe).

Martinique has an estimated population of slightly more than 385,000 (estimate 2018, UN World Population Prospects) and its main agricultural products are bananas, sugarcane, pineapples, avocados, vegetables, root crops, flowers, cattle, goats, pigs and poultry (https://en.wikipedia.org/wiki/Economy of Martinique#Economics)

The other islands belonging to the French Antilles (Saint Martin, Saint Barthelemy, Desirade and Les Saintes) have hardly any agriculture; data for the Marie Galante island are included in the sections about Guadeloupe.

15.2 History of biological control in French Guiana, Guadeloupe and Martinique

15.2.1 Period 1800 – 1969

15.2.1.1. Use of Giant Toad

Prior to 1850, *Bufo marinus* (L.) was introduced from French Guiana into Martinique to kill rats, *Rattus rattus* (L.), one of the principal pests of sugar cane. It is doubtful whether the toads had any effect upon the rat populations (Cock, 1985).

15.2.1.2 Use of introduced parasitoids against sugarcane borers in Martinique and Guadeloupe

The sugarcane borers, *Diatraea saccharalis* L., *D. impersonatella* Walker and *D. centrella* (Möschler) have long caused extensive damage to this crop in the West Indies (Stelhé, 1956). In 1938 the tachinid *Lydella* (*Metagonistylum minense*) Townsend was introduced. Then, in 1947, another tachinid, *Lixophaga diatraeae* Townsend was imported, and finally *Paratheresia claripalpis* (Van der Wulp) was introduced in 1954 (Cochereau, 1990). In 1970 in Guadeloupe and in 1976 in Martinique, the hymenopteran parasitoid *Cotesia flavipes* Cameron was introduced from Barbados. In 1986, the rate of cane infestation by borers was less than 6%, with no significant economic consequences (Boulet, 1986). Today, biocontrol of sugarcane borers is considered very satisfactory on these islands, especially as no insecticide treatment is applied.

15.2.2 Period 1970-2000

15.2.2.1 Classical biological control of the pink hibiscus mealybug in Martinique and Guadeloupe

The hibiscus pink mealybug, *Maconellicoccus hirsutus* Green, was accidentally introduced on the island of Grenada in 1994, and mainly attacking ornamental plants (Kairo *et al*., 2000). It then invaded northern Caribbean, including Martinique and Guadeloupe in 1998 (Etienne et al., 1998). Soon, research was conducted to introduce natural enemies against this pest, and two species were introduced in Guadeloupe and Martinique: the ladybird *Cryptolaemus montrouzieri* Mulsant and the parasitoid *Anagyrus kamali* Mursi. Mealybug populations have declined rapidly following the release of these two natural enemies in all countries where this biocontrol has been implemented (Kairo *et al*. 2000). Today, this mealybug has become very rare in Martinique and Guadeloupe.

15.2.2.2 Classical biological control of the Asian citrus psyllid in in Martinique and Guadeloupe

The Asian citrus psyllid, *Diaphorina citri* Kuwayama, is one of the vectors of the most serious citrus disease, HLB (huanglongbing), caused by the bacterium *Candidatus liberibacter asiaticus*. The psyllid was detected in Guadeloupe in 1998 (Etienne *et al*., 1998) and in Martinique in 2012 (Cellier *et al*., 2014). In 1999, its main parasitoid, *Tamarixia radiata* (Waterston) was introduced in Guadeloupe from a population of Reunion (Indian Ocean) and quickly dispersed over the island (Etienne *et al.,* 2001). Monitoring of parasitism on Guadeloupe was done in 2014 in several orchards and it parasitism varied between 40 to 70% (unpublished data). In Martinique, *T. radiata* was found shortly after the discovery of the psyllid, probably introduced on citrus plants imported from Guadeloupe. Only low densities of the psyllid were observed on Martinique, probably due to effective parasitism by *T. radiata* in orchards, which are not treated with insecticides today. Parasitism of *D. citri* on another host plant, *Murraya paniculata* (Rutaceae), sometimes exceeded 90% (unpublished data).

