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Review Article

Spiralling whitefly, *Aleurodicus dispersus,* in India

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Abstract

Aleurodicus dispersus, a native of the Caribbean region and Central America, probably came to India from Sri Lanka or the Maldives. It was first reported in 1993 from Kerala and later from other parts of peninsular India and the Lakshadweep islands. The pest is highly polyphagous and has been recorded on 253 host plants in India. At least two aphelinid parasitoids, *Encarsia guadeloupae* and *E.* sp. nr. *meritoria*, have been fortuitously introduced together with the host into several countries including India. Surveys for natural enemies of this pest in India showed several indigenous predators, mainly coccinellids and neuropterans. The natural enemies recorded from India are listed and doubtful records indicated. Classical biological control, involving introduction of natural enemies from the area of origin of the pest, appears to be the best option for managing *A. dispersus*. With the accidental introduction of both species of *Encarsia* into India, there has been a perceptible reduction in the population of *A. dispersus,* as witnessed in Nigeria, Benin, Tenerife (Canary Islands) and Taiwan. There is a need for careful assessment of the impact of these introduced parasitoids on the pest and also their interaction with the indigenous natural enemies.

Introduction

Aleurodicus dispersus Russell (Hom., Aleyrodidae) is a highly polyphagous pest and a native of the Caribbean region and Central America (Russell, 1965), where it is known from a wide range of host plants, but not regarded as a pest (Waterhouse & Norris, 1989). It is more commonly known worldwide as 'spiralling whitefly' because it lays eggs in a typical spiral pattern (Kumashiro *et al*., 1983). It was introduced and assumed pest status in the Canary Islands in 1962 and in Hawaii in 1978 (Paulson & Kumashiro, 1985), in American Samoa and Guam in 1981 (Firman, 1982) and then in most of the Pacific islands (Waterhouse & Norris, 1989). The whitefly later spread westwards into several regions including Africa (Akinlosotu *et al*., 1993; M'Boob & van Oers, 1994; Neuenschwander, 1994), Asia (Anon., 1987; Wijesekera & Kudagamage, 1990; Kajita *et al*., 1991; Wen *et al*., 1994; Palaniswami *et al*., 1995) and Australia (Carver & Reid, 1996; Lambkin, 1998).

In south Asia, it is presently found in Bangladesh (Scanlan, 1995), Sri Lanka (Wijesekera & Kudagamage, 1990), the Maldives (Martin, 1990) and India (Palaniswami *et al*., 1995). It was first reported from India in 1993 from Kerala (Palaniswami *et al*., 1995) and later from other parts of peninsular India (David & Regu, 1995; Mani & Krishnamoorthy, 1996; Prathapan, 1996; Geetha *et al*., 1998; Reddy & Chandurkar, 1999; Sathe, 1999) and the Lakshadweep islands (Ramani, 2000). There is no concrete evidence regarding its mode of entry into India or the country from which it was introduced, but it probably came from Sri Lanka or the Maldives.

Damage, Host Range and Population Dynamics

Adults and nymphs of the whitefly cause damage by direct feeding on plant sap and when present in very large numbers can cause leaf fall, but even heavy infestations are insufficient to kill the plants. The copious white, waxy, flocculent material secreted by all the stages of the pest is readily spread by wind, creating nuisance. Honeydew excreted by the nymphs encourages growth of sooty mould on leaf surfaces, reducing the photosynthetic capacity of the plant (Kumashiro *et al*., 1983).

Its extensive host range covers 481 host plants belonging to 295 genera and 90 families, including several vegetables, fruits, ornamentals and avenue trees (Srinivasa, 2000). In India, it has been reported on over 253 plant species belonging to 176 genera and 60 families (David & Regu, 1995; Palaniswami *et al*., 1995; Prathapan, 1996; Ranjith *et al*., 1996; Geetha *et al*., 1998; Muralikrishna, 1999; Gajendra Babu & David, 1999; Mani & Krishnamoorthy, 1999a; Geetha *et al*., 1999; Ramani, 2000; Srinivasa, 2000; Mariam *et al*., 2000; Geetha & Swamiappan, 2001a; Gopi *et al*., 2001). The major host plants of economic concern in India are banana, guava, avocado, papaya, coconut, cucurbits, dahlia, gerbera, gladiolus, tomato, mulberry, tapioca and bell pepper, in addition to several species of shade trees in the urban environment. The families Fabaceae, Asteraceae, Malvaceae, Myrtaceae, Euphorbiaceae and Moraceae seem to contain the most species of host plants (Srinivasa, 2000; Geetha & Swamiappan, 2001a).

