Review Article

Biological control of the coconut whitefly, *Aleurodicus pulvinatus*, in Nevis

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Abstract

*Aleurodicus pulvinatus* is a serious pest of coconuts and many ornamental species. Although it is native to certain parts of the Neotropics it appears to have become introduced into several islands in the Caribbean. Furthermore, it has the potential to become more widespread. A recent project has been focused on biological control of *A. pulvinatus* in Nevis and this work offers a good case study of challenges/problems in implementing this kind of project. Information on the taxonomy of the pest and its natural enemies is reviewed. Surveys for natural enemies carried out in Trinidad and Tobago showed that species within the genus *Aleurodicus* share a number of natural enemies. The natural enemy complex attacking *Aleurodicus* spp. includes several species of Aphelinidae in two genera (*Encarsiella* and *Encarsia*), one Encyrtidae (*Metaphycus* sp.) and several species of *Nephaspis* (Coccinellidae). The Code of Conduct for the Import and Release of Exotic Biological Control Agents was followed and thus the work provides a good model for other countries wishing to implement the Code. *Encarsiella* sp. D was introduced into Nevis and appears to have become established.

Introduction

Although the economic significance of coconuts (*Cocos nucifera*) as a crop in the Caribbean has diminished over the years, they are nevertheless still important particularly for the local fresh coconut water market. In addition they are important components of the landscape, contributing to the aesthetic beauty of many of the islands where tourism plays a key role in the economy. In recent years, several homopteran insects have become serious pests of coconuts on a number of islands, causing major concern (Barrow, 1991; Pollard, 1995, Martin & Watson, 1998; J. Laudat, P. Graham & S. Edwards, pers. comm.). In Nevis, for instance, the problems were so severe that the Food and Agriculture Organization of the United Nations (FAO) was requested by the Government of St Kitts and Nevis to provide assistance in the form of a Technical Cooperation Project (TCP/STK/4551): Management of Foliage Pests of Coconut in Nevis. As part of the initial activities of the project, a survey of the pests and their natural enemies was carried out in 1995. The most common pests were identified as two whitefly species, *Aleurodicus pulvinatus* (Maskell) (= *A. iridescens* Cockerell) and *Aleurotrachelus atatus* Bondar (Aleyrodidae), and the scale *Aspidiotus destructor* Signoret (Diaspididae). However, only *Aleurodicus pulvinatus* was considered to be of sufficient significance to require control measures (Cock & Watson, 1995).

The fundamental role of biosystematics in classical biological control cannot be understated. Often the identity of a pest species may be in doubt, and if this is not clarified, efforts at biocontrol may be wasted. For example, in Nevis, the whitefly causing problems was first thought to be *Aleurodicus cocois* Curtis (Barrow, 1991; Pollard, 1995). This species became sufficiently important as a pest of coconuts in Barbados to warrant a biological control programme in the 1950s. Of several natural enemies introduced from Trinidad during 1950 and 1951, the parasitic wasp, *Encarsiella noyesi* Hayat became established and provided excellent control (Cock, 1985). It was only after detailed biosystematic studies that the taxonomy of the whitefly in Nevis was clarified. Thus, its true identity was determined to be *A. pulvinatus*, which was synonymised with *A. iridescens* (Martin & Watson, 1998).

*Aleurodicus pulvinatus* is indigenous to Central and South America and several Caribbean islands, where a number of natural enemies normally keep its populations under control. During surveys for natural enemies in Nevis, although several species were found attacking
the whitefly (see Table 3), they apparently did not provide adequate control (Cock & Watson, 1995). Natural enemies that had co-evolved with *A. pulvinatus* would be expected to have specialized in preying upon this species and thus provide good levels of control. The lack of such specialist natural enemies suggested that *A. pulvinatus* might be exotic to Nevis. Hence, classical biological control was suggested as a sustainable long-term solution. Based on the excellent results following introduction of natural enemies in Barbados for control of *A. cocois*, prospects for success appeared good (Cock, 1985).

