

## Origin, introduction, distribution and management of the invasive spiralling whitefly *Aleurodicus dispersus* Russell in India

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**Abstract:** The spiralling whitefly *Aleurodicus dispersus* Russell poses threat to many crops in India. *Aleurodicus dispersus*, native to Caribbean islands and Central America probably came to India either from Sri Lanka or the Maldives. In India, it was first reported in 1993 at Thiruvananthapuram on tapioca and later from several other parts of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Maharashtra. The pest is highly polyphagous infesting about 280 plant species in India. Eggs are laid in a typical spiral pattern from which the whitefly derives its common name. Nymphs and adults suck the sap from the leaves causing damage to several crops in peninsular India. Development of spiralling whitefly from egg to adult occupies 20 to 30 days. Heavy sporadic rains and cool temperatures result in a temporary reduction in *A. dispersus* population. The population of spiralling whitefly is found to be relatively higher during summer months and the density of the whitefly is positively correlated with maximum temperature and negatively correlated with relative humidity. Application of chemicals like dimethoate, triazophos, monocrotophos, and cultural practices like pruning of the infested plants cause only temporary reduction in the population of spiralling whitefly. Survey revealed the presence of 45 predators and two parasitoids namely *Encarsia guadeloupae* Viggiani and *Encarsia haitiensis* Dozier. Both these accidentally introduced *E. haitiensis* and *E. guadeloupae* are likely to cover all the spiralling whitefly areas and cause remarkable reduction in the population of *A. dispersus* in India as witnessed in other countries.

**Key words:** Spiralling whitefly, *Aleurodiscus dispersus*, management, natural enemies, parasitoid, predators

### Introduction

The spiralling whitefly *Aleurodicus dispersus* Russell poses threat to many agricultural and horticultural crops both in the glasshouse and field conditions in India. *Aleurodicus dispersus*, native to Caribbean islands and Central America, is reported to occur in North America, South America, Asia, Africa, Australia and several Pacific islands (Anon., 2006). In India, it was first recorded in 1993 at Thiruvananthapuram, Kerala on tapioca (Palaniswami *et al.*, 1995) and later in several locations of all the five states in peninsular India (Mani *et al.*, 2001). The whitefly might have been introduced into India from the neighbouring countries like Maldives (Muniappan, 1996) and Sri Lanka (Ranjith *et al.*, 1996). Nymphs and adults suck the sap from the leaves causing damage to several crops particularly cassava, chillies, mulberry, guava, banana, papaya, groundnut etc. in peninsular India (Mani and Krishnamoorthy, 1999a). It is difficult to kill pest with conventional insecticides as they are covered with heavy waxy flocculent materials. But the natural enemies chiefly the parasitoids *Encarsia guadeloupae* Viggiani and *Encarsia (?) haitiensis* Dozier proved to be highly useful in suppressing the spiralling whitefly in Pacific Islands, African and Asian countries (Mani and Krishnamoorthy, 2002). The present paper covers information on various aspects of the work done in India on spiralling whitefly which will be useful to manage the pest.

### Origin and distribution

*Aleurodicus dispersus* is native to the Caribbean islands and Central America. In India, it was first reported in 1993 in Kerala (Palaniswami *et al.*, 1995). Later, it was observed in Tamil Nadu (David and Regu, 1995; Sivaprakasam and Chandramohan, 1997), Karnataka (Mani and Krishnamoorthy,

1996), Andhra Pradesh (Reddy and Chandarkar, 1999), Maharashtra (Sathe, 1999), Lakshadweep islands (Ramani, 2000) and of late Orissa and North East Region. The spiralling whitefly might have been introduced into India from Maldives (Muniappan, 1996) or Sri Lanka (Ranjith *et al.*, 1996). *Aleurodicus dispersus* was found in all the districts except Nilgiris in Tamil Nadu. Intensity of spiralling whitefly was more in Central and Southern Tamil Nadu (Geetha, 2000), while it was found in all the districts of Karnataka (Anon., 2001).

### Biology

Eggs are laid in a typical spiral pattern from which the whitefly derives its common name. Female whitefly lays yellowish white eggs, which hatch in 7 days (Ragumoorthy and Kempraj, 1996) and 4-6 days (Palaniswami *et al.*, 1995) and 5-8 days (Geetha, 2000). Fecundity ranges from 51.8 to 64.06 eggs/female (Mallapanavar, 2000). There are four nymphal instars, which are greenish, white and oval. The duration of first, second, third fourth instar lasts for 2.15-6.50, 2.7-5.00, 2.9- 5.96 days and 6.5- 8.1 days (Geetha, 2000). Fourth instar nymphs are covered with heavy wax material. The total nymphal period normally lasts for 12 to 14 days and pupal period lasts for 2 to 3 days (Palaniswami *et al.*, 1995). Development from egg to adult occupies 18 to 23 days (Palaniswami *et al.*, 1995) and 22.5-29.66 days (Geetha, 2000). Adults are larger with dark reddish brown eyes and fore wings with characteristic dark spots. Adults live for 13 to 22 days (Geetha, 2000).

### Ecology

Heavy sporadic rains and cool temperatures result in a temporary reduction in *A. dispersus* population. Palaniswami *et al.* (1995) reported the outbreaks during the post rainy dry season

between November and April reaching peak in February in Kerala. According to Ranjith *et al.* (1996), the whitefly had increased in number drastically in summer and decreased after the pre-monsoon showers in Kerala. Narayanaswamy and Ramegowda (1999) found high incidence of the pest on mulberry during April-June in and around Bangalore on mulberry. In Karnataka, the population of spiralling whitefly was found to be high during March-June and the density of the white fly was positively correlated with maximum temperature and negatively correlated with relative humidity on guava (Mani and Krishnamoorthy, 2000; Mallapanavar, 2000). Severe infestation was observed during March in the Lakshadweep islands (Ramani, 2000) which decreased with onset of rains. Gopi *et al.* (2001) found the incidence of spiralling whitefly to be higher during November – February in Coimbatore. Similar trend was observed around Pune and Hyderabad (Mani *et al.*, 2000b). Nymphal population was low in June–July and reached peak in November at Shimoga (Aiswariya *et al.*, 2007 b).

In Tamil Nadu, the whitefly population was high during May- October. Parasitism by *Encarsia haitiensis* Dozier, maximum temperature and rainfall had negative association while minimum temperature had positive relationship with spiralling whitefly (Geetha, 2000). The density of the spiralling whitefly was positively correlated with maximum temperature and negatively correlated with relative humidity and the parasitism by *E. guadeloupae* on banana (Mani *et al.*, 2002a). The density of the spiralling whitefly was not significantly correlated with weather factors except morning relative humidity. The partial regression coefficients of the spiralling whitefly and weather factors were also found to be non significant. However there was highly significant and negative relationship between the spiralling whitefly population and the parasitism by *Encarsia* spp. on guava (Mani *et al.*, 2003a).

### Host plants

*Aleurodicus dispersus* is highly polyphagous and is known to attack about 500 plants in different countries (Srinivasa, 2000) and 280 in India alone (Table 1). It was first collected on coconut in Florida (Russell, 1965). In India, the pest was first reported in 1993 on tapioca by Palaniswami *et al.* (1995). *Aleurodicus dispersus* was recorded on the plant species numbering 25 (David and Regu, 1995), 70 (Prathapan, 1996) and 22 (Ranjith *et al.*, 1996) and 45 (Mani and Krishnamoorthy, 1999a), 27 (Gajendra Babu and David, 1999), 53 (Asia Mariam *et al.*, 2000a), 27 (Ramani, 2000), 128 (Geetha and Swamiappan, 2001a), 94 (Muralikrishna, 1999), 102 (Mallapanavar, 2000) and 68 (Srinivasa, 2000) and 99 (Aiswariya *et al.*, 2007a). The host plants highly preferred by *A. dispersus* in India are tuber crop viz., *Manihot esculenta*, vegetables viz., *Capsicum annum*, *Solanum melongena*, *Lycopersicon esculantum*, *Abelmoschus esculentus*, *Cucurbita maxima*, oil seeds viz., *Arachis hypogaea* and *Ricinus communis*, fibre crop *Gossypium* spp, fruit trees viz., *Psidium guajava*, *Carica papaya*, *Musa* spp., *Punica granatum* and *Terminalia catappa*, ornamentals viz., *Rosa indica*, *Hibiscus* spp., *Acalypha indica*, *Poinsettia pulcherrima*

, *Michelia champaca* and shade trees viz. *Ficus religiosa*, *Baunia purpurea*, *Cassia fistula*, *Thespesia populnea*, *Manihot glaziovii* etc. (Geetha, 2000 ).

