

S. BARBAGALLO, S. LONGO, I. PATTI, C. RAPISARDA

### Efficiency of biological control against citrus whiteflies in Italy (\*)

**Abstract** - Three harmful citrus-feeding whiteflies reached Italy during the last twenty-five years; they all have been efficiently controlled through biological methods and the serious problems deriving from their initial infestations were rapidly solved. In particular, *Dialeurodes citri* (Ashmead), which invaded the Italian citrus orchards starting from the early sixties, has been pushed under low population levels by the introduction of *Encarsia lahorensis* (Howard); thus the whitefly only occasionally infests at present citrus groves, as a consequence of the relevant parasitization (up to 70-80%) by the Aphelinid. Two species of parasitoids have been more recently released for biological control of the Woolly Whitefly, *Aleurothrixus floccosus* (Maskell), which massively spread in Italy at beginning of the eighties; one of them, *Cales noacki* Howard, well established itself in the new agrosystems, performing, in lack of limiting factors (i.e. high temperatures and low relative humidity), a generally appreciable control of the whitefly, in spite of the frequent late summer outbreaks of the latter. Recently, at last, appreciable activity has been locally shown by *Encarsia meritoria* Gahan against the latest whitefly arrived in Italy, *Parabemisia myricae* (Kuwana); yet the most successful results in controlling this insect have been obtained through the introduction from Israel of *Eretmocerus debachi* Rose & Rosen, which allowed a quick reduction in the infestation levels by the whitefly.

**Riassunto** - *Efficacia del controllo biologico contro gli aleirodi degli agrumi in Italia.*

Negli ultimi venticinque anni gli agrumeti italiani sono stati progressivamente infestati da tre specie esotiche di Aleirodi, contro i quali il controllo biologico con l'impiego di entomofagi ha consentito di ottenere apprezzabili successi. In particolare, il *Dialeurodes citri* (Ashmead) ha raggiunto una notevole diffusione, con indici d'infestazione talvolta alquanto elevati, nel-

---

(\*) Paper presented at the XIX International Congress of Entomology, Beijing, China, June 28 - July 4, 1992.

Studies of the C.N.R. coordinate unit for Integrated Control of plant pests: N. 309.

la maggior parte delle aree agrumicole italiane, a partire dai primi focolai individuati sin dagli inizi degli anni sessanta. L'introduzione e la conseguente diffusione di *Encarsia lahorensis* (Howard) ha comunque determinato un notevole decremento nelle popolazioni del fitofago, che allo stato attuale, grazie ai rilevanti livelli di parassitizzazione da parte dell'Afelinide (fino al 70-80%), supera solo occasionalmente la soglia di dannosità. Più recentemente, per il controllo biologico di *Aleurothrixus floccosus* (Maskell), diffusosi negli agrumi italiani da poco più di un decennio, sono state introdotte due specie di parassitoidi di origine neotropica. Fra essi, il *Cales noacki* Howard ha evidenziato una brillante capacità di acclimatazione ai nuovi ambienti, fatta eccezione per la sua particolare sensibilità alle alte temperature e alla ridotta umidità relativa, che lo rendono alquanto vulnerabile nel corso dei mesi estivi; ciò determina molto spesso, a fine estate-inizio autunno, una crescita dei livelli d'infestazione da parte dell'aleirode, che si mantiene invece a basse densità di popolazione nella restante parte dell'anno. Per finire, in varie regioni agrumicole dell'Italia meridionale si è recentemente diffusa, a livelli di dannosità spesso assai elevati, la *Parabemisia myricae* (Kuwana), nei cui confronti l'Afelinide *Encarsia meritoria* Gahan ha manifestato apprezzabili capacità di controllo biologico solo in condizioni ambientali assai localizzate. Migliori risultati, con la conseguente rapida riduzione dei livelli d'infestazione da parte dell'aleirode, si sono invece ottenuti con l'introduzione da Israele di *Eretmocerus debachi* Rose & Rosen e la sua capillare diffusione negli areali agrumicoli infestati.

**Key words:** citrus whiteflies, biological control, Italy.

## INTRODUCTION

Plants of the genus *Citrus* L. are frequently infested all over the world by Homoptera Aleyrodoidea. As far as presently known, more than 60 whitefly species, both in the Aleyrodinae and Aleyrodicinae, are listed as living on such plants (Mound & Halsey, 1978). Some of them have a relevant economic importance in citrus-groves, deeply interfering with the productivity of such plants; on the contrary, the greatest part of species are of minor practical importance and their records on citrus, reported by the literature, should be mostly related to their unfrequent occurrence on these plants.

Such a distinction between economically important and non-important citrus-feeding whiteflies cannot have a permanent value, of course. In fact, all whitefly records on citrus plants are based on findings of young stages of these insects attached to the leaves, thus proving their non-casual occurrence but their real fitness for developing on the mentioned plants. In case of whiteflies which are accidentally introduced in a new area, starting from their native regions, deep differences may be found in the new environment, involving the regulating factors of their populations. Thus, when a whitefly species reaches a new

territory, the possible improvement in its biotic power and reproductive rate, together with the eventual lack of suitable alternative host plants, may cause a «whitefly/citrus host plant» relation which is almost different from the one the insect shows in the native region, leading to the outbreak of the pest. Moreover, it is worth to point out how the injuriousness of minor citrus-feeding whiteflies may also increase within their own native environments, as a consequence of the break down in biological balances, which is highly frequent in the agrosystems.

Therefore, our future attention should not be exclusively devoted to those whitefly species which presently damage citrus-groves in several parts of the World, but it should be extended to the whole group, in order to timely evidence possible outbreaks of secondary species or their diffusion.