The Pest

**Origin and distribution**

Based on Mound & Halsey (1978) and material in the Natural History Museum, London, UK (NHM) and the US National Museum of Natural History, Beltsville, Maryland (NMNH), *A. pulvinatus* occurs in Central and South America and the Caribbean. Current distribution records of *A. pulvinatus* include: Antigua, Barbados, Grenada, Jamaica, Montserrat, St Kitts and Nevis, St Vincent and the Grenadines, and Trinidad and Tobago in the Caribbean, Mexico, Panama, Belize, Bolivia, El Salvador, Honduras and Nicaragua in Central America, and Brazil, Colombia, Ecuador, Guyana, Peru and Venezuela in South America (Martin & Watson, 1998). It appears likely that the whitefly has been expanding its geographical range within the Caribbean. Thus, it may be a new introduction in some of the islands, notably Antigua, St Vincent and the Grenadines, and Grenada where it is apparently causing severe damage (J. Laudat, P. Graham & S. Edwards, pers. comm.). The most likely mode of transfer is through movement of nursery plants, particularly ornamentals.

The purpose of this paper is to summarize pertinent information on biological control for other countries faced with an invasion by the whitefly.

**Biology, damage and host plants**

The adult female lays its eggs in a typical spiral pattern just under the lower leaf surface. Studies on developmental biology in Trinidad at 26 ± 2°C and 60 ± 5% relative humidity revealed that the total life cycle takes 30-35 days, with the egg stage lasting 10-12 days, the first three instars 3-5 days each and the fourth instar/pupa 5-8 days.

As with other Aleurodidae, damage is caused by the immature stages, which feed by sucking plant sap. *Aleurodicus pulvinatus* has a fairly wide host range encompassing 17 families (Table 1). Feeding by the larvae reduces plant vigour and predisposes plants to attack by other insects. The larvae also produce a sugary excretum called honeydew, which encourages growth of black sooty moulds on leaf surfaces. This is unsightly and also reduces the ability of the plant to photosynthesise. The appearance of the plants is further marred by the appearance of the insects: both eggs and larvae are covered by an unsightly white waxy material. No studies have been carried out to determine the appearance of the insects: both eggs and larvae are covered by an unsightly white waxy material. No studies have been carried out to

determine the impact on tourism may include loss of repeat business.

**Surveys for Natural Enemies in Trinidad and Tobago**

In view of the fact that *A. pulvinatus* is not a serious pest in Trinidad and Tobago, it was assumed that effective natural enemies were present. Thus surveys were carried out in various parts of Trinidad and Tobago between 1996 and 1998, and focused on determining the natural enemy complex found on *Aleurodicus* spp. in general. The information obtained was also useful in deducing the host range of selected natural enemy species. A list of parasitoids found attacking *A. pulvinatus* and other closely allied species is given in Table 2.

Eight species of parasitoids were recorded: five Aphelinidae (two Encarsiella and three Encarsia), two Encyrtidae (both Metaphycus) and one Signiphoridae (*Signiphora* sp., possibly a hyperparasitoid). Among the predators, coccinellid species in the genus *Nephaspis* were most important. A summary of the natural enemies specifically found attacking *A. pulvinatus* in the Caribbean Basin is given in Table 3.

The surveys revealed that species in the genus *Aleurodicus* appeared to share a number of natural enemy species. Thus for Caribbean countries where *A. pulvinatus* becomes a serious pest, it will be prudent to carry out surveys to determine which natural enemies are already present before considering introduction of new ones. This is because natural enemies of other *Aleurodicus* species may adapt to exploit *A. pulvinatus*, in which case a new introduction may not be necessary.

Amongst the parasitoids in Trinidad and Tobago, two *Encarsiella* species (*Encarsiella* sp. D and *E. noyesi*), were the most important. With few exceptions, *Aleurodicus* spp. encountered on various hosts throughout the country were always attacked by one or both of these species (Table 2). Percent parasitism levels of up to 95% were observed. Often more than one parasitoid species occurred, and in such cases *Encarsiella* sp. D invariably dominated. In isolated sites where only one species was present, high levels of parasitism were also recorded. Of the predators present, *Nephaspis* spp. were clearly the most important (Lopez et al., 1997). However, an unidentified species of *Nephaspis* was recorded during surveys in Nevis and hence the introduction of *Nephaspis* from Trinidad was not considered. On the basis of these field observations, and in the light of the previous successful control of *A. cocois* in Barbados, *Encarsiella* sp. D and *E. noyesi* were prioritized for detailed studies.