### Damage

Nymphs and adults congregate generally on the lower surface, but sometimes on the upper surface of leaves of the host plants, stem (cassia) and fruits (papaya) and suck the sap. Geetha (2000) reported premature leaf fall and yellowing of leaves in groundnut in Tamilnadu. Yellow speckling, crinkling and curling of the leaves was noted when the infestation was severe on tapioca (Palaniswami *et al.*, 1995). The injury caused by heavy infestations was usually insufficient to kill the plants (Nambiar, 1997). The copious white, waxy flocculent material secreted by nymphs is readily spread elsewhere by wind and creates a very unsightly nuisance. Furthermore, honeydew is produced which serves as substrate for dense growth of sooty mould, which interfere with photosynthesis. The sticky honeydew carried by wind on the flocculent wax adheres to windows and cars and causes considerable annoyances. Complaints were received for allergies and dermatitis.

In the field, a heavy infestation of spiralling whitefly was observed on groundnut in Tamil Nadu in 1998 (Geetha *et al.*, 1998). In the case of papaya, the fruits were also heavily coated with *A. dispersus*. Severe infestation of spiralling whitefly reduces the quality of banana leaves commonly used to serve the food in all the functions in South India (Mani *et al.*, 2002a). Heavy incidence of spiralling whitefly caused yield reduction up to 53.10% in tapioca in India (Geetha, 2000). Chillies in the field were found damaged by the spiralling whitefly in Kerala (Beevi and Lyla, 2001). Heavy incidence of spiralling whitefly was observed on coconut during March-May 2000 in Maduari ( Razak , 2002) and attack by these pest causes unseasonal leaf fall and consequent yield reduction in rubber (Ranjith, 1996).

### Natural enemies

Natural enemies have been reported on *A. dispersus* in Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra and Lakshadweep islands. As many as 50 natural enemies (3 parasites, 45 predators and 2 pathogens) are known to attack the spiralling whitefly in different locations in India (Table 2).

### Parasitoids

Two parasitoids namely *Encarsia quadeloupae* and *Encarsia* (?) *haitiensis* and a parasitic mite *Leptus* sp. are known to attack *A. dispersus* in India. The two parasitoids might have been accidentally introduced along with the host into India.

### *Encarsia haitiensis*

Adults are yellow coloured and had body length of 0.57 mm and width of 0.26mm. Antennae are eight segmented, both wings are setaceous and legs have a tarsal formula of 5-4-5. The parasitised nymph turns black on 17<sup>th</sup> day of

## Origin, introduction, distribution . . . . .

parasitisation. The total developmental period is 31 days. Adults live for 4-6 days (Geetha, 2000).

### *Encarsia quadeloupae*

Adults are black in colour. They live for 2.7 days. Pupal period was 7.32 days. Adults live for 20 days at 30°C respectively (PDBC, 2001).

### *Leptus* sp.

They are reddish in colour. They are ectoparasites on *A. dispersus* which suck the body fluids. It causes up to 20% parasitism in Coimbatore (Geetha, 2000).

### Predators

A total of 45 species of predators mostly generalists and few host specific have been recorded in India. Predators numbering 22 (Mani *et al.*, 2004), 15 (Geetha, 2000) and 40 species (Ramani, 2000) were known to attack *A. dispersus*.

*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 highest densities (Anon., 2000; Mani & Krishnamoorthy, 1999a; Anon., 2001). Higher number of *Cybocephalus* sp was observed on tapioca at Coimbatore (Geetha, 2000).

Among the coccinellids, *Anegleis cardoni* (Weise), *Anegleis perrotteti* (Mulsant), *Axinoscymnus puttardriahi* Kapur & Munshi, *Cheilomenes sexmaculata* (F), three species of *Jauravia* and *Cryptolaemus montrouzieri* were commonly found in the spiralling whitefly colonies. *Axinoscymnus puttardriahi* is whitefly specific, and occurs throughout the year. *Anegleis cardoni* and *A. perrotteti* were found heavily feeding on the whitefly, the latter being predominant. Mani and Krishnamoorthy (1997b) found that the naturalized Australian ladybird beetle *Cryptolaemus montrouzieri* Mulsant preyed on the whitefly almost throughout the year in many areas in India. Mani and Krishnamoorthy (1999b) found all stages of *Chilocorus nigrita* (F.) feeding on the whitefly. A higher number of *C. nigrita* was found on guava at Coimbatore (Geetha, 2000).

Green lacewings are also commonly associated with the spiralling whiteflies. *Mallada astur* was frequently encountered on *A. dispersus* in several locations in south India. Several birds, ants and spiders have also been recorded feeding on *A. dispersus* in India (Gopi *et al.*, 2001).

### *Cryptolaemus montrouzieri*

The number of nymphs consumed by the first, second, third and fourth instar larva averaged to 23.50, 47.85, 74.60 and 149.80 respectively (Mani and Krishnamoorthy, 1999c). A single larva of *C. montrouzieri* consumed 138.60 eggs and 228 a total of 228 nymphs of *A. dispersus* during its developmental period of 16.60 days. A single adult consumed 89 eggs and 173 nymphs of spiralling whitefly (Geetha and Swamiappan, 2001b).

### *Axinoscymnus puttardriahi*

Eggs hatch in 4 days. Larval and pupal period are 7-8 and 5-6 days respectively. The total lifecycle from egg to adult was 16-18 days. Adults live for 31-47 days and lay 51-134 eggs. A single predator consumes 137.5 spiralling whitefly nymphs (PDBC, 2001).

### *Cybocephalus* sp.

Egg and larval and pupal period are 4, 7-8 and 16-17 days respectively. Adults live for 51-90 days and lay 112 eggs (PDBC, 2001). A single larva consumes 95.36 eggs and 49.13 nymphs of *A. dispersus*, while a single adult preys 41 eggs and 73 nymphs of spiralling whitefly (Geetha, 2000). They have a remarkable power of dispersion, long adult life, high reproductive potential and persistence at low prey densities.

### *Mallada astur*

The mean number of whitefly nymphs preyed by first, second and third instar larvae of *M. astur* was 60.2, 36.4 and 138.3, respectively (Mani and Krishnamoorthy, 1999d). A total of 200 nymphs were consumed by a single larva of *M. astur*. Early instars of *M. aster* prefer to feed on eggs whereas late instars prefer to prey more on nymphs (Geetha, 2000).

### *Oxyopius* sp.

A single spider consumes 949 eggs, 10.60 nymphs and 17.13 adults of *A. dispersus* (Geetha, 2000).

### Pathogens

*Paecilomyces farinosus* (Holms.) was known to infect the nymphs of spiralling whitefly in Bangalore (Mani *et al.*, 2001). The nymphs were found infected with *Verticillium lecanii* Zimm. at Dharwad (Mallappanavar, 2000). *Fusarium semitectum* and *V.lecanii* were known to cause 65-70% and 80-90% mortality of spiralling whitefly (Aiswariya *et al.*, 2007c).

### Management

Management of polyphagous invasive pests like spiralling whitefly becomes all the more difficult because of the multitude of host plants that grow wild in nature and support the build-up of the pests.

**Cultural control:** Use of clean planting material delays the appearance of the whitefly population. Pruning the heavily infested trees and shrubs was recommended to minimise the spiralling whitefly incidence. Subsequent to the pruning the population rapidly increased within 4-5 months on guava (Geetha, 2000).

**Physical control:** Light trap was more appropriate tool for monitoring. A simple method for trapping large number of *A. dispersus* with light traps coated with vaseline was suggested by Srinivasan and Mohanasundaram (1997). Fluorescent light smeared with castor oil attracted and trapped large number of adults (Asia Marium, 1999). Maximum adults were attracted and caught in yellow color sticky trap (Geetha, 2000).