From this point of view, whiteflies undoubtedly represent some of the most important citrus pests.

#### DAMAGES BY CITRUS-FEEDING WHITEFLIES

Injuries caused by the whiteflies to the infested plants are mainly related to their trophic activity, since both adults and, above all, nymphs of these insects sting the foliar tissues by means of their mouth stylets, sucking the sap. Production of honey-dew, especially abundant by the nymphs, is a direct consequence of both this kind of nutrition and the peculiar structure of the digestive system in the whiteflies. Sooty-mould usually stratify on these sugary excrements.

A large amount of protective waxy filaments is dorsally produced by the nymphs of numerous whitefly species, especially belonging to the subfamily Aleyrodicinae (however, various Aleyrodinae are worth mention, too, such as the species of the genus *Aleurothrixus* Quaintance & Baker); in case of strong infestations, the mixture of wax with honey-dew forms a continuous coat over the foliar surface, thus limiting the gaseous exchanges of the same leaf.

In conclusion, some citrus-feeding whiteflies may variously deform the infested plant tissues, as in the case of the characteristic leaf crenelation caused by *Parabemisia myricae*.

#### CITRUS-FEEDING WHITEFLIES OCCURRING IN ITALY

No whiteflies were known in the Italian citrus-groves up to the first half of the sixties. At present, less than thirty years after, a complex of six species has already been evidenced in this Country on plants of the genus *Citrus*

(Rapisarda, 1990b). Fortunately, not all these whiteflies are of practical importance, some of them playing a secondary role in the culture.

*Aleurothrixus floccosus* (Maskell). Probably of neotropical origin, this whitefly secondarily spread over North America, various African Countries, Canary Islands, Réunion and Western Mediterranean Region (France, Italy, Morocco, Portugal, Spain, Tunisia (Barbagallo et al., 1986; Chermiti, pers. comm.)). As to the latter basin, it is supposed to occur also in Algeria, Egypt, Lybia and Middle East (Liotta & Maniglia, 1983). In Italy, the insect has been firstly recorded in Liguria, during the early seventies (Onillon & Onillon, 1972); later on, it has been found in various other regions, such as Sicily (Genduso & Liotta, 1980), Campania (Iaccarino, 1981), Sardinia (Delrio et al., 1982), Calabria and Latium (Longo et al., 1985), Apulia (Ippolito & Laccone, 1987), Basilicata (Tranfaglia et al., 1989).

The whitefly has a wide range of host plants, being reported in the literature on plants of about twenty genera. However, in the newly colonized environments, such as the Mediterranean Region, it shows a marked preference for citrus, highly infesting all the cultivated species of the group. On these plants, and under the economical point of view, *A. floccosus* is presently the most important whitefly occurring in the Italian territory.

The insect shows in Italy 4-5 yearly generations (Liotta, 1982; Ortu & Ibba, 1985). It almost continuously develops during the year, yet its populations decline during winter as a consequence of both climatic conditions and the slackened flushing rhythm of its host plants. On the contrary, development of the insect is improved during summer, thus causing its stronger infestations in early autumn.

*Bemisia afer* (Priesner & Hosny). A widely diffused species, presently recorded in various African Countries, Madagascar, Great Britain, Italy, Spain, India, Pakistan and China (Mound & Halsey, 1978; Halstead, 1981; Bink-Moenen, 1983; Yan, 1988). In Italy (where it has been reported in the past under the names of *B. citricola* Gomez-Menor and *B. hancocki* Corbett), *B. afer* has been noted only in few regions up to now (Campania, Liguria and Sicily) (Mineo & Viggiani, 1975; Patti & Rapisarda, 1981; Vidano & Navone, 1987), but it is reasonable to believe in its wider diffusion and its ancient, endemic occurrence in this Country.

The whitefly is highly polyphagous and a lot of its host plants are reported in the literature; it also shows well marked variations in the characters of pupa case, in relation to the hair structure of the host leaves.

It is very common in the mentioned Italian citrus areas, but always in very low population densities, thus being of no economic importance.

*Bemisia tabaci* (Gennadius). A cosmopolitan and very polyphagous species, which is presently increasing its harmfulness to cultivated plants in various parts of the World. It has been known for a long time in the Italian territory, especially in the southern regions (Rapisarda, 1990a), yet its occurrence on plants of the genus *Citrus* (though at very low densities and apparently giving no damages) has been only recently (1991) verified in Sicily, on small sour-orange plants growing in a greenhouse. Such an attitude of the insect to develop on citrus was known till now only in Israel (Bodenheimer, 1951; Avidov & Harpaz, 1969).

*Dialeurodes citri* (Ashmead). It is probably native from the Indian region, but it is presently spread over nearly the whole temperate zone of the World, so that its geographical distribution involves, in addition to the Oriental and Palaearctic Regions, also the North and South American Countries (Mound & Halsey, 1978). The whitefly is widely present in Mediterranean environments and its occurrence is known in all the citrus areas of this Basin (Barbagallo et al., 1986). As to Italy, in particular, it is known in all regions where citrus are cultivated.

The whitefly lives on numerous plants of different families, though showing a remarkable preference for citrus, at least where it has been introduced. Suitable climatic conditions allow *D. citri* to perform up to 5-6 yearly generations; in Italy, it shows only 2-3 generations, overwintering in the nymphal stage (especially as 4<sup>th</sup> instar) and with adults flying in May, July and (only a fraction of the total population) in September-October (Barbagallo & Patti, 1978).