15.2.2.3 Classical biological control of the citrus blackfly in French Guiana

The citrus blackfly, *Aleurocanthus woglumi* Ashby, was a major pest of citrus fruit in the 1995s in French Guiana, and chemical control proved ineffective. A pest-specific parasitoid, *Encarsia opulenta* (Silvestri), has been introduced from Florida and has adapted well locally (Janelle *et al*. 2000). The orchards where the parasitoid was released soon showed good rates of parasitism, but it was found necessary to introduce parasitoids in each orchard because distances between orchards are large and they are separated by the Amazonian forest. During

the past 10 years, this whitefly has not been found in citrus orchards anymore (C. Gourmel, French Guiana, 2018, personal communication).

15.2.2.4 Classical biological control of the Carambola fruitfly in French Guiana

Although biocontrol was not included as element of the eradication programme carried out on the Caramboly fruitfly *Bactrocera carambolae* Drew & Hancock, some biocontrol activities were implemented in French Guiana along the border with Brazil in collaboration with EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária, Brazil). At the end of 2000, *Diachasmimorpha longicaudata* (Ashmead) was released along both sides of the Oyapock River (= border), from Taparabu to Clevelandia, including St Georges (Vayssières *et al*., 2013). About 2 million *Ceratitis capitata* Wied. pupae parasitized by the braconid *D. longicaudata* were transported by plane from the CENA (Centro de Energia Nuclear na Agricultura) laboratory in Piracicaba (Brazil). Between 2001 and 2003, emergence of *D. longicaudata* was regularly recorded from parasitized *B. carambolae* and also from *Anastrepha* spp. in fruit sampled from along the French side of the river Oyapock and in the areas of St Georges and Regina, so the parasitoid has well-established after its release in 2000 (Vayssières *et al*. 2013). Future biocontrol activities against the fruitfly include the introduction of other braconid parasitoids into French Guiana, such as *Fopius arisanus* (Sonan).

15.2.2.5 French Guiana, Guadeloupe and Martinique as providers of natural enemies

For control of the coffee leaf miner, *Perileucoptera coffeella* Guérin-Meneville, a local parasitic braconid, *Mirax insularis* Muesebeck, was introduced to Puerto Rico from Guadeloupe, and although it initially became established, it had negligible effect on the miner and may have died out later (Cock, 1985).

15.3 Current situation of biological control in French Guiana, Guadeloupe and Martinique

15.3.1 Introduction

At present, no new classical or augmentative control are applied in these territories, but projects are underway. It is mainly conservation biocontrol that is used in crops, while limiting the use of chemicals as much as possible. However, the effectiveness of conservation biocontrol varies greatly depending on the situation, the environment, the time of year and the target crop. For example, citrus orchards today hardly require insecticides or miticides, or can be limited to spot-wise treatments. On the other hand, in the absence of treatments, cucurbit crops are usually damaged by the melonworm *Diaphania hyalinata* (L.) and pickleworm *D. nitidalis* (Stoll) because these caterpillars have very few natural enemies.

15.3.2. Augmentative biological control

Since 2017, the Fédération Régionale de Défense contre les Organismes Nuisibles (FREDON; Regional Federation of Protection Against Damaging Organisms) of Martinique has a mass rearing of two beneficials: a polyphagous predator, the lacewing *Chrysoperla externa* (Hagen), and a parasitoid of lepidopteran eggs, *Trichogramma pretiosum* Riley. These natural enemies are particularly intended for vegetable crops.

15.3.3 Conservation biological control

Inventories of natural enemies of crop pests have been made for individual crops or for several related crops. General inventories have been made for vegetables (Ryckewaert and

Rhino, 2017) and fruit crops (Leblanc, 2000). Other inventories concern particular pests such as the whitefly *Bemisia tabaci* Gennadius (Ryckewaert and Alauzet, 2002; Pavis *et al*., 2003), the citrus weevil *Diaprepes abbreviatus* L. (Etienne and Delvare, 1991) or a specific group of natural enemies such as ladybirds (Nicolas, 2012; Lucas, 2012), thrips (Etienne et al., 2015), the genus *Coccophagus* (Panis, 2013) or predatory mites (Kreiter and de Moraes 1997; de Moraes *et al*.; Kreiter *et al*., 2013; Kreiter *et al*., 2018). However, and particularly in relation to conservation biocontrol, some groups of arthropods have been poorly studied, such as spiders and predators present on the soil. Tables 15.1 and 15.2 list the main species and genera found on Martinique and / or Guadeloupe. There is little knowledge of French Guiana, but many species mentioned in these tables are present there as well (Gourmel, 2014).