## Origin, introduction, distribution . . . . .

**Chemical control:** Application of chemicals to the lower surface of infested leaves thoroughly reduces the whitefly abundance but temporarily. Tobacco extract (4%) was found effective in minimising the spiralling whitefly (Muralikrishna, 1999). Spraying of neem oil (2%), fish oil rosin soap (4%) and detergent soap solution (5%) reduces the whitefly population (Ranjith, 1996; Asia Mariam, 1999 and Geetha, 2000). Contact insecticides like malathion and carbaryl at 0.10% were also found effective against young nymphs (Ragumoorthi and Kempraj, 1996). Dichlorvos 0.08% was found toxic to various stages of spiralling whitefly (Asia Mariam, 1999). Triazophos 0.08% and phosalone 0.07% were equally effective against spiralling whitefly (Geetha, 2000; Mallapanavar, 2000). Application of neem oil 2% and neem seed kernal extract 3% were found to be effective in suppressing the nymphal and adult whitefly population (Kavitha Kirubavathy et al., 1999). Troazophos at 0.03% was found to be highly effective against spiralling whitefly (Kambrekar and Awaknavar, 2004). Chorpyriphos at 0.04% was found to effective against *A. dispersus* (Dubey and Sundararaj, 2004)

**Biological control:** Pruning the infested plants is only a temporary measure since the reinfestation starts after some time. Though certain chemicals were recommended, there are certain difficulties in managing pest by chemical means. Synthetic insecticides do not adequately control this whitefly since the nymphs are covered with heavy waxy flocculent materials. Only the adults are susceptible to the insecticidal applications. Application of insecticides would temporarily reduce the whitefly abundance. Even if the whitefly is controlled on some plants, there is heavy migration from roadside trees to the cultivated crops. Chemical control is impracticable because of abundance of host plants including extremely large size trees and wide spread distribution. Therefore, alternate methods such as biological control could help in the suppression of *A. dispersus*. As *A. dispersus* is an exotic pest in most countries, classical biological control is considered to be the best option for a sustainable management. The aphelinid parasitoids *Encarsia* (?) *haitiensis* and *Encarsia guadeloupae* have given excellent control of spiralling whitefly in several countries Malaysia, Philippines, Benin, Togo, Ghana, Nigeria Guam, Taiwan, Australia, Hawaii and some other Pacific islands (Waterhouse and Norris, 1989; D'Almeida et al., 1998; Mani and Krishnamoorthy, 2002).

### Biological control attempts in India

The natural predator complex did not have any significant effect on the spiralling whitefly populations as witnessed in many countries. Inundative releases of *Cryptolaemus motrouzieri* and *Mallada astur* against *A. dispersus* had only in temporary reduction of the whiteflies during 1998-1999 in Karnataka (Mani et al., 2001). *Verticillium lecanii* (Zimm) @  $1.33 \times 10^7$  and Verticel @ 7.5 g/l were found to be most effective against spiralling whitefly 7, 15 and 21 days after spraying (Mallapanavar, 2000). Since the indigenous predators and pathogens temporarily reduce population and the parasitoids give excellent control of spiralling whitefly by Project Directorate of Biological control,

Bangalore to introduce *E. guadeloupae* Viggiani and *E. (?) haitiensis* from other countries.

### Survey and exploration

Prior to the introduction of the parasitoids, surveys were carried out by these two institutes. In Minicoy islands, the whitefly nymphs were found parasitised by aphelinids, which were identified later as *Encarsia* (?) *haitiensis* and *E. guadeloupae* (Ramani, 2000). In the mainland, Beevi et al. (1999) recorded *Encarsia* sp. for the first time in January 1998 which was closer to *Encarsia meritoria* Gahan on spiralling whitefly in Thrissur, Kerala. Srinivasa et al. (1999) reported a species of *Encarsia*, which was closely related to *E. haitiensis* and *E. meritoria* on spiralling whitefly in February in Bangalore. Geetha and Swamiappan (2001c) also recorded *Encarsia* sp., which was closer to *E. meritoria* on spiralling whitefly during December 1998 around Coimbatore. *Encarsia species* reported by Srinivasa et al. (1999), Beevi et al. (1999) and Geetha and Swamiappan (2001c) appeared to be *Encarsia* (?) *haitiensis*, which is closely related to or possibly conspecific with, *E. meritoria* (D'Almeida et al., 1998). The exploratory survey carried out around Thrissur and Thiruvananthapuram during February 2000 in Kerala yielded large number of *Encarsia* (?) *haitiensis* (Mani et al., 2000a). Hence it was decided not to import any *Encarsia* species since they were recorded in India itself.

### Colonisation of parasitoids

In India, *Encarsia* spp. were noticed only in 1998 though the spiralling whitefly was reported in 1993 indicating the time lag between the appearance of the spiralling whitefly and *Encarsia* spp. in the new locality. In the absence of parasitoids, the whitefly causes severe damage to many crops. Hence colonization of *Encarsia* (?) *haitiensis* and *E. guadeloupae* helps to spread them at a faster rate to suppress the pest population.

### *Encarsia guadeloupae*

A small consignment of *E. guadeloupae* collected from Lakshadweep was released in March 1999 in Bangalore and recovered indicating its establishment (Ramani, 2000). At Ivarakandapura (Bangalore), a total of 221 adults of *E. guadeloupae* were released during February – March 2000 on guava and the parasitism increased from 14.47 % in February 2000 to 62.74% in June 2000 on guava and poinsettia plants (Mani et al., 2001).

Field studies conducted from January 2000 to December 2001 on banana at Hebbal, Bangalore North indicated that *E. guadeloupae* was found to be the only major natural enemy encountered on the spiralling whitefly causing 20.70% parasitism in January 2000, which had increased to 95.68% by December 2001. Step-wise regression procedure employed to arrive at a multiple regression model which showed that about 67.94% of the whitefly population could be predicted by one factor namely parasitism by *E. guadeloupae* (Mani et al., 2004b). On egg plants, the parasitism by *E. guadeloupae* ranged from 17.85% to 64.27% during February – April 2002 (Mani

Table 1. Host plants of the spiralling whitefly *Aleurodicus dispersus* in India

Family	Plant	State	Reference
Acanthaceae	<i>Barleria cristata</i> L.  <i>Barleria</i> sp. <i>Crossandra undulaefolia</i> Salisb. <i>Crossandra</i> sp. <i>Rhinacanthus</i> sp.	Karnataka  Karnataka Karnataka Tamil Nadu Karnataka Karnataka Kerala	Mani & Krishnamoorthy,1999a Muralikrishna,1999 Mani & Krishnamoorthy,1999a Mani & Krishnamoorthy, 1999a Gajendra Babu&David,1999 Mani & Krishnamoorthy,1999a Mani & Krishnamoorthy,1999a Ranjith <i>et al.</i> ,1996
Amaranthaceae	<i>Amaranthus viridis</i> L.	Karnataka	Srinivasa, 2000
Amoryllidaceae	<i>Gladiolus</i> sp.	Karnataka	Srinivasa, 2000
Anacardiaceae	<i>Anacardium occidentale</i> L. <i>Rhus semialata</i> -Murr.	Tamil Nadu Kerala Karnataka Kerala	David&Regu,1995 Prathapan,1996 Muralikrishna,1999 Palaniswami <i>et al.</i> , 1995
Annonaceae	<i>Artabotrys odoratissimus</i> R.Br. <i>Annona reticulata</i> L. <i>Annona squamosa</i> L.      <i>Polyalthia longifolia</i> (Sonner) Thw.	Karnataka Tamil Nadu Kerala Karnataka Tamil Nadu Andhra Pradesh Kerala Karnataka Lakshadweep Tamil Nadu	Srinivasa, 2000 David & Regu,1995 Ranjith <i>et al.</i> , 1996 Mani & Krishnamoorthy, 1999a Gajendra Babu&David,1999 Geetha, 2000 Mani et al.,2001 Prathapan, 1996 Mani & Krishnamoorthy,1999a Muralikrishna,1999 Ramani, 2000 Gajendra Babu & David,1999
Apiaceae	<i>Centella asiatica</i> Urb	Karnataka	Muralikrishna,1999
Apocynaceae	<i>Nerium indicum</i> Mill <i>Ochrosia</i> sp. <i>Plumeria alba</i> L. <i>Plumeria acuminata</i> Ait. <i>Plumeria rubra</i> L. <i>Thevetia peruviana</i> (Pers.) Merr	Karnataka Lakshadweep Tamil Nadu Kerala Karnataka Andhra Pradesh Lakshadweep Tamil Nadu Lakshadweep Karnataka	Srinivasa, 2000 Ramani, 2000 Geetha, 2000 Prathapan, 1996 Muralikrishna,1999 Mani <i>et al.</i> ,2001 Ramani, 2000 Gajendra Babu & David,1999 Ramani, 2000 Muralikrishna, 1999
Aracaceae	<i>Areca catechu</i> L. <i>Cocos nucifera</i> L.	Karnataka Kerala Tamil Nadu Karnataka Lakshadweep	Srinivasa, 2000 Prathapan, 1996 David & Regu,1995;Geetha,2000 Mani & Krishnamoorthy,1999a Muralikrishna, 1999 Ramani, 2000
Araceae	<i>Colocasia</i> sp. <i>Sundopsis</i> sp.	Karnataka Karnataka	Srinivasa, 2000 Srinivasa, 2000
Asclepidaceae	<i>Asclepias curassavica</i> L. <i>Calotropis gigantean</i> (L)R.Br.	Karnataka Kerala Karnataka Lakshadweep	Muralikrishna, 1999 Prathapan, 1996 Mani & Krishnamoorthy, 1999a Ramani, 2000
Asteraceae	<i>Ageratum conyzoides</i> L. <i>Bidens pilosa</i> L <i>Centratherumanth elminticum</i> O.Kze. <i>Chromolaena adenophorum</i> Spreng. <i>Conyza</i> sp. <i>Dahlia</i> sp. <i>Emilia sonchifolia</i> DC. <i>Solidago canadensis</i> L. <i>Tithonia divaricata</i> Gray. <i>Tridax procumbens</i> L.	Karnataka Lakshadweep Karnataka Kerala, Tamil Nadu Karnataka Kerala Karnataka Karnataka Karnataka Karnataka Kerala, Tamil Nadu	Muralikrishna, 1999 Ramani, 2000 Srinivasa, 2000 David & Regu,1995 Srinivasa, 2000 Ranjith <i>et al.</i> , 1996; Prathapan, 1996 Muralikrishna,1999 Muralikrishna, 1999 Srinivasa, 2000 Srinivasa, 2000 David & Regu, 1995