Infestations by this whitefly have been very serious in Italian citrus-groves till about ten years ago, but it is presently an almost rare species, most likely as a consequence of the activity of its natural enemies. Nowadays, injurious infestations by *D. citri* may be only found in restricted citrus areas of the Country.

*Parabemisia myricae* (Kuwana). First record of this species in Italy goes back to summer 1990, when it has been found in citrus areas of Sicily (Rapisarda et al., 1990a) and Calabria (Longo et al., 1990b). Yet the Japanese Bayberry Whitefly was already known in the Mediterranean more than ten years ago, having been initially reported from Israel (Sternlicht, 1979) and soon after from Cyprus (Swirski, 1985), Turkey (Anonym, 1986) and Syria (Viggiani, 1988); moreover, the whitefly is further on enlarging its diffusion in this basin and its occurrence is already recorded in Spain (Martin, *in litteris*), Morocco (Abbassi, *in litteris*) and Tunisia (Chermiti, pers. comm.). In addition to the mentioned Countries, *P. myricae* occurs in the far eastern regions of Asia

(Japan, Malaysia, Taiwan) (where the species is likely to be native) and California (Mound & Halsey, 1978; Rose et al., 1981).

Similarly to the previous species, it is highly polyphagous but with a marked preference for Rutaceae of the genus *Citrus*. On these plants, *P. myricae* exclusively oviposits on very young sprouts, where its young stages settle, causing typical deformations of the leaves, such as crenulations of the margins and pittings of surfaces (Longo et al., 1990a; Rapisarda et al., 1990b).

As far as presently known, *P. myricae* is a parthenogenetic species, with very rare males (Rose et al., 1981; Swirski et al., 1986; Longo et al., 1990a). Various yearly generations (with frequent overlaps) are shown by this whitefly, which overwinters in the nymphal stage. In particular, seven generations have been performed by *P. myricae* in Southern Italy (Rapisarda & Pavone, 1992).

*Trialeurodes vaporariorum* (Westwood). A well known whitefly, occurring in nearly all the tropical and subtropical regions, as well as, under greenhouses, at higher latitudes. Its development on citrus is reported both in northern (Arzone & Vidano, 1983) and southern (Barbagallo et al., 1986) Italian regions; yet it is an occasional pest, normally of no practical importance on these plants.

#### BIOLOGICAL CONTROL OF CITRUS-FEEDING WHITEFLIES: GENERAL OUTLINES

Due to their negative action on development and productivity of the host plants, citrus-feeding whiteflies need to be directly controlled when serious infestations occur. Various researches have been carried out on this topic in several parts of the World, showing how good results may be achieved through the opportune application of biological control methods, indicated everywhere as the most suitable and resolute ones. The reasons of such a success should be mainly looked for in the positive effects which follow the restoration of natural antagonistic relationships between insect pests and their entomophagous species, particularly stressed in case of insects, such as the citrus-feeding whiteflies, of exotic origin and recently introduced in a new environment. For this reason, chemical control applications should be normally avoided, being required only for very strong infestations by citrus-feeding whiteflies, when it is necessary to timely reduce their populations. However, also in this case, a rational control intervention is completed when, after the treatment, the repopulating is ensured by the complex of entomophagous species.

Citrus-feeding whiteflies have efficacious antagonists within various groups of Arthropods. Among the predators, Mites may be firstly mentioned in a phylogenetic order, especially the species belonging to the family Phytoseiidae

(*Amblyseius* spp., *Euseius* spp. and *Typhlodromus* spp.), which actively prey upon whitefly eggs and nymphs (Wisoki & Cohen, 1983).

As to the Insects, various orders include predators of whiteflies. For instance, some Thysanoptera, of the families Phlaeothripidae and Thripidae, are reported in the literature as preying upon whiteflies, as in the case of *Aleurodothrips fasciapennis* (Franklin) and *Haplothrips merrilli* Watson, indicated as predators of *Dialeurodes citri* and *Aleurothrixus floccosus* respectively (Morrill & Back, 1912; Fulmek, 1943).

A lot of predator species are also known in the Rhynchota, normally having a wide food range but very often addressing their attention to the whiteflies. Such kind of behaviour has been noted in various Heteroptera Gymnocerata, such as Anthochoridae, Miridae and Reduviidae. Some of these species may show a relevant activity and may be properly used in biological control programs of economically important whitefly species, as in the case of Mirid bugs against the greenhouse whitefly *Trialeurodes vaporariorum* (Arzone et al., 1990).

Neuroptera are another group of commonly active predators of whiteflies. In particular, various Chrysopidae (*Chrysopa* spp., *Chrysoperla* spp.) may be evidenced on whitefly colonies during spring and autumn, thus in coincidence with aphid infestations, which are their basic preys; in such periods, both adults and larvae of these lacewings feed on eggs and nymphal stages of whiteflies (Bodenheimer, 1951). Similar behaviour is shown by various Conyopterigidae (*Conwentzia* spp., *Semidalis* spp.), whose occurrence among whitefly colonies is evidenced through the unmistakable subcircular, about 5 mm in diameter, cocoons, made up by the mature larvae on the leaves.

Occasional predators of Homoptera Aleyrodoidea are known also in the Diptera, such as species of the families Cecidomyiidae (*Cleodiplosis* spp., *Lestodiplosis* spp.), Drosophilidae (*Acletoxenus* spp.) and Syrphidae (*Bacca* spp.) (Mound & Halsey, 1978); yet they all are of negligible practical importance.

Last but not least, the group of Coleoptera Coccinellidae includes the most important predators of whiteflies, both for number of species and for the role they may play in the natural control of these pests. Whitefly preying ladybirds are known within different subfamilies, such as Chilocorinae, Coccidulinae, Coccinellinae, Scymninae. Most of these species prevalently prey upon aphids and scale insects, but secondarily adapt themselves to feed on whiteflies.

