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OLD SOLUTIONS TO NEW PROBLEMS: NEW PERSPECTIVES ON THE SUSTAINABLE MANAGEMENT OF PESTS THROUGH BIOLOGICAL CONTROL

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ABSTRACT. In recent years, the Caribbean has been facing several new and resurgent pest problems brought on by rapid means of transport and increased intra and extra regional trade. These have been a threat to both agricultural production and the environment. For most alien pests, classical biological control is often the solution. The application of biological control has been evolving to address new concerns, particularly those regarding the safety of introduced natural enemies. The recent successful introduction of exotic natural enemies against the hibiscus or pink mealybug, *Maconellicoccus hirsutus*, has heightened public awareness of biological control and opened up opportunities for developing integrated pest management (IPM) programmes. This paper examines two separate but related issues: safety of biological control and prospects for IPM in the Caribbean.

INTRODUCTION

In recent years, the Caribbean has seen the introduction of a number of new pest species as well as the resurgence or expansion of the geographical range of other species (Table 1). This is attributable to the rapid means of transport and increased movement of people and agricultural produce between countries. Exotic pests increase rapidly in their new environment, particularly in the absence of effective natural enemies, and attain epidemic status in a relatively short space of time. In such cases, classical biological control i.e. the introduction of appropriate natural enemies from the pest's area of origin, is often the solution. Biological control has several distinct advantages: it is cost-effective, long lasting, self-sustaining and least disruptive to the environment.

The case of the hibiscus mealybug (HMB) *Maconellicoccus hirsutus*, is noteworthy in this regard. There is no doubt that the HMB has been brought under good control following the introduction of natural enemies. The success of this programme has brought into sharp focus the fact that biological control works. Indeed, demonstration of the effectiveness of natural enemies to farmers and the public has opened up new opportunities in terms of development of integrated pest management. Biological control underpins most IPM programmes. Following the successful biological control programme for HMB, the climate is right to implement IPM.

This paper therefore focuses on two separate but related issues: the question of safety of biological control and prospects for development of integrated pest management.

Biological control in the Caribbean

Classical biological control has a long history in the Caribbean dating back to the 18th century. For some in the region, the thought of biological control conjures up a vision of introduction of the mongoose against the snakes. It is important, however, to emphasize that apart from a few early examples where generalist, vertebrate predators were imported with negative results, biological control has largely been safe to non-target organisms.

Table 1. Some pest species that were accidentally introduced or have expanded their geographical range in the Caribbean* during the 1980's and 1990's

Scientific/Common name	No. of countries affected	Main crops/species affected
Bemisia tabaci sp. B (= *B. argentifolli*) / sweet potato whitefly	10	Several cultivated Convolvulaceae, Cruciferae, Cucurbitaceae, Leguminoseae, Solonaceae, and ornamentals
Thrips palmi / southern yellow thrips	12	Several cultivated Cucurbitaceae, Solonceae
Phyllocnistis citrella / citrus leaf miner		Citrus spp.
Maconellicoccus hirsutus / pink hibiscus mealybug	Nearly all**	Polyphagous pest with wide host range, mainly Malvaceae (hibiscus, okra, sorrel, blue mahoe, *Sida* spp.), ornamentals, teak, and fruits of soursop, breadfruit, mango
Paracoccus marginatus / papaya mealybug	4	Papaya, ornamentals
Aleurodicus pulvinatus / coconut whitefly	3	Cocunut, seagrape, guava, guineppe (chenette)
Aleurocanthus woglumi / citrus blackfly	3	*Citrus* spp., coffee
Taxoptera citricida / brown citrus aphid	Nearly all	*Citrus* spp.

* all Caribbean islands, including Guyana ** except Antigua, Bahamas, Barbados, Jamaica

Indeed, several biocontrol introductions in the Caribbean (predating the modern era of biological control) provided substantial or complete control of several important pest species resulting in enormous economic and environment benefits (Cock, 1985). Examples of some of these are presented in Table 2. Since 1946, the Caribbean and Latin American Centre of CABI Bioscience, based in Trinidad, has played an important role in implementing biological control programmes of both exotic and indigenous pests of agricultural and environmental importance in the region.

Safety in biological control

Classical biological control programmes have generally been of benefit to agriculture and human health. There is, however, an increased concern over the potential negative effects of biological control on indigenous biodiversity, particularly non-target and beneficial species. Therefore, when mounting a classical biological control programme, it has become essential to undertake assessments of host specificity and host range of a potential biological control agent in order to determine its suitability (Sands, 1997).