Balsaminaceae	<i>Impatiens balsamina</i> L.	Kerala	Ranjith <i>et al.</i> , 1996
Bignoniaceae	<i>Bignonia venusta</i> Ker. <i>Stenolobium stans</i> Seem <i>Spathodea companulata</i> Beauv. <i>Tabebuia avellanedae</i> Lorentz <i>Tabebuia rosea</i> D.C. <i>Tabebuia</i> sp. <i>Tecomaria capensis</i> (Spach.) <i>Tecoma smithi</i> X.Hor. <i>Tecoma stans</i> (L.)H.B&K	Karnataka Tamil Nadu Karnataka Karnataka Karnataka Kerala Karnataka Karnataka	Srinivasa, 2000 Gajendra Babu & David,1999 Muralikrishna, 1999 Srinivasa, 2000 Mani & Krishnamoorthy, 1999a Srinivasa, 2000 Prathapan, 1996 Srinivasa, 2000 Srinivasa, 2000 Mani & Krishnamoorthy, 1999a
Bixaceae	<i>Bixa orellana</i> L.	Kerala Karnataka	Prathapan, 1996 Muralikrishna, 1999
Bombacaceae	<i>Bombax ceiba</i> L. <i>Bombax ellipticum</i> H.B&K <i>Pachira insignis</i> Bourd.	Karnataka Karnataka Karnataka	Muralikrishna, 1999 Srinivasa, 2000 Srinivasa, 2000
Boraginaceae	<i>Cordia myxa</i> Roxb. <i>Cordia oblique</i> auct.non.Willd. <i>Cordia</i> sp.	Karnataka Karnataka Karnataka	Muralikrishna, 1999 Muralikrishna, 1999 Srinivasa, 2000
Burseraceae	<i>Garuga pinnata</i> Roxb.	Karnataka	Muralikrishna, 1999
Cannaceae	<i>Canna indica</i> L.	Kerala; Tamil Nadu Karnataka Andhra Pradesh Maharashtra	David & Regu, 1995 Mani & Krishnamoorthy, 1999a; Muralikrishna, 1999 Mani <i>et al.</i> , 2001 Mani <i>et al.</i> , 2003a
Capparaceae	<i>Cleome gynandra</i> L.	Lakshadweep	Ramani, 2000
Caricaceae	<i>Carica papaya</i> L.	Kerala, Tamil Nadu Karnataka Lakshadweep	Prathapan, 1996; Mani&Krishnamoorthy,1999a Geetha,2000 Muralikrishna,1999; Ramani, 2000
Clusiaceae	<i>Calophyllum</i> sp. <i>Grcinia indica</i> Choisy	Kerala Kerala	Palaniswami <i>et al.</i> ,1995 Ranjith <i>et al.</i> , 1996
Combretaceae	<i>Calycopteris floribunda</i> Lam. <i>Quisqualis indica</i> L.  <i>Terminalia catappa</i> L.  <i>Thottea siliquosa</i> (Lam) Ding Hou.	Kerala Kerala Tamil Nadu Karnataka Kerala Tamil Nadu Karnataka Lakshadweep Karnataka	Prathapan, 1996 Prathapan, 1996; Ranjith <i>et al.</i> , 1996 David & Regu,1995 Muralikrishna, 1999 Prathapan, 1996 David & Regu,1995;Geetha,2000 Mani & Krishnamoorthy, 1999a Muralikrishna, 1999 Ramani, 2000 Muralikrishna, 1999
Convolvulaceae	<i>Argyreia cuneata</i> Ker-Gawler <i>Ipomoea batatas</i> (L.) Lam. <i>Ipomoea cairica</i> (L.) Sw <i>Ipomoea muricata</i> (L.) Jacq. <i>Ipomoea obscura</i> (L.) <i>Ipomoea palmate</i> Forsk. <i>Ipomoea obscura</i> (L.) K-G <i>Rivea</i> sp.	Karnataka Karnataka Karnataka Kerala Karnataka Tamil Nadu Karnataka Tamil Nadu Karnataka	Srinivasa, 2000 Muralikrishna, 1999 Srinivasa, 2000 Prathapan, 1996 Muralikrishna, 1999 Gajendra Babu & David,1999 Mani & Krishnamoorthy, 1999a Gajendra Babu & David,1999 Srinivasa, 2000

*Origin, introduction, distribution* . . . . .

Cucurbitaceae	<i>Benincasa hispida</i> (Thumb) Cogn. <i>Coccinia grandis</i> (L.) Voigt <i>Coccinia indica</i> W. & A. <i>Cucumis anguria</i> Rodsch <i>Cucumis</i> sp. <i>Cucurbita maxima</i> Duch. <i>Lagenaria siceraria</i> (Molina) Stand <i>Momordica charantia</i> L.	Karnataka Karnataka Kerala Karnataka Karnataka Karnataka Karnataka	Muralikrishna, 1999 Muralikrishna, 1999 Prathapan, 1996 Srinivasa, 2000 Srinivasa, 2000 Muralikrishna, 1999 Muralikrishna, 1999 Srinivasa, 2000
Cycadaceae	<i>Cycas</i> sp.	Karnataka	Srinivasa, 2000
Dilleniaceae	<i>Dillenia indica</i> L.  <i>Dillenia pentagyna</i> Roxb.	Karnataka Tamil Nadu Kerala Karnataka	Muralikrishna, 1999 Gajendra Babu & David, 1999 Prathapan, 1996 Muralikrishna, 1999
Ebenaceae	<i>Diospyros philippensis</i> Gurke.	Tamil Nadu	Gajendra Babu & David, 1999
Euphorbiaceae	<i>Acalypha godseffiana</i> Masters. <i>Acalypha hispida</i> Burm.f. <i>Acalypha indica</i> L. <i>Acalypha wilkesiana</i> M Arg. <i>Acalypha</i> sp. <i>Aleurites trisperma</i> Blanco <i>Bridelia retusa</i> Spreng <i>Breynia patens</i> Rolfe. <i>Codiaeum variegatum</i> Blume Bijid. <i>Croton sparsiflorus</i> Morong <i>Embllica officinalis</i> Gaertn <i>Euphorbia fulgens</i> Karw. <i>Euphorbia geniculata</i> Ort. <i>Euphorbia pulcherrima</i> Willd <i>Euphorbia</i> sp. <i>Excoecaria agallocha</i> L. <i>Jatropha podagrica</i> Hook <i>Jatropha</i> sp. <i>Jatropha multifida</i> L. <i>Macaranga peltata</i> M. <i>Mallotus philippinensis</i> (Lam) Muell <i>Manihot esculenta</i> Crantz. <i>Manihot glaziovii</i> Muel. <i>Manihot</i> sp. <i>Richinus communis</i> L. <i>Sauropus androgynus</i> Merr. <i>Sauropus</i> sp.	Kerala Karnataka Kerala Karnataka Lakshadweep Tamil Nadu Karnataka Tamil Nadu Kerala, Tamil Nadu Karnataka Kerala Karnataka Karnataka Lakshadweep Karnataka Tamil Nadu Kerala Kerala Kerala Karnataka Karnataka Kerala Karnataka Kerala Tamil Nadu Kerala Karnataka Tamil Nadu Kerala, Karnataka Kerala Karnataka Tamil Nadu Karnataka Tamil Nadu Kerala, Karnataka Lakshadweep Tamil Nadu Kerala Karnataka	Ranjith <i>et al.</i> , 1996 Mani & Krishnamoorthy, 1999a; Muralikrishna, 1999 Prathapan, 1996; Muralikrishna, 1999 Ramani, 2000 Geetha, 2000 Muralikrishna, 1999 Gajendra Babu & David, 1999 David & Regu, 1995 Srinivasa, 2000 Prathapan, 1996 Muralikrishna, 1999 Srinivasa, 2000 Ramani, 2000 Mani & Krishnamoorthy, 1999a Geetha, 2000 Prathapan, 1996 Prathapan, 1996 Prathapan, 1996 Mani & Krishnamoorthy, 1999a Srinivasa, 2000 Prathapan, 1996 Srinivasa, 2000 Prathapan, 1996; Gajendra Babu & David, 1999 Prathapan, 1996; Ranjith <i>et al.</i> , 1996 Muralikrishna, 1999 Ragumoorthy and Kemprij, 1996; Geetha, 2000 Prathapan, 1996, Palaniswami <i>et al.</i> , 1995 Muralikrishna, 1999 Prathapan, 1996 Mani & Krishnamoorthy, 1999a Muralikrishna, 1999 Geetha, 2000 Srinivasa, 2000 Geetha, 2000 Prathapan, 1996 Mani & Krishnamoorthy, 1999a Muralikrishna, 1999 Ramani, 2000 Geetha, 2000 Prathapan, 1996; Ranjith <i>et al.</i> , 1996 Srinivasa, 2000