All the mentioned predators appreciably contribute to naturally control whitefly pests, but they are not usually able to maintain their populations under the economic thresholds. For this purpose, on the contrary, various parasitoids (mostly specific and introduced from the native regions of the same whiteflies) have a greater effectiveness. Hundreds of whitefly parasitoids are known in the

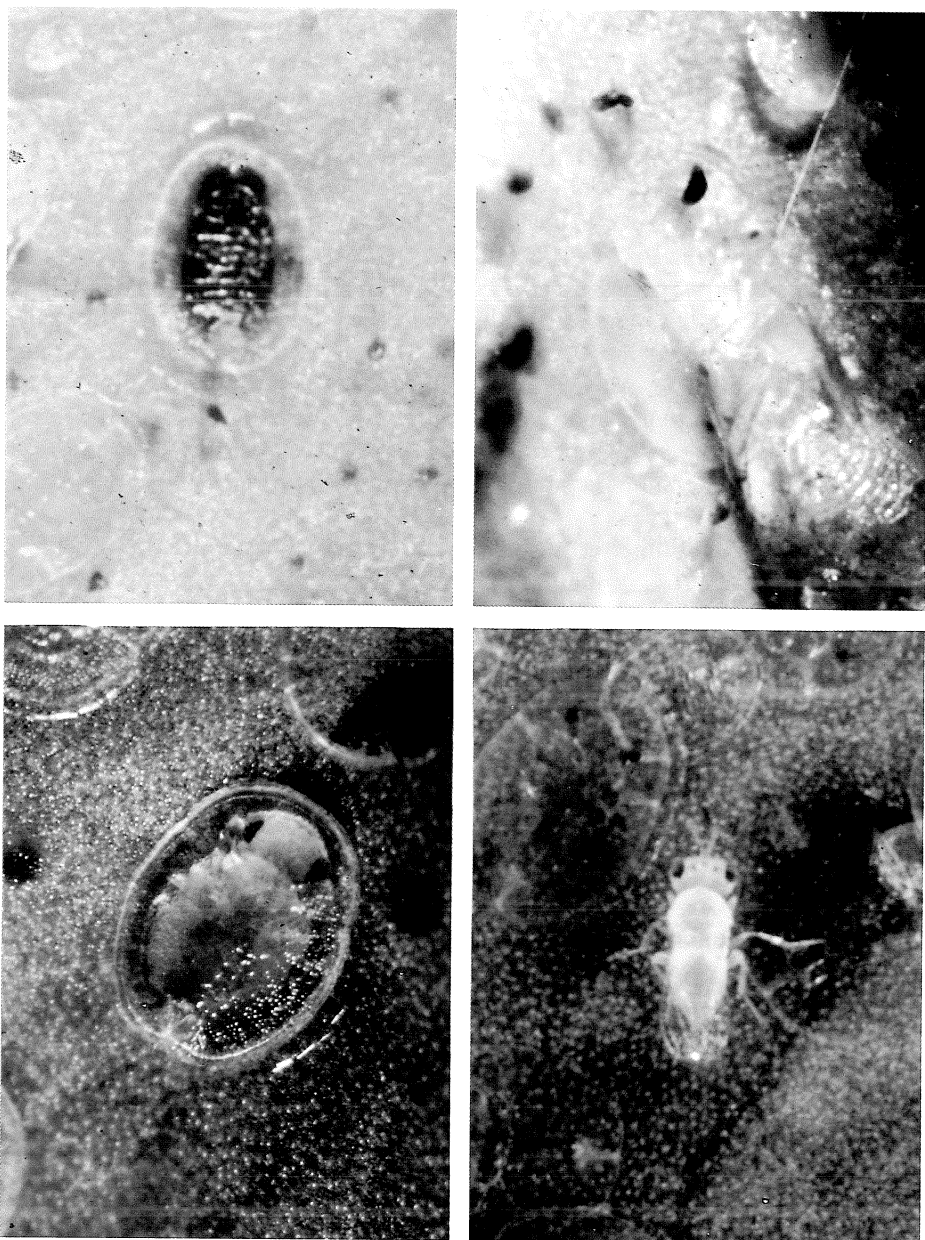


Fig. 1 - Parasitoids of *Parabemisia myricae* (Kuwana). Above: *Encarsia meritoria* Gahan, pupa (left) and adult (right); below: *Eretmocerus debachi* Rose & Rosen, pupa (left) and adult (right).



Hymenoptera, belonging to Chalcidoidea and Proctotrupeoidea. A more numerous swarm of species belongs to the first superfamily, which includes parasitoids of main practical importance for biological control of citrus-feeding whiteflies, as the Aphelinidae (*Encarsia* spp., *Eretmocerus* spp.) and Eulophidae (*Euderomphale* spp.), together with other secondary families, such as Encyrtidae, Eupelmidae, Mymaridae and Signiphoridae. Among the Proctotrupeoidea, Platygasteridae of the genus *Amitus* Haldeman are worth mention, too.

Most of the above parasitoids are the true agents of the good biological control which has been achieved all over the World on various whitefly pests, especially in citrus-groves. A wide analysis of biocenotic relationships within the agro-ecosystems and a close examination of the biotic power in the parasitoids, related to that one of their victims, should be necessary to satisfactorily explain the reasons of this success. Anyway, as in the case of biological control of scale insects, the relevant activity of parasitoids is partly due also to the favourable ease for their females to find the immovable nymphs of the whiteflies for ovipositing.