Wen *et al*. (1995) reported a loss in fruit yield of 80% in guava attacked by the pest for four months consecutively in Taiwan, but estimates of yield loss due to this pest are not available in India.

Ranjith *et al*. (1996) observed severe damage to many crops in Kerala and Geetha *et al*. (1998) observed severe incidence in a groundnut crop in Tamil Nadu. Heavy incidence of the whitefly caused yield reduction to an extent of 53.10% in tapioca (Geetha, 2000). Adverse impacts, such as longer larval duration, decreased food conversion and utilization and reduction in economic parameters of the cocoon, were noticed when the whitefly-infested mulberry leaves were fed to the silkworm, *Bombyx mori* (L.) (Lep., Bombycidae), due to reduced nutrition levels in affected leaves (Mariam, 1999; Ahamed *et al*., 1999; Narayanaswamy *et al*., 1999).

The whitefly was present throughout the year in Bangalore, with high populations in summer (March-June) and low ones in winter (October-January). The population was positively correlated with temperature and negatively correlated with humidity. Populations of indigenous predators remained low and did not have any impact on the whitefly (Mani & Krishnamoorthy, 2000). Narayanaswamy & Ramegowda (1999) found high incidence of the pest on mulberry during April-June in and around Bangalore. Palaniswami *et al*. (1995) reported outbreaks in the post-rainy dry season between November and April and peaks in February in Kerala. Severe infestation was observed during March in the Lakshadweeps (Ramani, 2000), which lessened during June with the onset of rains. Geetha (2000) found high populations in field crops during May-October while Gopi *et al*. (2001) found the incidence to be higher in cooler months (November-February) on several tree species in Coimbatore.

Options for Control

In the regions where *A. dispersus* occurs naturally, a number of natural enemies keep populations under check. In countries where it has been introduced, chemical and biological control methods have been tried. Insecticides and neem oil have been found effective against the pest in several countries (Wijesekera & Kudagamage, 1990; Wen *et al*., 1995; Alam *et al*., 1998). In India, tobacco extract, neem oil, fish oil, rosin soap and detergent solution in addition to several insecticides have been found effective (Ranjith *et al*., 1996; Mariam, 1999; Muralikrishna, 1999; Geetha, 2000). Chemical control is both uneconomic and impractical because of the pest's broad host range, widespread distribution and presence in areas with high human inhabitation (Kajita *et al*., 1991). Spraying a dilute aqueous solution of detergent to reduce infestations (Waterhouse & Norris, 1989) and use of light traps covered with Vaseline coating to trap adults (Srinivasan & Mohanasundaram, 1997), have been suggested. As *A. dispersus* is an exotic pest in most countries, classical biological control through introduction of natural enemies from the area of origin of the pest is considered the best option for a sustainable solution (Lopez *et al*., 1997a). In Hawaii, several Pacific islands, the Maldives, Taiwan and Tenerife (Canary Islands), biological control has been attempted by introducing natural enemies (aphelinids and coccinellids) from the Caribbean region or from other areas where the parasitoids have been introduced earlier and substantial control has been achieved (Kumashiro *et al*., 1983; Waterhouse & Norris, 1989; Greathead & Greathead, 1992; Chien *et al*., 2000; Nijhof *et al*., 2000). At least two host-specific parasitoids, *Encarsia guadeloupae* Viggiani and *Encarsia* sp. nr. *meritoria* Gahan (Hym., Aphelinidae) have also been fortuitously introduced into several countries such as Guam (Waterhouse & Norris, 1989), Malaysia, the Philippines, Benin, Togo, Ghana and Nigeria (Neuenschwander, 1996; D'Almeida *et al*., 1998) and India (Ramani, 2000), presumably together with the host.

Natural Enemies in India

In addition to the accidentally introduced aphelinids, several indigenous natural enemies have expanded their host range to this invading pest in India (Palaniswami *et al*., 1995; Mani & Krishnamoorthy, 1999a, b; PDBC, 2000; Ramani, 2000; Mani & Krishnamoorthy, 2000; Mani *et al*., 2000a; PDBC, 2001; Geetha & Swamiappan, 2001a). Natural enemies of this pest in India, including several new records, are listed and possible misidentifications/doubtful records indicated (Table 1).