**The Biocontrol Agents: Encarsiella Species**

**Taxonomy**

The genus *Encarsiella* belongs to the order Hymenoptera, superfamily Chalcidoidea, Family Aphelinidae. At one time, the genus was synonymised with *Dirphys* but was later reinstated as *Encarsiella* with six described species and two new species (Polaszek & Hayat, 1992). Five species have since been added to this list (Chou & Chou, 1994; Huang & Polaszek, 1996) and several more are currently in the process of being revised/described (A. Polaszek, pers. comm.).

**Biology**

Many genera of Aphelinidae have complex developmental biology involving autoparasitism (Viggiani, 1984). Mated females lay fertilized, diploid eggs in young and adult stages of Homoptera (whiteflies, mealybugs and scale insects) and these develop into female larvae which feed as primary endoparasitoids. Haploid eggs laid by both mated and unmated females develop into males. In some species, males develop as primary parasitoids but in many others, they develop as hyperparasitoids on females of their own or related species. In a few species, males may develop as primary parasites of eggs of other insects such as Lepidoptera (Polaszek, 1991). The biology of *Encarsiella* sp. D, is poorly known. Studies on *E. noyesi* attacking *Aleurodicus dugesii* Cockerell in California have revealed the existence of entirely thelytokous populations (T. Bellows, pers. comm.). Observations in Trinidad indicate that males of both *Encarsiella* sp. D and *E. noyesi* exhibit an autoparasitic mode of life.
Encarsia pergandiella is also possible that males may develop as primary parasitoids. In modes of egg laying have been reported amongst the Aphelinidae. It later when developing female larvae were already present. Both it was not clear if male eggs were laid together with female eggs or estimated to take at least 14 days.

First instar female larva (approx. 3 days old), male development is mental period. Since male development could in theory begin in the completed in 17-20 days. Males apparently had a shorter development of females of both Encarsiella species took 11-13 days from egg to prepupal stage, at which time the meconium (consisting of flat reddish-brown pellets) was discarded and the parasitoid larva was visible from the ventral surface of the whitefly pupa, which was more transparent than the dorsal surface. In 1-2 days, the empty pupal case of the whitefly hardened to form the ‘mummy’. The pupa was formed inside the mummy. The mummy of E. noyesi was slightly smaller and not as black as that of Encarsiella sp. D. The pupal stage lasted 4-5 days. The total life cycle of females was thus completed in 17-20 days. Males apparently had a shorter developmental period. Since male development could in theory begin in the first instar female larva (approx. 3 days old), male development is estimated to take at least 14 days.

It was not clear if male eggs were laid together with female eggs or later when developing female larvae were already present. Both modes of egg laying have been reported amongst the Aphelinidae. It is also possible that males may develop as primary parasitoids. In Encarsia pergandiella Howard, males are reported to develop both as primary parasitoids and as hyperparasitoids (Hunter et al., 1993). To test whether this occurred in the Encarsiella species being investigated in Trinidad, large numbers of newly emerged, unfertilized females were released on A. cocois. No males, however, were recovered up to 5 weeks later.

The sex ratio under field conditions was always biased towards females, with males often accounting for only 0-5% (occasionally higher) of the numbers encountered. The size of the parasitoids also varied depending on the host insect from which they were reared. For example, Encarsiella sp. D. reared from Aleurodicus maritimus Hempel measured 0.64 mm, from A. pulvinatus 0.80 mm and from A. cocois 1.0 mm, on average.