#### BIOLOGICAL CONTROL OF CITRUS-FEEDING WHITEFLIES IN ITALY

Biological control programs carried out in Italy up to now against citrus-feeding whiteflies, regard the three species of major economic importance which occur in the citrus areas of this Country.

*Dialeurodes citri* (Ashmead). Some years after the first records in Italy of *D. citri*, when its infestations were already harmfully diffused in nearly all the citrus areas of the Country, the specific parasitoid *Encarsia lahorensis* (Howard) (an Aphelinid of Indian origin, such as its whitefly host) was introduced to biologically control the Citrus Whitefly. The endophagous was first released, towards the middle of the seventies, in Campania (Viggiani, 1976; Viggiani & Mazzone, 1977, 1978). Further diffusions of the Aphelinid subsequently involved nearly all the Italian citrus regions, and the very good results of the parasitic action of *E. lahorensis*, in reducing the Citrus Whitefly populations, are reported also in Western (Liotta, 1978) and Eastern Sicily (Patti & Rapisarda, 1980; Barbagallo et al., 1981), Sardinia (Ortu & Prota, 1986), Apulia (Ippolito & Laccone, 1987), Liguria (Vidano & Navone, 1987). In all the Italian environments, the Aphelinid well adapted itself, reaching everywhere, within few months from its propagative field releases, relevant population levels on the Citrus Whitefly. The very good parasitization rates, up to 70-80%, found in releasing sites of the Aphelinid only one year after its

introductions, may explain the relevant success achieved in the control of this whitefly and how the latter one may be presently found at high population densities only in sporadic Italian citrus-groves.

Nevertheless, it is worth to point out how the basic role of *E. lahorensis*, as a biological control agent of *D. citri*, is also supported by the not negligible, though surely of secondary importance, action of various generic predators, such as Rhynchota Heteroptera, Neuroptera Chrysopidae and Conyopterigidae, Coleoptera Coccinellidae, having in the Citrus Whitefly colonies good possibilities for feeding and developing. In particular, *Clitostethus arcuatus* (Rossi) is worth of mention among the ladybirds, frequently occurring upon *D. citri* populations, and highly voracious both in the larval and the adult stage (Loi, 1978). The overall action of these generic predators, in particular, showed a relevant efficacy in environmental conditions of Northern Italy (Alma et al., 1991).

*Aleurothrixus floccosus* (Maskell). Good results have been also obtained in biological control of the Woolly Whitefly, even if they are usually not so sharply and permanently resolute as those mentioned for the previous species.

A research carried out in Sicilian environments, soon after the first records of the whitefly, showed how a group of generic predators (mostly indigenous) adapted itself to live on the new prey. Yet all these species, mainly represented by Neuroptera (Chrysopidae and Conyopterigidae) and Coleoptera (Coccinellidae), gave no satisfactory results to control the whitefly populations (Longo et al., 1985).

To this end, and in order to slacken the harmful diffusion of the pest, two species of Hymenoptera parasitoids, *Amitus spiniferus* (Br  thes) (Platygasteridae) and *Cales noacki* Howard (Aphelinidae), have been introduced in Italian regions. The first one well established itself in the north-western side of the Country (Liguria), showing there an appreciable parasitic activity (Arzone & Vidano, 1983); but it gave no good results in the southern regions (Sicily) (Longo et al., 1985; Maniglia, 1988). On the contrary, *C. noacki* showed to better adapt itself all over the Italian territory, reaching everywhere high parasitization levels on the whitefly nymphs (Arzone & Vidano, 1983; Liotta & Maniglia, 1983; Longo et al., 1985; Ortu & Prota, 1986; Ippolito & Laccone, 1987; Guerrieri & Viggiani, 1988; Maniglia et al., 1988). As regard to the southern regions, especially in citrus-groves where chemical control is not applied with large-spectrum insecticide, the Aphelinid may be often found to parasitize 100% of *A. floccosus* young stages, thus maintaining the whitefly populations under the intervention threshold for most of the year. Unfortunately, *C. noacki* development may be slowed down by the summer high temperatures and low relative humidity, so that high infestations of the

Woolly Whitefly may occur in late summer - early autumn, even in citrus orchards not infested by the pest during the rest of the year. In these cases, however, *A. floccosus* populations go quickly back to the ordinary low levels as soon as the weather becomes cooler in late autumn. Better results in biological control of *A. floccosus* may be therefore expected by introducing other exotic parasitoids, which may integrate the action of *C. noacki*, being more resistant to the Italian summer conditions.

*Parabemisia myricae* (Kuwana). Biological methods gave very successful and swift results also in the control of harmful infestations by the Japanese Bayberry Whitefly.

Similarly to the former species, a negligible efficiency has been shown on this pest by various polyphagous predators, such as Acarina Phytoseiidae, Neuroptera Chrysopidae and Conyopterigidae, Coleoptera Coccinellidae, Diptera Syrphidae, all of them frequently found among the whitefly colonies but not able to reduce its populations under the economic threshold (Longo et al., 1990a, 1990b).