Parasitoids

Two aphelinid parasitoids have been accidentally introduced along with the host. The species variously referred to as *Encarsia* sp. (a new species closely related to *Encarsia haitiensis* Dozier and *E. meritoria*) (Srinivasa *et al*., 1999), *E.* sp. nr. *haitiensis* (Ramani, 2000; Mani *et al*., 2000a, b) and more correctly as *E.* sp. nr. *meritoria* (Beevi *et al*., 1999; Geetha & Swamiappan, 2001b), was first recorded from Kerala in 1998 (Beevi *et al*., 1999), nearly five years after the pest was reported from the same state (Palaniswami *et al*., 1995). This species was later recorded from Bangalore (Srinivasa *et al*., 1999; Ramani, 2000) and other areas in peninsular India (Mani *et al*., 2000b). *Encarsia guadeloupae* was first reported from Minicoy Island in the Lakshadweeps in 1999 and later deliberately introduced into the mainland and established there (Ramani, 2000; Mani *et al*., 2000a, b; Beevi & Lyla, 2001). It is likely these parasitoids migrated from the Maldives into Minicoy and other islands of the Lakshadweeps and later, assisted by the intentional release and colonization, spread to other areas of peninsular India (Ramani, 2000; Mani *et al*., 2000b). It is also likely that the parasitoids were found only after their numbers increased phenomenally through breeding for several years on the expanding host population, although they had been introduced along with the host.

Beevi *et al*. (1999) and Srinivasa *et al*. (1999) recorded 0-38.88% parasitism of nymphs by *E.* sp. nr. *meritoria* on different host plants. Geetha & Swamiappan (2001b) recorded 70-80% parasitism in guava by *E.* sp. nr. *meritoria* during 1999 in Coimbatore. Higher parasitism rates of 60-92% were recorded in Bangalore and Thrissur during 1999-2000 (PDBC, 2001) and in Minicoy during 2000 (Ramani, 2000), probably by both *E. guadeloupae* and *E.* sp. nr. *meritoria* . Beevi & Lyla (2001) recorded 1-60% parasitism on different host plants in Kerala due to both species. Parasitism levels of 29-70% were observed due to both parasitoids in different parts of peninsular India during January-June 2000 and wherever there was heavy parasitism, the pest population was substantially reduced subsequently (Mani *et al*., 2000a,b). Parasitism levels were found to be highly density-dependent and also varied with host plants (Srinivasa *et al*., 1999; PDBC, 2000; Ramani, 2000; PDBC, 2001; Beevi & Lyla, 2001).

A survey in the Lakshadweep islands of Agatti and Kavaratti during June 2001, where both parasitoids had been released in 2000, showed parasitism levels of 60-100%, exclusively by *E. guadeloupae*. Parasitism levels in Bangalore during June-December, 2001 due to *E. guadeloupae* were 17-97% on four different host plants. *Encarsia guadeloupae* has become predominant and almost totally displaced *E.* sp. nr. *meritoria* in Kerala (Beevi & Lyla, 2001) and in several other areas in Karnataka and Tamil Nadu (PDBC, 2001), as has been seen in southern Taiwan. There, both the aphelinid species were released during 1996–98 and only *E. guadeloupae* had become established with 0-68% parasitism by 1998-99 (Chien *et al*., 2000). A classic serendipitous introduction of *E. guadeloupae* into Tenerife (Canary Islands) occurred when introduction of *E.* sp. nr. *meritoria* was attempted from Fiji and Taiwan, but *E. guadeloupae,* which had been unintentionally co-introduced in the culture, dominated and established well in laboratory cultures and later in the field on *A. dispersus* and *Lecanoideus floccissimus* Martin *et al.* (Hom., Aleyrodidae) (Nijhof

Table 1. Natural enemies of the spiralling whitefly, *Aleurodicus dispersus,* in India