### Host range

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus/species</th>
<th>Country records¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alismataceae</td>
<td>Echinodorus</td>
<td>not known</td>
</tr>
<tr>
<td>Araceae</td>
<td>Montrichardia arborescens ssp. aculeata</td>
<td>Guyana</td>
</tr>
<tr>
<td>Chrysobalanaceae</td>
<td>Chrysobalanus icaco</td>
<td>Mexico</td>
</tr>
<tr>
<td>Combretaceae</td>
<td>Terminalia catappa</td>
<td>Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>Hura crepitans; Jatropha</td>
<td>Costa Rica</td>
</tr>
<tr>
<td>Guttiferae</td>
<td>Vismia</td>
<td>Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>Lacistemataceae</td>
<td>Lacistema</td>
<td>Panama</td>
</tr>
<tr>
<td>Lauraceae</td>
<td>Persea americana</td>
<td>Trinidad &amp; Tobago</td>
</tr>
<tr>
<td></td>
<td>undetermined host</td>
<td>Belize</td>
</tr>
<tr>
<td>Moraceae</td>
<td>Ficus</td>
<td>not known</td>
</tr>
<tr>
<td>Musaceae</td>
<td>Musa</td>
<td>not known</td>
</tr>
<tr>
<td>Myrtaceae</td>
<td>Psidium guajava</td>
<td>Belize; St Kitts &amp; Nevis; Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>Palmae</td>
<td>Cocos nucifera</td>
<td>St Kitts &amp; Nevis; Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>Piperaceae</td>
<td>Piper nigrum</td>
<td>Brazil</td>
</tr>
<tr>
<td>Polygononaceae</td>
<td>Coccoloba belizensis</td>
<td>Belize</td>
</tr>
<tr>
<td></td>
<td>Coccoloba uvifera</td>
<td>Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>Coffea canephora</td>
<td>Ecuador</td>
</tr>
<tr>
<td></td>
<td>Isertia hypoleuca</td>
<td>Panama</td>
</tr>
<tr>
<td></td>
<td>Guettarda combesii</td>
<td>Belize</td>
</tr>
<tr>
<td>Sterculiaceae</td>
<td>Theobroma</td>
<td>not known</td>
</tr>
<tr>
<td>Verbenaceae</td>
<td>Petrea</td>
<td>not known</td>
</tr>
</tbody>
</table>

¹Based on NHM (Natural History Museum, London, UK) collections and FAO Nevis project results.

Under laboratory conditions (26 ± 2°C and 65 ± 5% RH), the development of females of both Encarsiella species took 11-13 days from egg to prepupal stage, at which time the meconium (consisting of flat reddish-brown pellets) was discarded and the parasitoid larva was visible from the ventral surface of the whitefly pupa, which was more transparent than the dorsal surface. In 1-2 days, the empty pupal case of the whitefly hardened to form the ‘mummy’. The pupa was formed inside the mummy. The mummy of E. noyesi was slightly smaller and not as black as that of Encarsiella sp. D. The pupal stage lasted 4-5 days. The total life cycle of females was thus completed in 17-20 days. Males apparently had a shorter developmental period. Since male development could in theory begin in the first instar female larva (approx. 3 days old), male development is estimated to take at least 14 days.

The host range of the males in both species is less well known. There is some evidence that males of one species could develop hyperparasitically on female larvae/pupae of the other species and vice versa. During field studies, males were never recovered from Encarsia spp., which occur in the same habitat. However, this was not sufficient evidence to discount the possibility that these species could be attacked. Indeed, although obligate autoparasitoids are known, most species are facultative and males may develop in several host species.
Table 2. Parasitoids reared from *Aleurodicus pulvinatus* and related Aleyrodidae in Trinidad & Tobago, 1996-98.