Origin, introduction, distribution . . . . .

Fabaceae	<i>Adenantha farnesiana</i> Willd.	Karnataka	Srinivasa, 2000
	<i>Adenantha pavonina</i> L.	Tamil Nadu	Gajendra Babu&David,1999
	<i>Arachis hypogaea</i> L.	Kerala	
	<i>Bauhinia acuminata</i> L.	Karnataka	Geetha <i>et al.</i> , 1998
	<i>Bauhinia malabarica</i> Roxb.	Karnataka	Ranjith <i>et al.</i> , 1996
	<i>Bauhinia purpurea</i> L.	Tamil Nadu	
		Karnataka	Muralikrishna, 1999
	<i>Bauhinia recemosa</i> Lam.	Karnataka	Mani & Krishnamoorthy, 1999a;
	<i>Bauhinia variegata</i> L.	Karnataka	Muralikrishna, 1999
	<i>Bauhinia</i> sp.	Tamil Nadu	Geetha
		Kerala	Muralikrishna, 1999
	<i>Butea monosperma</i> (Lemk) Taub.	Karnataka	
	<i>Caesalpinia pulcherrima</i> Swartz	Tamil Nadu	Muralikrishna, 1999
	<i>Cajanus cajan</i> (L.) Milsp.	Karnataka	Sunderaraj <i>et al.</i> ,2000
		Kerala	Gajendra Babu & David, 1999
	<i>Calliandra</i> sp.	Karnataka	Srinivasa, 2000
	<i>Calopogonium mucunoides</i> Desv.	Karnataka	Mani & Krishnamoorthy,1999a
	<i>Cassia fistula</i> L.	Karnataka	Gajendra Babu & David,1999
	<i>Cassia spectabilis</i> DC. Cat.	Karnataka	Prathapan, 1996;
	<i>Clitoria ternatea</i> L.	Karnataka	Muralikrishna, 1999
	<i>Crotalaria juncea</i> L.		Geetha, 2000
	<i>Dalbergia sissoo</i> Roxb.	Lakshadweep	Srinivasa, 2000
	<i>Desmodium</i> sp.		Prathapan, 1996
	<i>Erythrina umbrosa</i> H.B.&K.	Kerala	Mani & Krishnamoorthy,1999a;
	<i>Erythrina variegata</i> L.	Karnataka	Muralikrishna, 1999
	<i>Gliricidia maculata</i> L.	Tamil Nadu	Srinivasa, 2000
	<i>Glycine max</i> L.	Lakshdweep	
	<i>Gliricidia sepium</i> (Jacq.) Kunth	Karnataka	Muralikrishna, 1999
	<i>Gliricidia</i> sp.	Tamil Nadu	Muralikrishna, 1999
	<i>Inga laurina</i> Willd.	Kerala	Srinivasa, 2000
	<i>Lablab niger</i> Medic.		
	<i>Lablab typicus</i> L.	Tamil Nadu	Ramani, 2000
	<i>Leucaena leucocephala</i> (Lmk)De Wit	Kerala	Ranjith <i>et al.</i> , 1996; Muralikrishna, 1999
	<i>Mucuna pruriens</i> Dc.		Ramani, 2000
	<i>Peltophorum ferruginea</i> Benth.	Karnataka	Ranjith <i>et al.</i> , 1996;
		Karnataka	Muralikrishna, 1999
	<i>Phaseolus vulgaris</i> L.		Geetha, 2000
	<i>Pithecolobium dulce</i> Benth.		Ramani, 2000
	<i>Pongamia pinnata</i> (L.) Pierre	Karnataka	Srinivasa, 2000
			Gajendra Babu & David,1999
	<i>Pterocarpus marsupium</i> Roxb.	Kerala	David & Regu, 1995
	<i>Samanea saman</i> (Jacq.)Merr.	Tamil Nadu	
	<i>Sesbania grandiflora</i> Pers	Kerala	Geetha, 2000
	<i>Tipuana tipu</i> Benth.	Karnataka	Palaniswami <i>et al.</i> , 1995
		Tamil Nadu	Srinivasa, 2000
		Karnataka	
		Kerala Karnataka	Mani & Krishnamoorthy,1999a
		Karnataka	
		Karnataka	Srinivasa, 2000
			Prathapan, 1996
			Gajendra Babu & David,1999
			Prathapan, 1996
			Mani & Krishnamoorthy,1999a
			Muralikrishna, 1999

Geraniaceae	<i>Geranium</i> sp. <i>Impatiens balsamina</i> L. <i>Impatiens</i> sp.	Karnataka Karnataka Karnataka	Srinivasa, 2000 Srinivasa, 2000 Srinivasa, 2000
Lamiaceae	<i>Ocimum basilicum</i> L. <i>Ocimum sanctum</i> L. <i>Pentas lanceolatus</i> (Forsk.)Deflers <i>Salvia</i> sp.	Kerala Kerala Karnataka Kerala	Palaniswami <i>et al.</i> , 1995 Palaniswami <i>et al.</i> , 1995 Srinivasa, 2000 Prathapan, 1996
Lecythidaceae	<i>Careya arborea</i> Roxb. <i>Couroupita guianensis</i> Aub.	Kerala Tamil Nadu Karnataka	Prathapan, 1996 David & Regu, 1995 Srinivasa, 2000
Leeaceae	<i>Leea indica</i> (Burm.f.) Merr. <i>Leea macrophylla</i> Roxb.	Karnataka  Karnataka	Muralikrishna, 1999  Muralikrishna, 1999
Loranthaceae	<i>Dendrophthoe falcate</i> (L.f.) Ettingsh	Karnataka	Srinivasa, 2000
Lythraceae	<i>Lagerstroemia</i> sp. <i>Lagerstroemia indica</i> L. <i>Lagerstroemia purpuria</i> <i>Lagerstroemia tomentosa</i> Presl <i>Lawsonia inermis</i> L. <i>Woodfordia floribunda</i> Salisb	Tamil Nadu Karnataka Karnataka Karnataka Karnataka Karnataka	Gajendra Babu & David,1999 Srinivasa, 2000 Srinivasa, 2000 Srinivasa, 2000 Muralikrishna, 1999 Srinivasa, 2000
Magnoliaceae	<i>Magnolia fuscata</i> Andr. <i>Michelia champaca</i> L.  <i>Michelia nilagirica</i> Zenk.	Karnataka Kerala Tamil Nadu Karnataka Karnataka	Srinivasa, 2000 David & Regu, 1995; Mani & Krishnamoorthy, 1999a; Muralikrishna, 1999 Muralikrishna, 1999
Malvaceae	<i>Abelmoschus esculentus</i> (L.) Moench <i>Abutilon indicum</i> Sweet <i>Althea rosea</i> Hohen. <i>Dombeya spectabilis</i> Boj. <i>Gossypium hirsutum</i> L. <i>Hibiscus radiatus</i> L.  <i>Hibiscus rosinensis</i> L.  <i>Hibiscus tiliaceus</i> L. <i>Hibiscus</i> sp.  <i>Malvaviscus arboreus</i> L. <i>Sida acuta</i> Burm. <i>Sida</i> sp. <i>Thespesia populnea</i> (L.)Carr. <i>Urena lobata</i> L.	Kerala Tamil Nadu Karnataka Karnataka Tamil Nadu Karnataka Tamil Nadu Karnataka Kerala Tamil Nadu, Karnataka Lakshadweep Karnataka Lakshadweep Karnataka Kerala Kerala Karnataka Kerala Kerala Karnataka Tamil Nadu Kerala	Palaniswami <i>et al.</i> , 1995 Geetha, 2000 Mani & Krishnamoorthy,1999a Srinivasa, 2000 Geetha <i>et al.</i> , 1999 Mani & Krishnamoorthy,1999a Geetha, 2000 Muralikrishna, 1999 David & Regu, 1995 Mani & Krishnamoorthy,1999a Muralikrishna,1999 Ramani, 2000 Mani & Krishnamoorthy,1999a Ramani, 2000 Srinivasa, 2000 Palaniswami <i>et al.</i> , 1995 Prathapan, 1996 Muralikrishna, 1999 Prathapan, 1996 Prathapan, 1996 Muralikrishna, 1999 Geetha, 2000 Prathapan, 1996; Ranjith <i>et al.</i> , 1996
Meliaceae	<i>Azadirachta indica</i> Juss. <i>Dysoxylum alliaceum</i> BL.	Lakshadweep Karnataka	Ramani, 2000 Srinivasa, 2000