Higher activity, on the contrary, has been shown by several endophagous species. As to this aspect, studies on the parasitic biocenosis of *P. myricae*, carried out in Southern Italy, allowed to find a few Aphelinids spontaneously adapted to live on the whitefly, such as *Cales noacki* Howard, *Encarsia lutea* (Masi) and *E. meritoria* Gahan (Longo et al., 1990a, 1990b; Sinacori et al., 1991). The latter species, in particular, locally showed a good parasitic action, especially in restricted citrus orchards of Calabria; therefore, it has been ulteriorly diffused in citrus areas infested by the whitefly and where the parasite did not occur before. In such attempts, *E. meritoria* showed to be highly exigent as regard to climatic conditions, thus the mentioned propagative releases of the parasitoid gave not the expected results, since it efficaciously settled only in very few biotopes, most of which closely reproducing the particular environmental conditions of the area where the Aphelinid has been firstly found in Calabria. Best results, on the contrary, were achieved through the introduction, from Israel, of a species of the genus *Eretmocerus*, very recently described as *E. debachi* Rose & Rosen (1992); numerous parthenogenetic females of this Aphelinid have been kindly sent by Prof. E. Swirski (Volcani Center - Bet Dagan), during spring-summer 1991 (Rapisarda et al., 1991). Propagative releases of the parasitoid have been realized in various citrus areas of Sicily and Calabria, by the Institutes of agricultural Entomology of the Universities of Catania and Palermo and the Institute of Plant Protection of the University of Reggio Calabria. Moreover, part of material which arrived from Israel have been bred, in Catania and Reggio Calabria, on small citrus plants artificially infested by *P. myricae* and reared in both

glasshouse and open air. In few months time, a huge material of *E. debachi* was possible to be drawn from the mentioned insectaries and used for further, massive introductions in both the two Italian regions. As result of this program, *E. debachi* showed to well establish itself in all the new areas, reaching appreciable parasitization levels (Longo et al., 1992). It also showed a good and quick active diffusion in the newly colonized biotopes, having been recaptured also far from releasing sites. Through such a way, a resolute biological control of *P. myricae* has been achieved, as it happened for the previous citrus whiteflies, especially for *D. citri*.

#### CONCLUSIVE REMARKS

Citrus-feeding whiteflies represent an increasing problem in Mediterranean environments. As to Italy, apart from secondary species, it can be stated how the introduction occurred in the citrus areas of this Country of about one harmful whitefly species every ten years. Other ones are reasonably to be expected in the next future.

Luckily, all citrus-feeding whiteflies introduced in Italy up to now have been appreciably pushed under biological control by active exotic parasitoids, so that they all are presently of negligible phytosanitary importance. The only exception may be occasionally represented by the Woolly Whitefly, as a consequence of a certain developmental reduction showed by its parasitoid *Cales noacki* during summer.

Anyway, it is worth to point out how the application times of biological control programs have been markedly reduced against citrus-feeding whiteflies, probably as a consequence of both the greater attention payed to this problem by various Italian reseachers and, above all, of the better taxonomic knowledge that has been recently acquired on both citrus-feeding whiteflies and their natural enemies. As to this aspect, and in conclusion, it is interesting to note how nearly ten years passed from the first records in Italy of *Dialeurodes citri* and the introduction in this Country of its parasitoid *Encarsia lahorensis*, while a similar process took only eleven months for *Parabemisia myricae*.

#### REFERENCES

- ALMA A., ARZONE A., TAVELLA L., 1991 - Biocenosi di *Dialeurodes citri* (Ashm.) in Piemonte (Rhynchota: Aleyrodidae). - Atti XVI Congr. naz. ital. Entomologia: 323-328.
- ANONYM., 1986 - *Parabemisia myricae* (Kuwana). Distribution maps of pests. - Commonwealth Institute of Entomology, map. n. 479.

- ARZONE A., ALMA A., TAVELLA L., 1990 - Ruolo dei Miridi (Rhynchota Heteroptera) nella limitazione di *Trialeurodes vaporariorum* Westw. (Rhynchota Aleyrodidae). - Boll. Zool. agr. Bachic., ser. II, 22 (1): 43-51.
- ARZONE A., VIDANO C., 1983 - Indagini sui parassiti di *Aleurothrixus floccosus* in Liguria. - Inf.tore fitopat. 33 (6): 11-18.
- AVIDOV Z., HARPAZ I., 1969 - Plant pests of Israel. Israel University Press, Jerusalem: X + 549 pp.
- BARBAGALLO S., LONGO S., PATTI I., 1981 - Primi risultati di lotta biologica-integrata in Sicilia orientale contro il Cotonello e il Dialeurode degli agrumi. - Fruits 36: 115-121.
- BARBAGALLO S., LONGO S., RAPISARDA C., 1986 - White-flies and psyllids injurious to citrus. - Proc. Exp. Meet. «Integrated pest control in citrus-groves», A.A. Balkema publs., Rotterdam, Boston: 89-98.
- BARBAGALLO S., PATTI I., 1978 - Note biologiche ed orientamenti di lotta contro *Dialeurodes citri* (Ashm.) in Sicilia orientale. - Atti Giornate fitopat. 1: 237-244.
- BINK MOENEN R.M., 1983 - Revision of the African whiteflies (Aleyrodidae), mainly based on a collection from Tchad. - Mon. Ned. ent. Ver. 10: 211 pp. + 1 tav.
- BODENHEIMER F.S., 1951 - Citrus entomology in the Middle East. - Uitgeverij Dr W. Junk «S - Gravenhage»: XII + 663 pp.
- DELRIO G., ORTU S., PROTA R., 1982 - Fitofagi di recente introduzione nelle colture agrumicole della Sardegna. - Studi sassaresi, sez. III, Ann. Fac. Agr. Sassari 28: 57-64.
- FULMEK L., 1943 - Wirtsindex der Aleyrodiden und Cocciden-Parasiten. - Ent. Beih. Berl. - Dahlem 10: 100 pp..
- GENDUSO P., LIOTTA G., 1980 - Presenza di *Aleurothrixus floccosus* (Mask.) (Hom. Aleyrodidae) sugli Agrumi in Sicilia. - Boll. Ist. Ent. agr. Oss. fitopat. Palermo 10: 205-211.
- GUERRIERI E., VIGGIANI G., 1988 - Osservazioni sull'*Aleurothrixus floccosus* (Mask.) (Homoptera: Aleyrodidae) e sul suo antagonista *Cales noacki* How. (Hymenoptera: Aphelinidae) in Campania. - Ann. Fac. Sc. agr. Univ. Napoli, Portici IV, 22: 11-17.
- HALSTEAD A.J., 1981 - A whitefly pest of sweet bay. - Plant Pathology 30 (2): 123.
- IACCARINO F.M., 1981 - Aleirodidi nuovi o poco noti per l'Italia. - Boll. Lab. Ent. agr. «Filippo Sivestri», Portici 38: 143-156 + 1 tav.
- IPPOLITO R., LACCONE G., 1987 - Distribuzione e parassiti di *Aleurothrixus floccosus* Mask. e *Dialeurodes citri* Ashm. (Hom. Aleyrodidae) su agrumi in Puglia. - Entomologica 22: 157-164.
- LIOTTA G., 1978 - Introduzione in Sicilia della *Prospaltella lahorensis* How. (Hym. Aphelinidae) parassita specifico del *Dialeurodes citri* (Ashm.) (Hom. Aleyrodidae). - Atti Giornate fitopat. 1: 231-236.
- LIOTTA G., 1982 - La mosca bianca fioccosa degli agrumi. - Inf.tore fitopat. 32 (12): 11-16.
- LIOTTA G., MANIGLIA G., 1983 - Introduzione, allevamento e diffusione di nemici naturali indigeni ed esotici di *Aleurothrixus floccosus* (Mask.) (Hom., Aleyrodidae). II. Ruolo di *Cales noacki* How. (Hym., Aphelinidae) nel controllo di *Aleurothrixus floccosus* (Mask.) in Sicilia. - Phytophaga 1: 133-142.
- LOI G., 1978 - Osservazioni eco-etologiche sul coleottero coccinellide Scimmino *Clitostethus arcuatus* (Rossi), predatore di *Dialeurodes citri* (Ashm.) in Toscana. - Frustula entomologica 1: 123-145.

