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Encarsia Forester (Hymenoptera: Aphelinidae) - Effective Parasitoids of Armored Scale Insects (Hemiptera: Diaspididae) in Egypt

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Abstract: *Encarsia* Forester (Hymenoptera: Aphelinidae) species are some of the most important biological control agents of armored scale insects (Hemiptera: Diaspididae) worldwide. The results of our studies indicate that there are 5 species of *Encarsia* associated with armored scale insects in Egypt: *Encarsia aurantii* (Howard), *E. berlesei* (Howard), *E. citrina* (Craw), *E. lounsburyi* (Berlese & Paoli) and *E. perniciosi* (Tower). The seasonal abundance of these five species was observed on four crops infested with five armored scale insect species in five governorates of Egypt in 2011 and 2012. Results indicate that *E. aurantii* had the highest effective rates of parasitism on *Parlatoria oleae* (Colvee), reaching 40.2 and 45.2% respectively in the two years of the investigation. The comparable maximum parasitism rates for the other species were: *E. citrina* 33.2 and 26.4% on *Parlatoria ziziphi* (Lucas), *E. berlesei* 28.4 and 26.4% on *Pseudaulacaspis pentagona* (Targioni Tozzetti), *E. lounsburyi* 19.5 and 15.4% on *Aonidiella aurantii* (Maskell), and *E. perniciosi* 11.3 and 11.9% on *Lepidosaphes pallida* (Maskell). A diagnosis and a key to the species of *Encarsia* parasitising armored scales in Egypt is provided, along with information on the distribution and role that each species plays in the biological control of its hosts.

Key words : *Encarsia*, Aphelinidae, armored scale insects, Diaspididae, parasitoids, biocontrol, % parasitism, survey.

Introduction

Armored scale insects (Hemiptera: Diaspididae) are notorious plant pests on fruit and nut trees, ornamental shade trees, shrubs and ground cover, forest trees and in greenhouses and indoor plants (Miller, Davidson 2005). The main injury is caused by their injection of toxic saliva, which is manifested in the reduction of plant vigor. Severely infested plants grow poorly, leaves drop prematurely, and trees suffer dieback of twigs and branches; some can be so weakened that they die. Control of these pests by the application of chemical insecticides is a quick and easy step towards the reduction of their population density. However, the use of pesticides is accompanied by many problems, which include the toxic effects on humans and animals as well as on beneficial insects. Pesticides also badly affect soil fauna through their accumulation in the soil. However, the control of armored scale insects in Egypt still relies on the use of insecticides, such as organophosphates or mineral oils, especially in the summer during heavy infestations (Abd-Rabou 1997).

Encarsia Forester species (Hymenoptera: Aphelinidae) have played a prominent role in the history of the control of diaspidids (Noyes, Hayat 1994) and their abundance in Egypt has been commented on by several authors (Priesner, Hosny 1940; Abd-

Rabou 1997, 2000, 2001; Evans, Abd-Rabou 2005). As far as we know, the first successful use of *Encarsia* involved the introduction of *E. berlesei* (Howard) to Italy in 1905-6 to control *Pseudaulacaspis pentagona* (Targioni-Tozzetti), an armored scale that was seriously threatening Italian sericulture. Another historical example of the successful use of *Encarsia* was that of *E. aurantii* (Howard) to control *Melanaspis obscura* (Comstock) in California. Also, *Encarsia perniciosi* (Tower) (Clausen 1978) has been important in the control of San Jose Scale, *Diaspidiotus perniciosus* (Comstock). The host-specificity of *Encarsia* species makes them ideal as biological control agents. Given this host specificity and enormous diversity, *Encarsia* species represent a huge, untapped resource for the biological control of armored scales.

The present work outlines the diagnoses, distribution, abundance and role in biological control of armored scale insects in Egypt by *Encarsia* species.