Taxonomic group	Species	Reference(s)
PARASITES		
Acari		
Erythraeidae	*Leptus* sp.	Geetha & Swamiappan 2001b
Hymenoptera		
Aphelinidae	*Encarsia guadeloupae* Viggiani[2]	Ramani 2000; Mani *et al*. 2000b; Beevi & Lyla 2001
	Encarsia sp. nr. *haitiensis* Dozier[1,2]	Ramani 2000; Mani *et al*. 2000b; Beevi & Lyla 2001
	Encarsia sp. nr. *meritoria* Gahan[1,2]	Beevi *et al*. 1999; Geetha & Swamiappan 2001b
	Encarsia sp. (closely related to *E. haitiensis* and *E. meritoria*)[1,2]	Srinivasa *et al*. 1999
INSECT PREDATORS		
Coleoptera		
Coccinellidae	*Anegleis cardoni* (Weise)[2]	PDBC 2001
	Anegleis perrotteti (Mulsant)[2]	New record
	Axinoscymnus puttarudriahi Kapur & Munshi[2]	Mani & Krishnamoorthy 1999a; Ramani 2000
	Cheilomenes sexmaculata (F.)	Palaniswami *et al*. 1995; Mani & Krishnamoorthy 1997; Geetha *et al*. 1999
	Chilocorus nigrita (F.)[3]	Mani & Krishnamoorthy 1999a,c, 2000; Mani *et al*. 2000a
	Cryptolaemus montrouzieri Mulsant[3]	Mani & Krishnamoorthy 1999a,b
	Curinus coeruleus (Mulsant)	Mani *et al*. 2000a; PDBC 2001
	Horniolus sp.	New record
	Jauravia dorsalis (Weise)[2]	New record
	Jauravia pallidula Motschulsky[2]	New record
	Jauravia sp.[2]	PDBC 2001
	Nephus regularis (Sicard)[2]	New record
	Pseudaspidimerus flaviceps (Walker)[2]	Ramani 2000
	Pseudaspidimerus trinotatus (Thunberg)[2]	New record
	Pseudoscymnus sp.[2]	New record
	Rodolia amabilis Kapur	New record
	Rodolia breviuscula Weise	New record
	Rodolia fumida Mulsant	New record
	Scymnus coccivora Ramakrishna Ayyar	New record
	Scymnus latemaculatus Motschulsky	New record
	Scymnus nubilus Mulsant	PDBC 2001; Ramani 2000
	Scymnus posticalis Sicard	New record
	Scymnus saciformis Motschulsky[2]	New record
	Scymnus (*Pullus*) sp.	Mani & Krishnamoorthy 1996
	Scymnus sp.	Palaniswami *et al*. 1995
	Serangium parcesetosum Sicard	PDBC 2001; Ramani 2000
Nitidulidae	*Cybocephalus* sp.[2]	Mani & Krishnamoorthy 2000; Ramani 2000
Diptera		
Cecidomyiidae	*Triommata coccidivora* (Felt)	PDBC 2000

Table 1. (Continued) Natural enemies of the spiralling whitefly, *Aleurodicus dispersus,* in India

Taxonomic group	Species	Reference(s)
Chamaemyiidae	*Leucopis* sp.	PDBC 2000, 2001
Drosophilidae	*Acletoxenus indicus* Malloch[2]	Mani & Krishnamoorthy 1999a; PDBC 2000
Hymenoptera		
Formicidae	*Oecophylla smaragdina* (F.)	Gopi *et al*. 2001
	Solenopsis geminata (F.)	Gopi *et al*. 2001
Lepidoptera		
Lycaenidae	*Spalgis epeus* (Westwood)	PDBC 2001
Neuroptera		
Chrysopidae	*Apertochrysa* sp.	Mani & Krishnamoorthy 1999a; Geetha *et al*. 1999
	Chrysoperla carnea (Stephens)	Mani & Krishnamoorthy 1999a
	Mallada astur (Banks)[2]	Mani & Krishnamoorthy 1999a, 2000
	Mallada boninensis (Okamoto)	Mani & Krishnamoorthy 1999a, 2000
	Nobilinus sp.	Mani & Krishnamoorthy 1999a, 2000
Coniopterygidae	Unidentified	PDBC 2001
Hemerobiidae	*Hemerobius* sp.	PDBC 2001
	Notiobiella viridinervis Banks[2]	Mani & Krishnamoorthy 2000; PDBC 2000
OTHER PREDATORS		
Araneae	Indeterminate spiders	Gopi *et al*. 2001
Aves	House sparrow, *Passer domesticus* (L.)	Gopi *et al*. 2001
	Lesser spider hunter, *Arachnothera longirostris* (Latham)	Gopi *et al*. 2001
	Pied bushchat, *Saxicola caprata* (L.)	Gopi *et al*. 2001
	Sunbirds	Gopi *et al*. 2001
	Tailor bird, *Orthotomus sutorius* (Pennant)	Gopi *et al*. 2001
PATHOGENS		
Deuteromycetes		
Moniliales	*Paecilomyces farinosus* (Holm.) Brown & Smith	Mani *et al*. 2000a; PDBC 2001

[1] Refer to the same species
[2] Predominant species in whitefly colonies
[3] Doubtful record

et al., 2000). However, in Benin, *E*. sp. nr. *meritoria* was more abundant and widespread than *E. guadeloupae* initially, but later *E. guadeloupae* also became abundant in localities surveyed (D'Almeida *et al*., 1998).