- LONGO S., PATTI I., RAPISARDA C., RUSSO A., SISCARO G., 1992 - Biological control of *Parabemisia myricae* with *Encarsia meritoria* and *Eretmocerus* sp. in Italy. - Proc. VII Int. Citrus Congress, Acireale (Italy) (in press).
- LONGO S., RAPISARDA C., RUSSO A., 1985 - Risultati del controllo biologico dell'*Aleurothrixus floccosus* (Maskell) in agrumeti della Sicilia orientale. - Atti XIV Congr. naz. ital. Entomologia: 841-848.
- LONGO S., RAPISARDA C., RUSSO A., SISCARO G., 1990a - Rilievi bio-etologici preliminari su *Parabemisia myricae* e sui suoi entomofagi in Sicilia e Calabria. - Boll. Zool. agr. Bachic., ser. II, 22 (2): 161-171.
- LONGO S., RUSSO A., SISCARO G., 1990b - I nemici naturali di *Parabemisia myricae*, un «nuovo» aleirodide dannoso agli agrumi. Inf.tore agrario 46 (42): 135-137.
- MANIGLIA G., 1988 - Osservazioni biologiche su *Amitus spiniferus* (Bréthes) (Hym. Platygastriidae) parassitoide di *Aleurothrixus floccosus* (Mask.) (Hom. Aleyrodidae). - Atti XV Congr. naz. ital. Entomologia: 1007-1012.
- MANIGLIA G., PERRICONE M.C., BISSANTI G., 1988 - Osservazioni sulla dinamica di popolazione di *Aleurothrixus floccosus* (Mask.) (Hom. Aleyrodidae) in presenza del parassitoide *Cales noacki* How. (Hym. Aphelinidae). - Atti XV Congr. naz. ital. Entomologia: 527-534.
- MINEO G., VIGGIANI G., 1975 - Sulla presenza di *Bemisia citricola* Gomez-Menor (Homoptera - Aleyrodidae) in Italia. - Boll. Lab. Ent. agr. «Filippo Silvestri», Portici 32: 47-51.
- MORRILL A.W., BACK E.A., 1912 - Natural control of whiteflies in Florida. - Bull. U. S. Bur. Ent. 102: 78 pp.
- MOUND L.A., HALSEY S.H., 1978 - Whitefly of the world. British Museum (Natural History) and J. Wiley & Sons, Chichester VIII + 340 pp.
- ONILLON J.C., ONILLON J., 1972 - Contribution a l'étude de la dynamique des populations d'Homoptères inféodés aux agrumes. III. Introduction, in dans les Alpes-Maritimes, de *Cales noacki* How. (Hymenopt., Aphelinidae), parasite d'*Aleurothrixus floccosus* Mask. (Homopt., Aleyrodidae). - C.r.hebd. Séanc. Acad. Agric. Fr. 58: 365-370.
- ORTU S., IBBA I., 1985 - *Aleurothrixus floccosus* (Mask.) in Sardegna. - Atti XIV Congr. naz. ital. Entomologia: 607-614.
- ORTU S., PROTA R., 1986 - Brevi considerazioni sulle recenti introduzioni in Sardegna di entomofagi a protezione della coltura agrumicola. - Frustula entomologica 7-8 (1984-85): 115-123.
- PATTI I., RAPISARDA C., 1980 - Efficacia dell'entomofago *Encarsia lahorensis* (How.) nel controllo biologico del Dialeurode degli agrumi. - Tecnica agricola 32 (5): 291-299.
- PATTI I., RAPISARDA C., 1981 - Reperti morfo-biologici sugli Aleirodidi nocivi alle piante coltivate in Italia. - Boll. Zool. agr. Bachic., ser. II, 16: 135-190.
- RAPISARDA C., 1990a - La *Bemisia tabaci* vettore del TYLCV in Sicilia. - Inf.tore fitopat. 40 (6): 27-31.
- RAPISARDA C., 1990b - Gli aleirodi degli agrumi in Italia. - Phytophaga 3 (1985-89): 173-198.
- RAPISARDA C., PAVONE D., 1992 - Phenology and population dynamics of *Parabemisia myricae* in Eastern Sicily (Homoptera Aleyrodoidea). - Proc. VII Int. Citrus Congress, Acireale (Italy) (in press).
- RAPISARDA C., SISCARO G., LEOCATA S., ASERO C., 1990a - Una nuova «mosca bianca» negli agrumeti italiani. - Terra e Vita 31 (41): 30-31.