Materials and Methods

Information on the abundance of *Encarsia* parasitoids of armored scale insects was gathered in five governorates: El-Minya, Giza, Qalyubyia, Northern Coast and Sharqiya on citrus (*Citrus* sp.), oranges (*Citrus sinensis*), apricot (*Prunus armeniaca*), olive (*Olea europaea*) and mango (*Mangifera indica*). The orchards selected for these investigations had received no chemical control measures for several years and those infested with armored scale insects were examined in the field during 2011 and 2012, using a pocket lens. Ten trees of approximately similar age, size, shape and growth condition were randomly chosen for sampling. Infested parts of each crop were collected at monthly intervals from each location and consisted of 30 leaves and 15 twigs (20cm long) infested with scale insects. These were placed separately in paper bags for further examination in the laboratory, where each leaf was stored in a well-ventilated emergence glass tube and monitored daily for parasitoid emergence. Identification of *Encarsia* was made by examining slide mounted adults in Hoyer's medium. The rate of parasitism was determined by dividing the number of emerged parasitoids from each sample by the number of hosts scales present in the sample. The data on percentage parasitism and weather factors were analysed by simple correlations and regressions using the Statistical Analysis System (SAS Institute 1989)

Results and Discussion

During the present survey, 5 species of *Encarsia* associated with armored scale insects were collected from the samples, namely: *E. aurantii* (Howard); *E. berlesei* (Howard); *E citrina* (Craw); *E lounsburyi* (Berlese & Paoli), and *E. perniciosi* (Tower)

Key to the Egyptian *Encarsia* attacking armored scale insects

1. Stigmal vein of fore wing with an evident asetose area proximally. Longest seta on marginal fringe of fore wing equal to or greater than the maximum width of wing disc……
……**2**

- Stigmal vein of fore wing without an evident asetose area proximally. At least one small seta proximal to stigmal vein ……...……
……..... **3**

2. Submarginal vein of fore wing with 1 seta ……..…***E. lounsburyi*** **(**Berlese & Paoli)

- Submarginal vein of fore wing with 2 setae..... ***E. citrina*** **(**Craw)

3. F1 and F2 similar in length, each about 1.5x as long as wide; valvulae III pale; marginal fringe 0.3× as long as width of wing, marginal vein with 8 or 9 setae .....
..... E. berlesei (Howard)

- F1 about half as long as F2, F1 transverse to slightly or longer than wide; valvulae III pale or dark brown; marginal fringe more than 0.3× as long as width of wing 4

4. Head yellow with a dark transverse band between eyes above toruli; valvulae III dark brown with parallel sides ……..…….
.....***E. perniciosi*** **(**Tower)

- Head dark brown with yellow frontovertex, without a dark transverse band between eyes above toruli; valvulae III yellow with slightly concave dark brown sides ……..……
……..……..***E. aurantii*** **(**Howard**)**

1. *Encarsia aurantii* (Howard)

Diagnosis: Body dark brown with yellowish areas on frontovertex of head, posterior third of midlobe, entire scutellum, and apex of gastral segment T7; face without dark brown cross bands above toru-

li, forewing infuscate under marginal vein; legs yellow with dark brown coxae and hind coxae; midlobe of mesoscutum with 4 pairs of setae; side lobes of mesoscutum each with two or fewer setae. Antennal club 3-segmented F1 very short, transverse, less than half as long as F2. Ovipositor very short, clearly much shorter than mid tibia.

Distribution: Beheira, Fayoum, Ismailia, Matruh, Northern Coast, Qalyubiya and Sharqiya governorates.

Remarks: This species was recorded for the first time in Egypt by Hafez (1988).

Abundance: *E. aurantii* emerged from *Parlatoria oleae* (Colvee) collected on olive trees from the Northern Coast. The maximum parasitism rate reached 40.2%/per 30 leaves and 15 twigs (2011) and 45.2% (2012) in mid-November (with mean parasitism rates of 14.2 and 17.7% respectively). The density of *P. oleae* was considered moderate at 951 (2011) and 812/30 leaves and 15 twigs (2012) (Fig. 1). Simple correlations between maximum and minimum temperature, % relative humidity and the percent parasitism of this parasitoid were not significant (r = -0.31, -0.40 and 0.085 respectively during 2011; r = -0.42, -0.51 and 0.076 respectively for 2012); similarly the simple regressions for these parameters were also not significant (b = 2.14, 4.35 and 0.16 for 2011; and b = 2.23, 3.346 and 0.19 respectively for 2012).