Origin, introduction, distribution . . . . .

Menispermaceae	<i>Cocculus hirsutus</i> Diels <i>Tinospora cordifolia</i> (Wild) H & T	Karnataka Karnataka	Srinivasa, 2000 Srinivasa, 2000
Moraceae	<i>Artocarpus communis</i> Forst. <i>Artocarpus heterophyllus</i> Lam <i>Artocarpus hirsutus</i> Lam <i>Ficus benghalensis</i> L.  <i>Ficus carica</i> L.  <i>Ficus elastica</i> Roxb  <i>Ficus gibbosa</i> Bl. <i>Ficus glomerata</i> Roxb. <i>Ficus pandrata</i> Sander <i>Ficus recemosa</i> L. <i>Ficus religiosa</i> L.  <i>Ficus repens</i> Roxb. <i>Ficus</i> sp.  <i>Morus alba</i> L.  <i>Streblus asper</i> Lour	Lakshadweep  Kerala Karnataka Karnataka Lakshadweep Tamil Nadu Tamil Nadu Karnataka Kerala Karnataka Kerala Tamil Nadu Karnataka  Karnataka Kerala Karnataka Karnataka Karnataka Kerala Tamil Nadu  Lakshadweep Karnataka	Ramani, 2000  Ranjith <i>et al.</i> , 1996 Muralikrishna, 1999 Prathapan, 1996 Muralikrishna, 1999 Mani & Krishnamoorthy, 1999a Ramani, 2000 Geetha, 2000 Geetha, 2000 Muralikrishna, 1999 Prathapan, 1996 Muralikrishna, 1999 Prathapan, 1996 Prathapan, 1996 Gajendra Babu & David, 1999 Srinivasa, 2000 Muralikrishna, 1999 Prathapan, 1996 Muralikrishna, 1999 Prathapan, 1996 Srinivasa, 2000 Palaniswami <i>et al.</i> , 1995 Ramani, 2000 David & Regu, 1995, Sivaprakasam & Chandramohan, 1997 Ramani, 2000 Muralikrishna, 1999
Moringaceae	<i>Moringa oleifera</i> Lam. <i>Moringa</i> sp.	Karnataka Karnataka	Srinivasa, 2000 Muralikrishna, 1999
Musaceae	<i>Heliconia rostrata</i> Ruis & Pav. <i>Heliconia</i> sp. <i>Musa paradisiaca</i> L.  <i>Musa</i> sp.	Kerala Karnataka Kerala, Karnataka Lakshadweep Karnataka, Kerala	Ranjith <i>et al.</i> , 1996 Srinivasa, 2000 David & Regu, 1995; Muralikrishna, 1999 Ramani, 2000 Mani & Krishnamoorthy, 1999a Palaniswami <i>et al.</i> , 1995, Prathapan, 1996
Myrtaceae	<i>Callistemon cuandra</i> <i>Eucalyptus</i> sp. <i>Eugenia benthaminana</i> W <i>Psidium guajava</i> L.  <i>Syzygium aqueum</i> L. <i>Syzygium cumini</i> (L.) Skeels. <i>Syzygium jambos</i> (L) Alst. <i>Syzygium</i> sp.	Karnataka Karnataka Karnataka Karnataka Tamil Nadu Lakshadweep Kerala Karnataka Karnataka	Srinivasa, 2000 Muralikrishna, 1999 Muralikrishna, 1999 Mani & Krishnamoorthy, 1999a, Muralikrishna, 1999 Gajendra Babu & David, 1999 Ramani, 2000 Prathapan, 1996 Mani & Krishnamoorthy, 1999a Mani & Krishnamoorthy, 1999a
Nyctaginaceae	<i>Bougainvillea</i> sp.	Karnataka	Srinivasa, 2000
Oleaceae	<i>Jasminum grandiflorum</i> L. <i>Jasminum</i> sp.	Karnataka Kerala	Mani & Krishnamoorthy, 1999a Palaniswami <i>et al.</i> , 1995
Piperaceae	<i>Piper betel</i> L. <i>Piper nigrum</i> L.	Karnataka Kerala	Srinivasa, 2000 Ranjith <i>et al.</i> , 1996
Plumbaginaceae	<i>Plumbago zeylanica</i> L.	Kerala, Karnataka	Prathapan, 1996 Muralikrishna, 1999
Polygonaceae	<i>Antigonon leptopus</i> Hook. & Arn.	Kerala Lakshadweep	Prathapan, 1996; Ramani, 2000
Punicaceae	<i>Punica granatum</i> L.	Karnataka  Tamil Nadu	Mani & Krishnamoorthy, 1999a; Muralikrishna, 1999 Gajendra Babu & David, 1999

Rhamanaceae	<i>Zizyphus mauritiana</i> Lamk. <i>Zizyphus oenoplia</i> Mill.	Kerala	Prathapan, 1996
		Kerala	Prathapan, 1996
Rosaceae	<i>Rosa indica</i> Lindl.	Kerala Tamil Nadu Karnataka Karnataka Tamil Nadu	David & Regu, 1995 Palaniswami <i>et al.</i> , 1995 Mani & Krishnamoorthy, 1999a Muralikrishna, 1999 Gajendra Babu & David, 1999
	<i>Rosa</i> sp.		
Rubiaceae	<i>Coffea arabica</i> L.	Karnataka	Srinivasa, 2000
	<i>Morinda</i> sp.	Karnataka	Srinivasa, 2000
Rutaceae	<i>Citrus aurantifolia</i> (chistm.) Swingle	Tamil Nadu	Gajendra Babu & David, 1999
	<i>Citrus paradisi</i> Macfad	Tamil Nadu	Gajendra Babu & David, 1999
	<i>Citrus sinensis</i> (L.) Osbeck.	Tamil Nadu	Gajendra Babu & David, 1999
	<i>Citrus</i> sp.		
	<i>Murraya exotica</i> L. <i>Murraya koenigii</i> (L.) Spreng	Kerala Tamil Nadu Tamil Nadu Kerala Karnataka	Palaniswami <i>et al.</i> , 1995 Gajendra Babu & David, 1999 Gajendra Babu & David, 1999 Ranjith <i>et al.</i> , 1996 Mani & Krishnamoorthy, 1999a Muralikrishna, 1999
Salicaceae	<i>Salix babylonica</i> L.	Tamil Nadu	Gajendra Babu & David, 1999
Santalaceae	<i>Santalum album</i> L.	Kerala Karnataka	Prathapan, 1996 Mani & Krishnamoorthy, 1999a Muralikrishna, 1999 Gajendra Babu & David, 1999
		Tamil Nadu	
Sapindaceae	<i>Cardiospermum halicacabum</i> L.	Kerala	Prathapan, 1996
	<i>Felicium decipines</i> L.	Karnataka	Muralikrishna, 1999 Mani & Krishnamoorthy, 1999a Srinivasa, 2000
	<i>Nephelium logana</i> Camb.	Karnataka	
	<i>Schleichera trijuga</i> Willd.	Karnataka	Srinivasa, 2000
Sapotaceae	<i>Achras sapota</i> L	Karnataka Kerala Kerala	Srinivasa, 2000 Palaniswami <i>et al.</i> , 1995 Prathapan, 1996
	<i>Chrysophyllum cainito</i> L.		
Simaroubaceae	<i>Ailanthus excelsa</i> Roxb.	Karnataka	Muralikrishna, 1999
	<i>Ailanthus malabarica</i> Roxb.		
	<i>Simarouba glauca</i> DC.	Tamil Nadu Kerala Karnataka Karnataka	Gajendra Babu & David, 1999 Prathapan, 1996 Muralikrishna, 1999 Srinivasa, 2000

*et al.*, 2003a). Release of *Encarsia guadeloupae* on the plants infested with whitefly (Mani *et al.*, 2001) resulted in its establishment around Hyderabad in 2000 (Mani *et al.*, 2003b).