- RAPISARDA C., SISCARO G., LEOCATA S., ASERO C., 1990b - *Parabemisia myricae*, un nuovo aleirode degli agrumi in Italia. - Inf.tore fitopat. 40 (12): 25-30.
- RAPISARDA C., SISCARO G., RUSSO A., LONGO S., 1991 - Primi dati bionomici e notizie sul controllo biologico di *Parabemisia myricae* in Calabria e Sicilia orientale (Homoptera Aleyrodoidea). - Atti XVI Congr. naz. ital. Entomologia: 423-427.
- ROSE M., DE BACH P., WOOLLEY J., 1981 - Potential new citrus pest: Japanese Bayberry Whitefly. - California Agriculture 35: 22-24.
- ROSE M., ROSEN D., 1992 - *Eretmocerus debachi* n. sp. (Hymenoptera: Aphelinidae), an effective parasite of *Parabemisia myricae* (Homoptera: Aleyrodidae). - Israel J. Entomology 25-26: 199-207.
- SINACORI A., LO VERDE G., MINEO G., 1991 - Parassitoidi di *Bemisia afer* (Priesner & Hosny) e *Parabemisia myricae* (Kuwana) (Hom.: Aleyrodidae) in Sicilia occidentale. - Atti XVI Congr. naz. ital. Entomologia: 437-441.
- STERNLICHT M., 1979 - *Parabemisia myricae*, a new pest in Israel. - Hassadeh, 59: 1830-1831.
- SWIRSKI E., 1985 - Integrated control of Arthropods of subtropical fruit trees in the Mediterranean Region. - Atti XIV Congr. naz. ital. Entomologia: 781-799.
- SWIRSKI E., IZHAR Y., WYSOKI M., BLUMBERG D., 1986 - Overwintering of the Japanese Bayberry Whitefly, *Parabemisia myricae*, in Israel. - Phytoparasitica 14: 281-286.
- TRANFAGLIA A., BATTAGLIA D., SPICCIARELLI R., 1989 - Primi reperti sull'aleurode fioccoso degli agrumi (*Aleurothrixus floccosus* Mask.) (Hom. Aleyrodidae) e sul suo antagonista *Cales noacki* How. (Hym. Aphelinidae) in Basilicata. - Professione Agricoltore 5-6: 25-27.
- VIDANO C., NAVONE P., 1987 - Osservazioni su *Dialeurodes citri* (Ashm.), *Bemisia afer* (Priesn. & Hosny) e loro parassitoidi in Liguria. - Atti Convegno su «Il recente contributo della ricerca allo sviluppo dell'agrumicoltura italiana», Cagliari, 29/4 - 3/5/1986, Ed. C. Delfino, Roma: 527-532.
- VIGGIANI G., 1976 - Sull'introduzione di *Prospaltella lahorensis* How. per il controllo biologico di *Dialeurodes citri* (Ashm.) in Italia. - Atti XI Congr. naz. ital. Entomologia: 375-377.
- VIGGIANI G., 1988 - Citrus Pests in Mediterranean Basin. - Proc. VI Int. Citrus Congress, Balaban publs., Philadelphia: 1067-1073.
- VIGGIANI G., MAZZONE P., 1977 - Introdotta in Italia la *Prospaltella lahorensis* How. per il controllo biologico di *Dialeurodes citri* (Ashm.). - Inf.tore fitopat. 27 (10): 5-7.
- VIGGIANI G., MAZZONE P., 1978 - Morfologia, biologia e utilizzazione di *Prospaltella lahorensis* How. (Hym. Aphelinidae), parassita esotico introdotto in Italia per la lotta biologica al *Dialeurodes citri* (Ashm.). - Boll. Lab. Ent. agr. «Filippo Silvestri», Portici 35: 99-160 + 1 tav.
- WISOKI M., COHEN M., 1983 - Mites of the family *Phytoseiidae* (Acarina, Mesostigmata) as predators of the Japanese bayberry whitefly, *Parabemisia myricae* Kuwana (Hom. Aleyrodidae). - Agronomie 3 (8): 823-825.
- YAN F.M., 1988 - New records of Aleyrodidae from China. - Experientia 10 (1-2): 50.

PROF. SEBASTIANO BARBAGALLO, PROF. ISIDORA PATTI, PROF. CARMELO RAPISARDA - Istituto di Entomologia agraria, Università degli Studi, Via Valdisavoia 5, I-95123 Catania.

PROF. SANTI LONGO - Istituto di Difesa delle Piante, Università degli Studi, Piazza S. Francesco 2, I-89061 Gallina (Reggio Calabria).

Ricevuto il 7 luglio 1992; pubblicato il 16 luglio 1992.