Table 15.1 Predators cited from Martinique and Guadeloupe (sources: de Moraes *et al*., 1999; Gourmel, 2014; Kreiter and de Moraes, 1997; Kreiter *et al*., 2013; Kreiter *et al*., 2018; Lucas, 2012; Nicolas, 2012; Ryckewaert and Rhino, 2017)

Predators	**Main Prey Species**
Predatory mites Many species, mainly from the Phytoseiidae family	 mites
Spiders Theridiidae, Araneidae, Thomisidae, Salticidae, Tetragnathidae, Oxypidae	 polyphagous
Predatory bugs *Orius insidiosus* Say. *O. pumilio* (Champion) *Macrolophus nr praeclarus* (Distant), *Nesiodocoris tenuis* Reuter, *Cyrtopeltis* sp. *Zelus longipes* (L.), *Nabis capsiformis* Germar	 thrips, aphids, whiteflies, mites aphids, whiteflies, larvae, caterpillars aphids, whiteflies, larvae, caterpillars polyphagous
Lacewings *Chrysoperla externa* (Hagen), *Ceraeochrysa cubana* (Hagen), *Leucochrysa floridana* (Banks), *Chrysopa, Chrysocerca, Chrysopodes*	 aphids, psyllids, caterpillars
Hoverflies *Pseudodorus clavatus* (F.), *Syrphus, Allograpta, Ocyptamus, Toxomerus, Baccha*	 aphids
Ladybirds (main species) *Coleomegilla* (= *Megilla*) *maculata* (De Geer) *Cycloneda sanguínea* (L.) *Coccinella septempunctata* L., *Coelophora inaequalis* F. *Zagreus* (= *Exochomus*) *bimaculosus* Mulsant *Chilocorus nigritus* (F.), *Chilocorus cacti* (L.), *Cladis nitidula* F. *Delphastus pusillus* Le Conte, *D. pallidus* Le Conte *Cryptolaemus montrouzieri* Mulsant *Rodolia cardinalis* Mulsant	 aphids, caterpillars, worms aphids, psyllids aphids scales scales aphids, scales whiteflies mealybugs *Icerya purchasi*
Ants (main species) *Solenopsis geminata* (Fabricius), *Pheidole fallax* Mayr, *Wasmannia rochai* Forel, *Nylanderia fulva* (Mayr), *Odontomachus brunneus* (Patton), *Camponotus sexguttatus* (Fabricius)	 polyphagous
Wasps *Polistes* spp.	 caterpillars, larvae
Predatory thrips *Franklinothrips vespiformis* (Crawford)	 thrips, mites
Carabids Species not determined	 polyphagous
Staphylinids *Oligota* sp.	 mites

Table 15.2 Parasitoids cited from Martinique and Guadeloupe (from Boulet, 1986; Etienne and Delvare, 1991; Gourmel, 2014; Janelle *et al*., 2000; Kairo *et al*., 2000; Leblanc, 2000; Panis, 2013; Pavis *et al*., 2003; Ryckewaert and Rhino, 2017; Stehlé, 1956; Vayssières *et al*., 2013)