<table>
<thead>
<tr>
<th>Species</th>
<th>Ex: host</th>
<th>Host plant</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Encarsiella noyesi</em> Hayat</td>
<td><em>Aleurodicus pulvinatus</em> (Maskell)</td>
<td>Coccoloba uvifera (seagrape)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Terminalia catappa</em> (tropical almond)</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus cocois</em> Curtis</td>
<td>Cocos nucifera (coconut)</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus maritimus</em> Hempel</td>
<td>Psidium guajava (guava)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Cajanus cajan</em> (pigeonpea)</td>
</tr>
<tr>
<td><em>Encarsiella</em> sp. D</td>
<td><em>Aleurodicus pulvinatus</em></td>
<td>Coccoloba uvifera</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Psidium guajava</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus cocois</em></td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus maritimus</em></td>
<td><em>Cajanus cajan</em></td>
</tr>
<tr>
<td><em>Encarsia guadeloupae</em> Viggiani</td>
<td><em>Aleurodicus pulvinatus</em></td>
<td>Coccoloba uvifera</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Psidium guajava</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus cocois</em></td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus maritimus</em></td>
<td><em>Veitchia merrillii</em> (manila palm)</td>
</tr>
<tr>
<td></td>
<td><em>Lecanoideus mirabilis</em> (Cockerell)</td>
<td><em>Polyalthia longifolia</em> (ashoka tree)</td>
</tr>
<tr>
<td><em>Encarsia</em> sp. nr. <em>meritoria</em> Gahan sp. A. (= <em>E. haitiensis</em>)</td>
<td><em>Aleurodicus pulvinatus</em></td>
<td>Psidium guajava</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus cocois</em></td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus maritimus</em></td>
<td><em>Veitchia merrillii</em></td>
</tr>
<tr>
<td></td>
<td>unknown <em>?Aleurodicus</em> sp. or <em>?Lecanoideus</em> sp.</td>
<td><em>Pimenta racemosa</em> (bay leaf tree)</td>
</tr>
<tr>
<td></td>
<td><em>Aleurothrixus flocosus</em> Maskell</td>
<td><em>Spondias dalcis</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Citrus</em> sp.</td>
</tr>
<tr>
<td><em>Encarsia</em> sp. nr. <em>meritoria</em> Gahan sp. B</td>
<td><em>Aleurodicus cocois</em> + <em>?Aleurotrachelus</em> sp.</td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td><em>Metaphycus</em> sp. 1</td>
<td><em>Paraleyrodes</em> sp.</td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td><em>Metaphycus</em> sp. 2</td>
<td><em>Aleurodicus cocois</em></td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td></td>
<td><em>Aleurodicus maritimus</em> + <em>Aleurothrixus flocosus</em></td>
<td>Psidium guajava</td>
</tr>
<tr>
<td><em>Signiphora</em> spp. (hyperparasitoids)</td>
<td>unidentified parasitoid of <em>Aleurodicus cocois</em></td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td></td>
<td>unidentified parasitoid of <em>?Aleurotrachelus</em> sp.</td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td></td>
<td>unidentified parasitoid of <em>?Aleurotrachelus</em> sp.</td>
<td>Capsicum sp.</td>
</tr>
</tbody>
</table>

Table 3. Known natural enemies of *Aleurodicus pulvinatus* in the Caribbean Basin area.

<table>
<thead>
<tr>
<th>Country</th>
<th>Natural enemy</th>
<th>Family</th>
<th>Species</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belize</td>
<td>Parasitoids</td>
<td>Aphelinidae</td>
<td><em>Encarsia</em> sp. near <em>meritoria</em> (= <em>E. haitiensis</em> in literature)</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Encarsia</em> noyesi Hayat</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Encarsia guadeloupae</em> Viggiani</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eulophidae</td>
<td><em>Entedonocremnus</em> sp.</td>
<td>Watson 1996</td>
</tr>
<tr>
<td>Nevis</td>
<td>Parasitoids</td>
<td>Aphelinidae</td>
<td><em>Encarsia</em> guadeloupae</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Encarsia guadeloupae</em> Viggiani</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eulophidae</td>
<td><em>Aleoctonus vittatus</em> (Dozier)</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td>Predators</td>
<td>Coccinellidae</td>
<td><em>Delphastus nebulosus</em> Chapin</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Nephaspis</em> sp.</td>
<td>Watson 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chrysopidae</td>
<td><em>Neosuarius collaris</em> Schneider</td>
<td>Watson 1996</td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>Parasitoids</td>
<td>Aphelinidae</td>
<td><em>Encarsiella noyesi</em></td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Encarsiella sp. D</em></td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Encarsia</em> haitiensis</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Encarsiella guadeloupae</em></td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td>Predators</td>
<td>Coccinellidae</td>
<td><em>Nephaspis</em> spp.</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Scymnus</em> spp.</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chrysopidae</td>
<td>unidentified species</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Syrphidae</td>
<td>unidentified species</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phytoseiidae</td>
<td>several species of predatory mites</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Araneae</td>
<td>several species of spiders</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td>Venezuela</td>
<td>Parasitoids</td>
<td>Aphelinidae</td>
<td><em>Dirphys larensis</em> Chavez</td>
<td>Chavez 1996</td>
</tr>
</tbody>
</table>


Table 4. Host range of Encarsiella species.