Role as a biological control agent. *E. aurantii* is one of the more effective parasitoids attacking armored scale insects in Egypt. The highest level of parasitism was recorded from *Hemiberlesia lataniae* (Signoret) and *P. oleae*, with 61% and 71% respectively. About 44,000 *E. aurantii* were released on olive trees infested by *P. oleae* in the Northern Coast region and the percentage parasitism increased from 44% to 71% (Abd-Rabou 2001).

2. *Encarsia berlesei* (Howard)

Diagnosis: Body dark brown except for following yellowish areas: frontovertex of head; anterior third of midlobe, entire scutellum, and apex of T7 segment; face without dark brown cross bands above toruli. F1 and F2 longer than wide, subequal and without longitudinal sensillae; club with 3 very elongate segments; midlobe with 4 pairs of setae; side lobes of mesoscutum each with two or fewer setae. Ovipositor either subequal in length to mid tibia or slightly shorter.

Distribution: Alexandria and Qalyubyia governorates.

Remarks: This species was recorded for the first time in Egypt by Priesner, Hosny (1940).

Abundance: *E. berlesei* was found associated with *P. pentagona* infesting apricot trees in Qalyubyia. The maximum parasitism rates reached 28.4 % per 30 leaves and 15 twigs in 2011 and 26.4 in 2012 at the beginning of October; mean parasitism rates were 11.8 and 10.0% respectively (Fig.2); The maximum population of *P. pentagona* was 1412/30 leaves and 15 twigs in 2011 and 1283 in 2012. The simple correlations between maximum and minimum temperatures, % relative humidity and the percent parasitism were not significant (r = 0.40, -0.25 and -0.024 respectively for 2011; r = 0.51, 0.36 and -0.035 respectively for 2012). The simple regressions for the same parameters were also not significant (b = 4.35, 1.52 and 0.0025 respectively for 2011; and b = 5.32, 1.63 and 0.045 respectively for 2012).

Role as a biological control agent. During the present work, this species was collected only associated with *P. pentagona*, of which it is a specific parasitoid

3. *Encarsia citrina* (Craw)

Diagnosis: Body largely dark brown with pale areas as follows: head, posterior third of midlobe, scutellum and apex of T7 gastral segment. Midlobe with 2 pairs of setae, first pair of scutellar setae very short; longest seta on marginal fringe of fore wing less than maximum width of wing disc. Submarginal vein of fore wing with 2 setae.

Distribution: Cairo, North Sinai (El-Arish), Giza and Qalyubiya governorates.

Remarks: This species was recorded for the first time in Egypt by Priesner, Hosny (1940).

Abundance: *Enacrsia citrina* was collected associated with *Parlatoria ziziphi* (Lucas) on citrus in Giza. The maximum parasitism rate reached 33.2 % per 30 leaves and 15 twigs (2011) and 26.4 (2012) at the beginning of December; the mean parasitism rates were 13.1% and 10.2 % respectively. The population of *P. zizyphi* was considered moderate at 641 in 2011 and 526/30 leaves and 15 twigs in 2012 (Fig.3). Simple correlations between maximum and minimum temperature, relative humidity % and the percent parasitism of this parasitoid were significant (r = 0.62, 0.57 and 0.42 respectively during the 2011; r = 0.71, 0.58 and 0.48 respectively in 2012).