Parasitoids	**Hosts**
Encarsia nigricephala (Dozier), *E. sophia* (= *transvena*) (Girault & Dodd), *E. luteola* (Howard) / *E. formosa* Gahan, *E. hispida* De Santis, *E. meritoria* Gahan, *E. tabacivora* (= *pergandiella*) Viggiani *Eretmocerus tejanus* Rose & Zolnerow, *Amitus bennetti* Viggiani & Evans, *A. fuscipennis* McGown & Nebeker, *Signiphora* sp.	*Bemisia tabaci* (Gennadius) and / or *Trialeurodes vaporariorum* Westwood
Encarsia cubensis Gahan	*Aleurotrachelus trachoides* Back
E. sophia (Girault & Dodd)	*Aleyrodes proletella* (L.)
Encarsia dispersa Polazeck, *E. guadeloupae* Viggiani, *Encarsiella noyesi* Hayat, *Aleuroctonus vittatus* (Dozier)	*Aleurodicus dispersus* Russell
Encarsia basicincta (Gahan), *E. nigricephala* (Dozier) *Eretmocerus portoricensis* (Dozier)	*Aleurothrixus floccosus* (Maskell)
Encarsia opulenta (Silvestri)	*Aleurocanthus woglumi*(Ashby)
Aphelinus gossypii Timberlake, *Diaeretiella rapae* (Mc Intosh), *Aphidius colemani* Viereck, *Lysiphlebus testaceipes* (Cresson), *Syrphophagus aphidivorus* (Mayr), *Pachyneuron aphidis* (Bouché)	aphids
Aphytis sp., *Encarsia lounsburyi* (Berlèse & Paoli), *Coccophagus pulvinariae* Compere, *C. basalis* Compere, *Aprostocetus* sp., *Anagyrus kamali* Moursi, *Gyranusoidea* sp.	scales, mealybugs
Cotesia (= *Apanteles*) *plutellae* (Kurdj.), *Conura hirtifemora* (Ashmead), *Oomyzus sokolowski* (Kurdjumov), *Trichogramma chilonis* Ishii	*Plutella xylostella* (L.)
Ageniaspis citrícola Logvinovskaya, *Galeopsomyia fausta* LaSalle & Pena, *Horismenus* spp., *Cirrospilus* sp., *Elasmus* sp., *Zagrammosoma* sp.	*Phyllocnistis citrella* Stainton
Cotesia sp., *Apanteles* sp., *Pseudapanteles* sp., *Trichogramma pretiosum* Riley	*Diaphania* spp.
Cotesia flavipes Cameron, *T. Pretiosum*, *Lydella minense* Townsend, *Lixophaga diatraeae* Townsend, *Paratheresia claripalpis* (Van der Wulp)	*Diatraea saccharalis* (F.) *D. impersonatella* (Walker) *D. centrella* (Moschl)
Copidosoma floridanum (Ashmead), *Euplectrus* sp. , *Telenomus remus* Nixon, *Trichogramma nubilale* Ertie & Davis	noctuids (*Spodoptera*, *Helicoverpa*…)
Telenomus sp.	*Manduca sexta* (L.)
Pteromalus puparum (Linné), *Brachymeria* sp.	*Ascia monuste* (L.)
Dacnusa sp., *Opius* sp., *Chrysocharis caribea* Boucek, *Ch. vovones* (Walker), *Closterocerus purpureus* (Howard), *Diaulinopsis callichroma* Crawford, *Diglyphus begini* (Asmead), *Halticoptera circulus* (Walker)	*Liriomyza* spp.
Zaeucoila sp.	*Amauromyza maculosa* (Malloch)
Aprostocetus gala (Walker), *A. haitiensis* (Gahan), *Aprostocetus* sp., *Baryscapus fennahi* (Schauff), *Ceratogramma etiennei* Delvare	*Diaprepes abbreviatus* L.
Goetheana parvipennis (Gahan), *Thripastichus gentilei* (Del Guercio), *Megaphragma* sp., *Cerasinus sp.*	thrips

15.4 Conclusions

Biocontrol brings many benefits to agriculture in Martinique, Guadeloupe and French Guiana, while avoiding numerous chemical treatments. However, current biocontrol in these territories is not always sufficient and might be improved by importation of new, exotic species or by augmentative releases of already present natural enemies. However, the profitability of mass releases is not always obvious, while the introduction of exotic species is subject to very strict and regulations in relation to environmental risks. Table 15.3 provides a summary of the biocontrol projects in French Guiana, Guadeloupe and Martinique. Based on the areas with a

certain crop and natural enemies used (Table 15.3), we estimate that at least 20,000 ha are under classical biocontrol. In the near future, also augmentative biocontrol may be applied.