Host specificity is defined as the degree to which a species restricts its diet, and host range as the number of hosts or prey species that are used as food under natural conditions (Nechols *et al.*, 1997). A species is considered a generalist when it feeds on many, often unrelated, hosts (polyphagous) and a specialist when the host range is restricted to one (monophagous) or a few related species (oligophagous). A monophagous species would be the ideal candidate for introduction, however, this approach is not always feasible. Very few natural enemies are strictly monophagous, and it may, in fact, be of advantage to introduce a natural enemy that is not absolutely specific to the target pest since this may help in its establishment in the new environment. The target species should, however, be the *preferred host* of an oligophagous natural enemy.

Table 2. Some examples of biological control programmes in the Caribbean that produced substantial or complete control (from Cock, 1985)

Pest Species (common name) / crop	Effective control agent	Countries
Insect pests		
Aleurocanthus woglumi Ashby (citrus blackfly) / *Citrus* spp., Coffee	*Encarsia opulenta* (Silv.) *Eretmocerus serius* Silv.	Bahamas, Barbados, Cayman Islands, Jamaica
Aleurodicus cocois (Curt.) (coconut whitefly) / coconut	*Encarsiella noyesi* Hayat	Barbados
Aspidiotus destructor Sign. / (coconut scale) / coconut	*Crytognatha nodiceps* Mshl.	St. Kitts, Nevis, perhaps other island
Diatraea saccharalis (F.) (sugarcane borer) / Sugarcane	*Apanteles flavipes* (Cam.)	Barbados
	Lixophaga diatraeae Tns.	Antigua, Barbados, Dominica, St. Kitts
	Metagonistylum minense Tns.	Guyana, St. Lucia
	Paratheresia claripalpis (Wulp.)	Dominica
Icerya purchasi Mask. (cottony Cushion scale) / *Citrus* spp., Pigeonpea, ornamentals	*Rodolia cardinalis* (Muls.)	?Antigua, Bahamas, Barbados, Cayman Islands, Jamaica, Montserrat, St. Kitts/Nevis
Plutella xylostella (L.) (diamond-Back moth) / cabbage & other Crucifers	*Apanteles plutellae* Kurd.	Barbados
Spodoptera frugiperda (J.E. Smith) (army worm) / sugarcane	*Telenomus remus* Nixon	Barbados
Weeds		
Opuntia spp. (cactus)	*Cactoblstis cactorum* (Berg.)	Antigua, ?Cayman Islands, Montserrat, ?St. Kitts, Nevis
Tribulis cistoides L. (punture vine)	*Microlarinus lypriformis* (Woll.)	St. Kitts

It is important to recognize is that there is no 'risk free' introduction and that there are potentially undesirable consequences to the introduction of any species into a new environment (Nechols *et al.*, 1997). Thus, when considering an exotic natural enemy for introduction, the benefits to be derived from the importation should be weighed against the possible negative impacts on non-target species and the environment. The Code of Conduct for the Import and Release of Exotic Biological Control Agents (FAO, 1996) (hereafter referred to as "the Code") ensures safe importation and utilization of natural enemies.

The Code provides guidelines to achieve international standards of phytosanitary measurements and is intended to facilitate the safe importation of exotic biological control agents for research and/or release into the environment. "Biological control agents" include parasitoids, predators, parasites, phytophagous arthropods, phatogens and organisms packaged or formulated as commercial products, all of which are capable of self-replication. To achieve this, the Code lists responsibilities of governmental authorities, exporters and importers and other organizations or agencies involved, in fulfilling objectives and requirements of the Code (Greathead, 1997). As with other Codes, implementation of this Code is voluntary.

Implementation of the Code in the Caribbean

The introduction of the hibiscus or pink mealybug, *Maconellicoccus hirsutus* (HMB) into the Caribbean occurred around the same time as when the Code was being ratified. This provided an ideal opportunity for implementing the Code during the introduction of the natural enemies. CABI Bioscience provided assistance to the affected countries under the FAO-sponsored biological control programmes, in collaboration with regional and international partners.

For many countries in the region, this was the first time that an importation was carried out following guidelines provided in the Code. This in itself was a major step forward. However, it is important that countries develop a framework for implementation of the Code. This includes designation of natural authorities that will be responsible for drafting legislation to support implementation of the Code, reviewing dossiers and ensuring that elements of the Code are implemented.