*Encarsia guadeloupae* was released in Devarahalli and Linganaahalli in Karnataka and Madanapalli in Andhra Pradesh during 2002-2003 (PDBC, 2003). The parasitism went up to 96% on rose, 86.45 on Hibiscus, 90.4% on poinsettia and 39.86% on acalypha (Mani and Krishnamoorthy, 2006).

#### *Encarsia haitiensis*

*Encarsia haitiensis* was not present on the plants

infested with spiralling whitefly at Bangalore North as on February 2000. Inoculative release of 187 *E. haitiensis* adults was made on guava. A steady decline in the population of spiralling whitefly was observed, and a very low level of 3.40/leaf was recorded during February 2003 (Fig.1). *Encarsia haitiensis* was found to be the only major natural enemy encountered initially up to October 2000, which was replaced steadily later by *E. guadeloupae* on the spiralling whitefly. A mean of 28.92% parasitism was observed in March 2000 following the release of *E. haitiensis*, and the parasitism steadily increased up to 92.52% by February 2003. There was highly significant and negative relationship ( $r = -0.837$ ) between the spiralling

Solanaceae	<i>Capsicum annuum</i> L.  <i>Capsicum frutescens</i> L.  <i>Capsicum</i> sp. <i>Datura stramonium</i> L. <i>Datura</i> sp. <i>Lycopersicum esculentum</i> Hill <i>Physalis minima</i> L. <i>Solanum melongena</i> L.  <i>Solanum nigrum</i> L. <i>Solanum trilobatum</i> L. <i>Solanum torvum</i> Sw. <i>Solanum seaforthianum</i> Andr. <i>Solanum</i> sp.	Kerala,  Karnataka  Lakshadweep Tamil Nadu Kerala Karnataka Karnataka Karnataka  Kerala Karnataka Tamil Nadu Kerala  Kerala  Karnataka, Tamil Nadu Lakshadweep Kerala  Tamil Nadu Karnataka Karnataka Kerala Tamil Nadu	Prathapan,1996; Palaniswami <i>et al.</i> , 1995 Mani & rishnamoorthy,1999a, Muralikrishna,1999 Ramani, 2000 Geetha, 2000 Prathapan, 1996 Muralikrishna, 1999 Ramani, 2000 Srinivasa, 2000 Muralikrishna, 1999  Prathapan, 1996 Mani & Krishnamoorthy,1999a Geetha, 2000 Ranjith <i>et al.</i> , 1996  Prathapan,1996;Palaniswami <i>et al.</i> , 1995 Muralikrishna, 1999 Geetha, 2000 Ramani, 2000 Prathapan, 1996  Geetha <i>et al.</i> , 1999 Muralikrishna, 1999 Srinivasa, 2000  David & Regu, 1995
Sterculiaceae	<i>Browsonetia papyrifolia</i> (L.)L'Her <i>Guazuma tomentosa</i> Kunth <i>Helicteres isora</i> L.	Karnataka  Karnataka  Karnataka	Srinivasa, 2000  Srinivasa, 2000  Muralikrishna, 1999
Tiliaceae	<i>Grewia tiliaefolia</i> Vahl	Tamil Nadu	Gajendra Babu & David,1999
Verbenaceae	<i>Callicarpa</i> sp. <i>Clerodendrum thomsonae</i> Balf. <i>Holmskioldia sanguinea</i> Retz. <i>Lantana</i> sp. <i>Lantana camara</i> L. <i>Petrea volubilis</i> L. <i>Tectona grandis</i> L.  <i>Vitex altissima</i> L.f.  <i>Vitex negundo</i> L.	Karnataka Kerala Karnataka Tamil Nadu Karnataka  Karnataka Tamil Nadu Kerala Karnataka Tamil Nadu Kerala Tamil Nadu	Srinivasa, 2000 Prathapan, 1996 Srinivasa, 2000 Gajendra Babu & David,1999 Srinivasa, 2000 Muralikrishna, 1999 Geetha, 2000 Prathapan, 1996 Muralikrishna, 1999 Geetha, 2000 Prathapan, 1996 Gajendra Babu & David,1999 David & Regu, 1995
Vitaceae	<i>Vitis vinifera</i> L.	Tamil Nadu	Geetha, 2000
Zingiberaceae	<i>Hedychium coronarium</i> Koen	Karnataka	Srinivasa, 2000

whitefly population and the parasitism by *Encarsia* spp. Step-wise regression procedure employed to arrive at a multiple regression model which showed that about 70% of the whitefly population could be predicted by one factor namely parasitism by *Encarsia* spp. which played a major role in suppressing the spiralling whitefly( Mani *et al.*,2004b). Periodic releases of *Encarsia* (?) *haitiensis* resulted in 81.1% parasitism around Coimbatore in January 2000 (Geetha, 2000). In Minicoy, the whitefly nymphs on papaya and castor were parasitised by

*Encarsia* (?) *haitiensis* and *E. guadeloupae*, the latter comprised nearly 60% of parasitoids found in these islands. During March 2000, the two aphelinids were abundant on the spiralling whitefly in Minicoy, Amini, Kadmath islands. During March 2000, the parasitism went up to 92.4% on papaya and 59.40% parasitism on tapioca (Ramani, 2000).

#### Extent of spread of *Encarsia* spp.

The survey conducted in South India during January

Table 2. Natural enemies of *Aleurodicus dispersus* in India

Natural enemies	Family & Order	Reference
<b>Parasitoids</b>		
<i>Encarsia haitiensis</i> Dozier (= <i>Encarsia meritoria</i> Gahan)	Aphelinidae Hymenoptera	Anon., (2000) Srinivasa <i>et al.</i> (1999); Beevi <i>et al.</i> (1999); Mani <i>et al.</i> (2001); Geetha & Swamiappan, 2001c)
<i>Encarsia guadeloupae</i> Viggiani	„	(1999, 2002); Mani <i>et al.</i> (2001); Beevi <i>et al.</i> (2001)
<i>Leptus</i> sp.	Erythraeidae Acarina	Geetha & Swamiappan (2001c)
<b>Predators</b>		
<i>Axinoscymnus puttarudiahii</i> Kapur and Munshi	Coccinellidae, Coleoptera	Mani & Krishnamoorthy (1999a,c) Asia Mariam (1999); Muralikrishna (1999)
<i>Curinus coeruleus</i> Muls.	„	Mani <i>et al.</i> (2001)
<i>Horniolus</i> sp.	„	Anon., (2002)
<i>Cheilomenes sexmaculata</i> (Fab.)	„	Palaniswami <i>et al.</i> (1995) Mani & Krishnamoorthy (1999a) Asia Mariam (1999); Muralikrishna (1999) Geetha (2000)
<i>Cryptolaemus montrouzieri</i> Muls	„	Mani & Krishnamoorthy (1999a) Muralikrishna (1999) Geetha (2000)
<i>Chilocorus nigrata</i> (Fab.)	„	Mani & Krishnamoorthy (1999b) Geetha (2000)
<i>Anegleis cardoni</i> (Wiese)	„	Mani <i>et al.</i> (2001) Asia Mariam (1999); Geetha (2000)
<i>Anegleis perrotteti</i> (Muls.)	„	Anon. (2002)
<i>Jauravia dorsalis</i> (Wise.)	„	Anon. (2002)
<i>Jauravia pallidula</i> Motseh.	„	Anon. (2002)
<i>Rodolia amabilis</i> Kapur	„	Anon. (2002)
<i>Rodolia breviscula</i> Weise	„	Anon. (2002) Geetha (2000)
<i>Rodolia fumida</i> Mulsant	„	Anon. (2002); Geetha (2000)
<i>Serangium parcesetosum</i> Sic	„	Mani <i>et al.</i> (2000a); PDBC (1999)
<i>Nephus regularis</i> Sic,	“	Anon. (2001)
<i>Scymnus</i> sp.	„	Anon. (1999)
<i>Pseudoscymnus</i> sp.	„	Anon. (2000)
<i>Keiscymnus</i> sp.	„	Anon. (2000)
<i>Scymnus coccivora</i> Ayyar	„	Anon. (2002)
<i>Scymnus latemaculatus</i> Motsch.	„	Anon. (2002); Geetha (2000)
<i>Scymnus posticalis</i> Sic	„	Anon. (2002)
<i>Scymnus saciformis</i> Motsch.	„	Anon. (2002)
<i>Scymnus nubilus</i> Muls.	„	Anon. (1999)
<i>Pseudaspidimerus flaviceps</i> (Walk.)	„	Anon. (2002)
<i>Pseudaspidimerus trinotatus</i> (Walk.)	„	Anon. (2001)