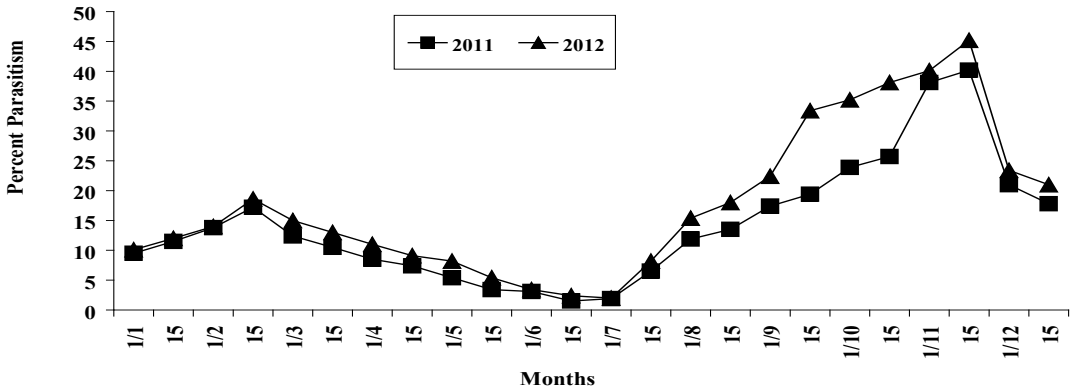

Fig. (1). Percent parasitism of *Parlatoria oleae* infesting olive in Northern Coast by Encarsia aurantii during 2011and 2012

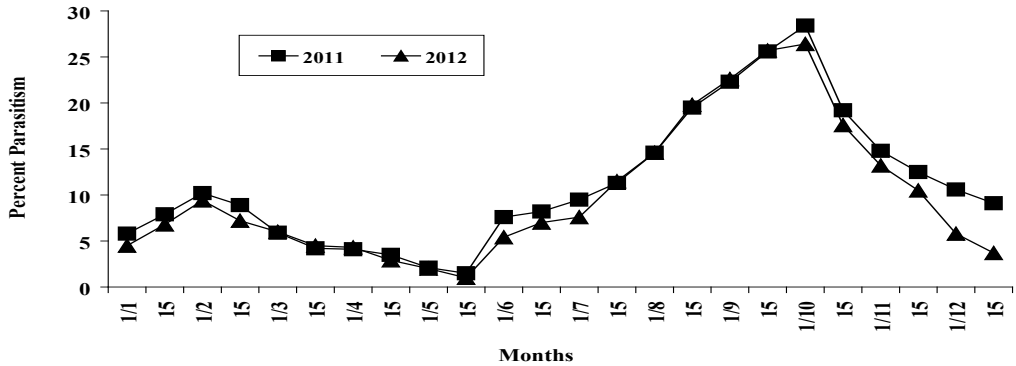

Fig. (2). Percent parasitism of *Pseudaulacaspis pentagona* infesting apricot in *Qalyubyia governorate* by *Encarsia berlesei* during 2011and 2012

However, simple regressions of maximum, minimum temperature, % relative humidity and the percent parasitism were not significant (b = 0.77, 0.62 and 0.51 respectively for 2011; and b = 0.81, 0.55 and 0. 41 respectively for 2012).

Role as a biological control agent. This species has been reared from 8 species of diaspidid scale insects, namely *Aonidiella aurantii* (Maskell), *Aspidiotus nerii* Bouche, *Chrysomphalus aonidum* (Linnaeus), *Chrysomphalus dictyospermi* (Morgan), *Lepidosaphes gloverii* (Packard), *Lepidosaphes beckii* (Newman), *Lindingaspis floridana* Ferris, *Parlatoria ziziphi* (Lucas), and the maximum parasitism rates ranged between 23 and 65%. It is considered a promising biological control agent of armored scale insects in Egypt (Abd-Rabou 1997).

4. *Encarsia lounsburyi* (Berlese & Paoli)

Diagnosis: Head, midlobe and scutellum pale yellow; axillae and gaster dark brown; midlobe with 2 pairs of setae; first pair of scutellar setae very short; longest seta on marginal fringe of fore wing less than maximum width of wing disc; submarginal vein of fore wing with 1 seta.

Distribution: Assiut, Aswan, Beni-Suef, El-Minya, Fayoum, Giza and Sohag governorates.

Remarks: This species was recorded for the first time in Egypt by Priesner, Hosny (1940).