In line with the Code, CABI Bioscience produced/updated dossiers on the three exotic biological control agents, *Anagyrus kamali*, *Cryptolaemus montrouzieri* and *Scymnus coccivora* (Peterkin and Kairo, 1998; Peterkin *et al.*, 1998a, b). In each dossier, an assessment was provided of the potential hazards and risks associated with the importation of the natural enemy to crop species, non-target organisms (including beneficial species), and human and animal health and those handling the natural enemies. A list of potential contaminants was also provided with details on procedures adopted to eliminate them.

Another programme in which CABI Bioscience implemented the Code was the biological control of *Aleurodicus pulvinatus*. Under this programme, dossiers were prepared on two natural enemie, *Encarsiella* sp. and *E. noyesi* (Lopez *et al.*, 1998a, b). One of them, *Encasiella* sp. D, was introduced into Nevis in April 1998 for the biological control of *A. pulvinatus* and has reportedly become established.

Farmer-participatory IPM

The classical mode of 'top-down' recommendations for pest control, transferred from researchers via extensionists, has frequently failed to reduce pest damage or pesticide use at farm level. This is because researchers have been insufficiently aware of farmers' real problems and perceptions. Such recommendations have therefore proved to be a particularly inappropriate mechanism for helping farmers learn about the complexities of IPM.

One of the most impressive advances in integrated pest management has been the development of the Farmer Field School (FFS) approach, as a training method to help farmers step off the pesticide treadmill. The success of the FFS approach lies in its focus on the farmer as the key decision-maker in pest management and on the facilitation of a discovery-learning process using non-formal education methods. The field is the primary classroom and the four major principles are (i) grow a healthy crop, (ii) observe fields weekly, (iii) conserve natural enemies, and (iv) farmers understand ecology and become experts in their own fields.

There are no standard recommendations or packages of technology offered. In the FFS, farmers observe a sample of crop plants in the field of one of the participants in order to collect data on pests, diseases, beneficials and the general condition of the plants. The observations are recorded visually by the farmers who draw an agro-ecosystem analysis poster. This is then used to facilitate a group discussion of the management practices, which need to be carried out according to field results. By comparing plots under conventional chemical control, as practised by local farmers, with plots where pesticide application and other management practices are under IPM decision-making by the group, participants see the consequences and costs of calendar spraying for themselves over the course of an entire crop season. Discovery-learning exercises and other experiments are also used to help farmers learn about ecological processes. These include studying pest and natural enemy behaviour and lifecycles by keeping specimens in jars or cages known as 'insect zoos'; assessment of the effects of pesticides on natural enemies; simulated foliage damage experiments to explore plant compensation for pest damage; and simple parasitism and predation studies.

Through a FFS-IPM training programme for highland vegetables in the Philippines, farmers took part in releases of the diamondback moth parasitoid *Diadegma* sp. in their cabbage terraces. They built simple wooden emergence boxes, dubbed "Diadegma hotels", in which to place parasitized cocoons distributed by the local university. From their observation of parasitized diamondbacks moth larvae and exercises demonstrating the effects of commonly used insecticides on the parasitoids, participating farmers began to question visiting agrochemical salesmen on whether the products they were pushing were "Diadegma-friendly". Since 1994 over 1700 farmers have been trained in vegetable IPM at 65 FFS sites. Before the FFS project, farmers in the region were applying an average of 14.6 litres of pesticide applications and they have now decreased insecticide use by 80% to 2.9 litres. Instead of their previous reliance on broad spectrum insecticides, farmers are now using *Bt* on a needs basis if *Diadegma* and other mortality factors alone are not enough to keep the diamondback moth in check. Farmers now rely much less on information from pesticide salesmen and more on their own experiences shared during FFS sessions (Anon., 1998).

The success of the FFS training programme in the Philippines influenced local government decision-makers of the value of biological control to such an extent that the mayor of Atok town in the Cordillera region recently banned all advertising of chemical insecticides in his municipality. This is the kind of policy change needed to make a profound difference to biocontrol promotion at research or training level.

CONCLUSIONS

- CABI Bioscience is committed to implementing the Code in making introductions of exotic biological control agents.

  Detailed information provided in the dossiers ensured that authorities in the importing countries were made fully aware of risks involved in undertaking the importation.
- With the continued presence of biological control agents in the environment, other control measures are no longer required, thus making biological control cost-effective.

  Increased public awareness of the biological control programmes has aided in the establishment of introduced natural enemies.
- The time for building on this public awareness is NOW, through pilot projects in farmer-participatory IPM programmes in the region, particularly in vegetable production where chemical pesticide usage is high.
- The IPM programmes can be based successful farmer field school projects in the Philippines, tailored to suit local conditions.

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