The taxonomy of whitefly parasitoids provides a challenge and species level identification of hymenopteran families parasitizing the whiteflies, mainly the Aphelinidae, is most problematic. A continuing problem exists in the identity of the species used for biological control of *A. dispersus*, referred to as *E*. sp. nr. *haitiensis*, *E. haitiensis* and *E*. sp. nr. *meritoria*, and only DNA sequence data utilizing RAPD-PCR (randomly amplified polymorphic DNA – polymerase chain reaction) analysis of *Encarsia* species will solve this (Polaszek, 1999). The competitive interaction between the two parasitoids also merits a more critical and careful study in areas where the two have been introduced in the light of recent experiences of the dominance of *E. guadeloupae* over *E*. sp. nr. *meritoria* in Tenerife, Taiwan and India.

Besides the aphelinids, Geetha & Swamiappan (2001b) recorded the ectoparasitic mite, *Leptus* sp., on third and fourth instar nymphs to the extent of 3-30%.

Predators

More than 40 indigenous predators, mostly generalists and few host-specific species, have been recorded in India. The major predators are neuropterans (chrysopids, hemerobiids and an unidentified coniopterygid), an apparently new species of nititulid beetle, *Cybocephalus* sp. (Tian Mingyi & S. Ramani, pers. obs.), and several coccinellids. Many coccinellid predators and aphelinid parasitoids (*Encarsia* spp.) were found on whitefly species in Trinidad and some were utilized for classical biological control in Hawaii and other regions (Cock, 1985; Kumashiro *et al*., 1983). Lopez *et al*. (1997b) found three species of the coccinellid *Nephaspis* and a number of generalist predators including syrphids, chrysopids, spiders and ants preying on whitefly in Trinidad and Tobago. The phenomenon of indigenous natural enemies moving onto the

introduced pest has been also observed in Hawaii (Kumashiro *et al*., 1983), Sri Lanka (Wijesekera & Kudagamage, 1990), Indonesia (Kajita *et al*., 1991) and the Canary Islands (Manzano *et al*., 1995).

Cybocephalus sp. was recorded for the first time from Minicoy (Ramani, 2000) and later found commonly occurring in and around Bangalore, in association with the whitefly almost throughout the year, especially at high host densities (PDBC, 2000; Mani & Krishnamoorthy, 2000; PDBC, 2001). *Cybocephalus* spp. are known to be mainly predators of diaspine scales (Blumberg & Swirski, 1982), but some species like *Cybocephalus aleyrodiphagus* Kirejtshuk *et al.* on *Orchamoplatus citri* (Takahashi) (Kirejtshuk *et al*., 1997) and this species have been recorded preying on whiteflies. *Cybocephalus* sp. has also been recorded from Indonesia (Kajita *et al*., 1991). Ahmad (1970) attributes to *Cybocephalus* spp. qualities of value for biological control including a remarkable power of dispersion, long adult life, high reproductive potential and persistence at low prey densities and ranks them next to coccinellids in importance as predators of armoured scales. Kiretjshuk *et al*. (1997) rate *C. aleyrodiphagus* as a highly effective predator of *O. citri* with trends of abundance corresponding well with the prey, indicating a functional response. This new nitidulid, with its close and predominant association with the whitefly, merits detailed study.

Out of the 26 species of coccinellids, the ones commonly found in the spiralling whitefly colonies are *Anegleis cardoni* (Weise), *Anegleis perrotteti* (Mulsant), *Axinoscymnus puttarudriahi* Kapur & Munshi, *Cheilomenes sexmaculata* (F), three species of *Jauravia*, *Nephus regularis* (Sicard), *Pseudoscymnus* sp., *Pseudaspidimerus flaviceps* (Walker) *Pseudaspidimerus trinotatus* (Thunberg), and *Scymnus saciformis* Motschulsky. *Scymnus* sp. was recorded as a common predator in Costa Rica (Metzler & Laprade, 1998). *Axinoscymnus* sp. and *C. sexmaculata* have also been found in Indonesia (Kajita *et al*., 1991) and *A. puttarudriahi* was found feeding on the eggs of the whitefly in Sri Lanka (Wijesekera & Kudagamage, 1990). *Axinoscymnus puttarudriahi* is whitefly-specific and occurs throughout the year. Although members of the tribe Coccinellini are primarily aphidophagous, *Anegleis cardoni* and *A. perrotteti* were found heavily feeding on the whitefly, the latter being predominant.