Table 15.3 Overview of major biocontrol activities in French Guiana, Guadeloupe and Martinique

Biocontrol agent / exotic (ex), native (na)	**Pest / crop**	**Type* of biocontrol /since**	**Effect /Area under biocontrol in hectares**	**Reference**
French Guiana				
Encarsia opulenta / e	Citrus blackfly, citrus	CBC / 1995s	control / established 1,650 [1]	Janelle et al 2000
Diachasmimorpha longicaudata / ex	Carambola fruitfly, vars fruit	CBC / 2000	partial control / established	Vayssieres 2013
Fopius arisanus / ex	idem	CBC / testing	testing	idem
Gyranusoidea tebygi / ex	Mango mealybug, mango & vars fruit	CBC / testing	testing	Vayssieres 2017
Anagyrus mangicola / ex	idem	CBC / testing	testing	idem
Guadeloupe				
Lydella minense / ex	Sugarcane borers, sugarcane	CBC / 1938	partial control / established	Cochereau 1990
Lixophaga diatraeae / ex	idem	CBC / 1947	partial control / established	idem
Paratheresia claripalpis / ex	idem	CBC / 1954	partial control / established	idem
Cotesia flavipes / ex	idem	CBC / 1970	control / established 14,173[2]	Boulet 1986
Anagyrus kamali / ex	Pink hibiscus mealy bug, ornamentals	CBC / 1999	control / established	Kairo et al 2000
Cryptolaemus montrouzieri / ex	idem	CBC / 1999	control / established	idem
Tamarixia radiata / ex	Asian citrus psyllid, citrus	CBC / 1999	control / established 694[3]	Etienne et al 2001
Tamarixia radiata / ex	idem	ABC / 2018	boost biocontrol on young citrus	Ryckewaert pers com
Martinique				
Bufo marinus / ex	Rats, sugarcane	CBC / 1850	no control / established	Cock 1985
Lydella minense / ex	Sugarcane borers, sugarcane	CBC / 1938	partial control / established	Cochereau 1990
Lixophaga diatraeae / ex	idem	CBC / 1947	partial control / established	idem
Paratheresia claripalpis / ex	idem	CBC / 1954	partial control / established	idem
Cotesia flavipes / ex	idem	CBC / 1976	control / established 4,046[4]	Boulet 1986
Anagyrus kamali / ex	Pink hibiscus mealy bug, ornamentals	CBC / 1999	control / established	Kairo et al 2000
Cryptolaemus montrouzieri / ex	idem	CBC / 1999	control / established	idem
Tamarixia radiata / ex	Asian citrus psyllid, citrus	CBC / 2012	control / established 440 ha[5]	Ryckewaert pers com
Chrysoperla externa / na	Pests in vegetables	ABC / 2017	testing phase	Ryckewaert pers com
Trichogramma pretiosum / na	idem	ABC / 2017	testing phase	idem

15.5 New developments of biological control in French Guiana, Guadeloupe and Martinique

15.5.1 Augmentative biological control with Tamarixia radiata *in Guadeloupe*

Parasitism rates of the psyllid *Diaphorina citri* are often insufficient after the planting of young citrus plants. Therefore, a project is underway at FREDON Guadeloupe to start a mass rearing of the parasitoid *T. radiata* with as host plant the orange jasmine (*Murraya paniculata*).

15.5.2 Classical biological control of the mango mealybug in French Guiana

The mango mealybug, *Rastrococcus invadens* Williams, native to Asia, was discovered in French Guiana in 2014 (Germain *et al*., 2015). It attacks at least 26 fruit (mango, citrus, bananas, etc.) and ornamental plant species, and this invasive pest may eventually invade neighboring countries and spread over the Caribbean (Vayssières, 2017). Without effective biocontrol agents the mango mealybug population are increasing in size every year in all of French Guiana. Thirty years ago this was well controlled in West Africa after the introduction of *Gyranusoidea tebygi* Noyes and *Anagyrus mangicola* Noyes and often recorded in the field (Neuenschwander *et al*., 1994; Neuenschwander, 2003; Bokonon-Ganta *et al*. 2002). A donor supported biocontrol project in French Guiana will be based on introduction of these exotic parasitoids in controlled conditions at first, in order to test their behaviour on locally available potential hosts. Field release will then be considered as a second step, together with monitoring and efficiency records.

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15.7 References

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