<table>
<thead>
<tr>
<th>Encarsiella spp.</th>
<th>Host species</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. aleurodici</em> (Girault)</td>
<td>unknown host</td>
<td>A. Polaszek, pers. comm.</td>
</tr>
<tr>
<td><em>E. magniclava</em> (Girault)</td>
<td><em>Eudialeurodicus bodkini</em> Quaintance &amp; Baker</td>
<td>A. Polaszek, pers. comm.</td>
</tr>
<tr>
<td><em>E. noyesi</em> Hayat</td>
<td><em>Aleurodicus palvinatus</em> (Maskell)</td>
<td>Nevis project¹</td>
</tr>
<tr>
<td></td>
<td><em>A. cocois</em> Curtis</td>
<td>A. Polaszek, pers. comm.; Nevis project</td>
</tr>
<tr>
<td></td>
<td><em>A. maritimus</em> Hempel</td>
<td>Nevis project</td>
</tr>
<tr>
<td>Encarsiella sp. A</td>
<td><em>A. dagesei</em> Cockerell</td>
<td>A. Polaszek, pers. comm.</td>
</tr>
<tr>
<td>Encarsiella sp. B</td>
<td>(no host)</td>
<td>A. Polaszek, pers. comm.</td>
</tr>
<tr>
<td>Encarsiella sp. C</td>
<td><em>A. floccosus</em> Maskell</td>
<td>A. Polaszek, pers. comm.</td>
</tr>
<tr>
<td>Encarsiella sp. D</td>
<td><em>A. iridesens</em> Cockerell (<em>= A. palvinatus</em>)</td>
<td>A. Polaszek, pers. comm.</td>
</tr>
<tr>
<td></td>
<td>?<em>A. floccosus</em></td>
<td>A. Polaszek, pers. comm.</td>
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<td></td>
<td><em>A. palvinatus</em></td>
<td>Nevis project</td>
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<td></td>
<td><em>A. cocois</em></td>
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<td></td>
<td><em>A. maritimus</em></td>
<td>Nevis project</td>
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Dossiers

With the ratification of the international Code of Conduct for the Import and Release of Exotic Biological Control Agents (FAO, 1996) as an International Standard for Phytosanitary Measures, it was expected that provisions of this Code would apply in the implementation of any new biological control project. This project has offered practical opportunities for training national staff in implementation of the Code and also to increase overall awareness among stakeholders. Thus the project in Nevis was carried out in full compliance with the Code. To this end, dossiers were prepared for Encarsiella sp. D and *E. noyesi* (Lopez et al., 1998a, b). In each dossier relevant information on the pest and parasitoid species was summarized. This included an assessment of potential risks posed to non-target organisms (particularly other whitefly species and beneficial insects), to human and animal health, and to persons handling the parasitoids. Both species have a narrow host range, which appears to be restricted to Aleurodicus spp. The information contained in the dossiers would be relevant to any country which may wish to introduce the same natural enemies, although it may necessary to consider risks separately for each country.

The dossier on Encarsiella sp. D was submitted to the Department of Agriculture, Nevis in February 1998. Approval for the introduction was granted in March and the species was introduced into Nevis in April. The dossier on *E. noyesi* recommended that introduction of this species be withheld pending reports of the establishment of Encarsiella sp. D in order to facilitate ease of both establishment (of the parasitoid) and monitoring (of the parasitoid’s establishment and its effects on the target pest).

Importation of Encarsiella sp. D into Nevis

In seven shipments, a total of 2739 parasitoids were sent to Nevis between April and June 1998. Introduced parasitoids were released directly in the field on coconut and another host plant, seagrape (*Coccoloba uvifera*). Two release strategies were adopted: part of the material was released into sleeve cages while the rest was released in the open. The latter proved more successful.

During field releases, a eulophid parasitoid, *Aleuroctonus vittatus* (Dozier), recorded in low numbers during surveys in 1995 (Cock & Watson, 1995), was found to be relatively abundant. The role of this parasitoid needs to be looked at in the overall assessment programme.

It was not possible to conduct regular sampling to assess the impact of the natural enemies; however, there is ample evidence that the parasitoid has become established and is spreading from initial release sites.

Conclusions

*Aleurodicus palvinatus* appears to be continuing to expand its distribution within the Caribbean. However, a useful framework for carrying out biological control has been established and has been described here. This should be useful for any countries wishing to implement control programmes against the pest.

Although extensive monitoring of the situation in Nevis was not sustained, there was evidence to suggest that Encarsiella sp. D became established. However, there is still need for a more comprehensive evaluation of the effectiveness of the introduced natural enemy.

Acknowledgements

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References


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