Mani & Krishnamoorthy (1997) found that the naturalized Australian ladybird beetle, *Cryptolaemus montrouzieri* Mulsant preyed on the whitefly almost throughout the year, but had little effect in reducing the pest population. Mani & Krishnamoorthy (1999b) and Geetha & Swamiappan (2001c) have also studied the predatory potential and developmental period of *C. montrouzieri* on the whitefly in the laboratory. It was also recorded in Hawaii (Paulson & Kumashiro, 1985). *Cryptolaemus montrouzieri* mainly feeds on pseudococcids and may in all probability be an incidental record in mixed infestations of whiteflies and pseudococcids, especially those containing *Ferrisia virgata* (Cockerell). Mani & Krishnamoorthy (1999c) found all stages of *Chilocorus nigrita* (F.) feeding on the whitefly and also observed that the larvae could complete their development exclusively on the whitefly in the laboratory. This record is most likely to be a misidentification of the completely melanic form of *A. perrotteti*, a highly polymorphic species commonly found with *Aleurodicus dispersus*, and also *Chilocorus* spp. are known to be exclusive scale predators. *Curinus coeruleus* (Mulsant) has been recorded feeding on *A. dispersus* in India (Mani *et al*., 2000a; PDBC, 2001) and also in Hawaii (Waterhouse & Norris, 1989) and the Philippines (Villacarlos & Robin, 1992).

Several birds, ants and spiders have also been recorded feeding on *A. dispersus* in India (Gopi *et al*., 2001).

Pathogens

The only pathogen recorded on *A. dispersus* has been *Paecilomyces farinosus* (Holm.) Brown & Smith from areas near Bangalore (Mani *et al*., 2000a; PDBC, 2001).

Interaction between Indigenous Predators and Introduced Parasitoids

The ability of a predator to avoid parasitized prey and select unparasitized prey is a very useful attribute when both are used together in pest management programmes (Hoelmer *et al*., 1994). In laboratory studies by Ramani & Bhumannavar (2002), adults of *Axinoscymnus puttarudriahi* and *Cybocephalus* sp. were able to discriminate between parasitized and unparasitized whitefly nymphs and completely avoided feeding on parasitized nymphs, both in the presence and absence of unparasitized prey, indicating a very favourable interaction between the two. Lopez *et al*. (1997b) found similar results with *Nephaspis bicolor* Gordon. A more careful study is needed to investigate the exact stage of the parasitized whitefly at which this avoidance behaviour is exhibited by the predators, especially when early parasitized whitefly nymphs are present, as has been done for the coccinellid *Delphastus pusillus* (LeConte) on the whitefly *Bemisia tabaci* (Gennadius) parasitized by *Encarsia transvena* (Timberlake) (Hoelmer *et al*., 1994) and *N. bicolor* on whiteflies parasitized by aphelinids (Lopez *et al*., 1997b). In naturally occurring high populations of the spiralling whitefly the predators are more likely to feed among high densities of eggs and early-instar nymphs while the aphelinids oviposit on early-instar nymphs, thus increasing the temporal separation between them and enhancing the use of them in the management of the pest in conjunction with the aphelinid parasitoids. Studies in Hawaii indicated that *Nephaspis* spp. were very effective at high prey densities while the aphelinid parasitoids were effective when the population was small (Kumashiro *et al*., 1983; Yoshida & Mau, 1985), but their combined effect brought about drastic reductions in *Aleurodicus dispersus* populations. There is ample evidence of complementary action of the predators and parasitoids and there is a good potential for integration of both in management programmes for spiralling whitefly.

Conclusion

With the accidental introduction of both species of *Encarsia* into India, a visible reduction in the population of *A. dispersus* has been noticed in Minicoy, Agatti and Kavaratti islands of Lakshadweep, Karnataka and Kerala, similar to that witnessed in Hawaii, Guam and other Pacific islands, West Africa and Tenerife. In south Asia, *A. dispersus* has been reported from Bangladesh, Sri Lanka and the Maldives in addition to India, but the two introduced aphelinid parasitoids have not been so far reported from Sri Lanka and Bangladesh. These parasitoids have done well in areas where the pest has been recently introduced, such as West Africa, as well as where they have been intentionally introduced, such as Tenerife and Taiwan. The impact of the accidental introductions of the parasitoids in conjunction with the indigenous natural enemies, on the whitefly populations has to be carefully assessed in India, before any further introductions are considered.

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