Origin, introduction, distribution . . . . .

<i>Cybocephalus</i> sp.	Nitidulidae Coleoptera	Mani & Krishnamoorthy (2001) Muralikrishna (1999) Geetha (2000)
<i>Mallada astur</i> (Banks)	Chrysopidae Neuroptera	Mani & Krishnamoorthy (1977c) Asia Mariam(1999); Geetha (2000)
<i>Apertochrysa</i> sp.	„	Mani & Krishnamoorthy (1999a)
		Geetha <i>et al.</i> (1999)
<i>Nobilinus</i> sp.	„	Mani & Krishnamoorthy (1999a)
<i>Mallada boninensis</i> (Okomato)	„	Mani & Krishnamoorthy (1999a)
<i>Chrsoperla carnea</i> (Steph)	„	Geetha <i>et al.</i> (2000)
<i>Symherobius barberi</i> (Banks)	Hemerobiidae Neuroptera	Paulson & Kumashiro (1985)
<i>Hemerobius</i> sp.	„	Mani <i>et al.</i> (2001)
<i>Notiobiella viridinervis</i> Banks	„	Mani <i>et al.</i> (2001)
<i>Leucopsis</i> sp.	Chamaemyiidae Diptera	Anon. (2000)
<i>Triommato coccdivora</i> (Felt)	Cecidomiidae, Diptera	Mani & Krishnamoorthy (1999a)
<i>Acletoxenus indicus</i> Malloch	Drosophilidae, Diptera	Mani & Krishnamoorthy (1999a)
<i>Spalgis epeus</i> (West wood)	Lycanidae Lepidoptera	Mani <i>et al.</i> (2001)
<i>Oecophylla smaragdina</i> (F)	Formicidae, Hymenoptera	Gopi <i>et al.</i> (2001)
<i>Solenopsis geminata</i> (F)	Formicidae, Hymenoptera	Gopi <i>et al.</i> (2001)
<i>Oxopes</i> sp.	Oxypidae, Acari	Geetha (2000)
House sparrow, <i>Passer domesticus</i> (L)	Aves	Gopi <i>et al.</i> (2001)
Spider hunter <i>Archnothera longirostris</i> (Latham)	Aves	Gopi <i>et al.</i> (2001)
Pied bushchat <i>Saxicola caprata</i> (L)	Aves	Gopi <i>et al.</i> (2001)
Tailor bird <i>Orthotomus sutorius</i>	Aves	Gopi <i>et al.</i> (2001)
Pathogens		
<i>Pacilomyces farinosus</i> (Brown& Smith)	Moniliales, Deutromycetes	Mnai <i>et al.</i> (2001)
<i>Verticillium lecanii</i> Zimm.	Moniliales, Deutromycetes	Mallappanavar(2000)

– July 2000 indicated that *E. haitiensis* was known to occur at Thiruvananthapuram and Thrissur (Kerala), Erode and Krishnagiri (Tamil Nadu). Chitradurga, Bangalore, Sirsi and Puttur (Karnataka), while *E. guadeloupae* was collected in Thrissur, Erode, Bangalore, Davangere, Kolar and Mysore (Karnataka). The activity of the parasitoids on the spiralling whitefly was extended to Pune (Maharashtra) and Hyderabad (Andhra Pradesh) (Mani *et al.*, 2001). Suveys in Tamil Nadu revealed the presence of *E. haitiensis* in Coimbatore, Pollachi, Erode, Salem and Namakkal causing 5.42 to 59.45 % (Geetha, 2000) and 59.93% on chillies in Thrissur ( Beevi and Lyla, 2001). Recent survey at Trichur revealed that the extent of parasitism was high in March-April 20002 on guava, chillies, rubber, brinjal,

tapioca, balsam and banana (PDBC, 2002) The population of spiralling whitefly was monitored around Bangalore on papaya, guava, Cassia and Michelia. The population of whitefly was found in negligible level during January – February 2002 (PDBC, 2002). Both *E. haitiensis* and *E. guadeloupae* are expected to spread to many more areas resulting in remarkable reduction in the population of *A. dispersus* in India.

#### Competitive displacement of *Encarsia* spp.

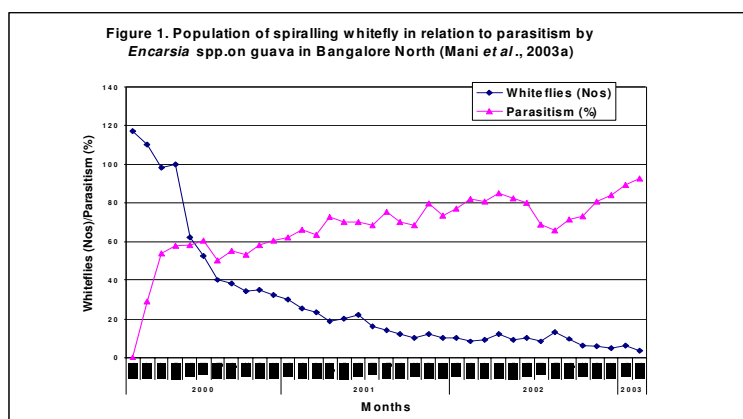
*Encarsia haitiensis* was found to be the only parasitoid encountered on spiralling whitefly initially up to October 2000 and remained at higher proportions till December 2001 in a guava

orchard at Hosallipalaya, Bangalore. *Encarsia guadeloupae* was detected for the first time in this orchard in November 2000. The proportion of *E. guadeloupae* had increased from 7.88 in November 2000 to 92.90% in June 2002. By July 2002, *E. haitiensis* was completely replaced by *E. guadeloupae*. Similar kind of replacement of *E. haitiensis* by *E. guadeloupae* was reported by Ramani *et al.* (2000) and Beevi and Lyla (2001) in India. Srinivasa *et al.* (1999) reported *E. haitiensis* on spiralling whitefly for the first time in Bangalore in January 1998. By June-December 2001, *E. guadeloupae* has become predominant causing up to 97% parasitism on different host plants replacing *E. haitiensis* around Bangalore (Ramani *et al.*, 2000). In Thrissur too, Beevi *et al.* (1999) initially observed only *E. haitiensis* on spiralling whitefly in January 1998. By March 2001, only *E. guadeloupae* was present replacing *E. haitiensis* completely (Beevi and Lyla, 2001). When both the species were released in Agathi and Karveretti Islands of Laskshadweep, *E. guadeloupae*

became dominant (Ramani, 2000) as witnessed in Tenerife (Nijhof *et al.*, 2000), Benin (D'Almeida *et al.*, 1998) and Taiwan (Chien *et al.*, 2000).

### Future thrust

*Aleurodicus dispersus* is capable of spreading very fast from one location to another location. In the next few years, the spiralling whitefly may well be discovered in many more states in India. Available evidence suggests that new infestations have often resulted from transportations of infested plants. Chemical control is not practicable because of the abundance of host plants including some large size avenue trees and wide spread distribution. It is fortunate to note that biological control agents can readily reduce the spiralling whitefly populations to sub-economic numbers. It would seem to be highly desirable to introduce the host specific natural enemies *E. haitiensis* or *E. guadeloupae* to any locality seeking biological control.



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