Abundance: *Encarsia lounsburyi* was found associated with *Aonidiella aurantii* (Maskell) on citrus in El-Minya. The maximum parasitism rate reached 19.5% in 2011 and 15.4% in 2012 per 30 leaves and 15 twigs in mid-May; the mean parasitism rates were 8 and 4.7% respectively. The populations of *A. aurantii* were considered to be moderate at 1512 (2011) and 1154 (2012)/30 leaves and 15 twigs (Fig.4). Simple correlations between maximum and minimum temperature, % relative humidity and the percent parasitism of this parasitoid were significant (r = 0.71, 0.65 and 0.46 respectively for 2011; r = 0.62, 0.52 and 0.41 respectively for 2012), while the simple regressions for the same parameters were not significant (b

= 0.68, 0.63 and 0.49 respectively for 2011; b = 0.77, 0.63 and 0. 52 respectively for 2012).

Role as a biological control agent. Abd-Rabou (2000) recorded this species associated with 13 species of armored scale insects in Egypt and considered it to be an effective parasitoid on armored scale insects.

5. *Encarsia perniciosi* (Tower)

Diagnosis: Body dark brown except for face, posterior third of midlobe and scutellum; valvulae III dark brown; face with dark brown cross bands above toruli; antennae with F2 about twice as long as F1 and with 2 linear sensilla . Fore wings with 2 or 3 setae basal to parastigma. Marginal fringe varying from slightly longer than one sixth to two-fifth of wing width.

Distribution: Sharqiya governorate.

Remarks: This species was recorded for the first time in Egypt by Evans, Abd-Rabou (2005).

Abundance: *Encarsia perniciosi* was collected associated with *Lepidosaphes pallida* infesting mango in Sharqiya. In mid-November, the maximum parasitism rate reached 11.3% in 2011 and 11.9% in 2012 per 30 leaves and 15 twigs; mean parasitism rates were 4.2 and 3.1% respectively. The populations of *L. pallida* were considered to be moderate at 878 (2011) and 779 (2012) per 30 leaves and 15 twigs respectively (Fig.5). Simple correlations between maximum and minimum temperatures, % relative humidity and the percent parasitism of this parasitoid were significant (r = 0.62, 0.56 and 0.49 respectively for 2011; r = 0.58, 0.61 and 0.44 respectively for 2012). Simple regressions of the same

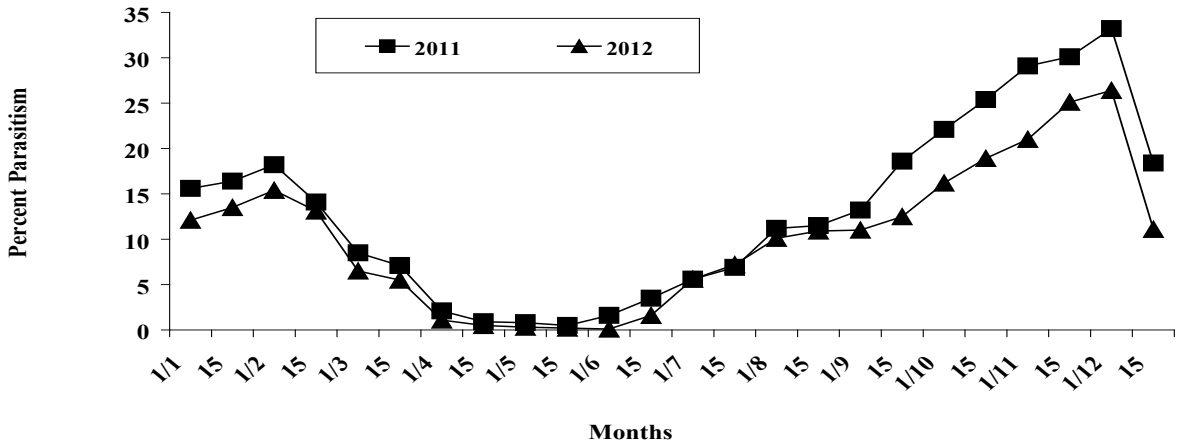

Fig. (3). Percent parasitism of *Parlatoria ziziphi* infesting citrus in Giza governorate by *Encarsia citrina* during 2011and 2012

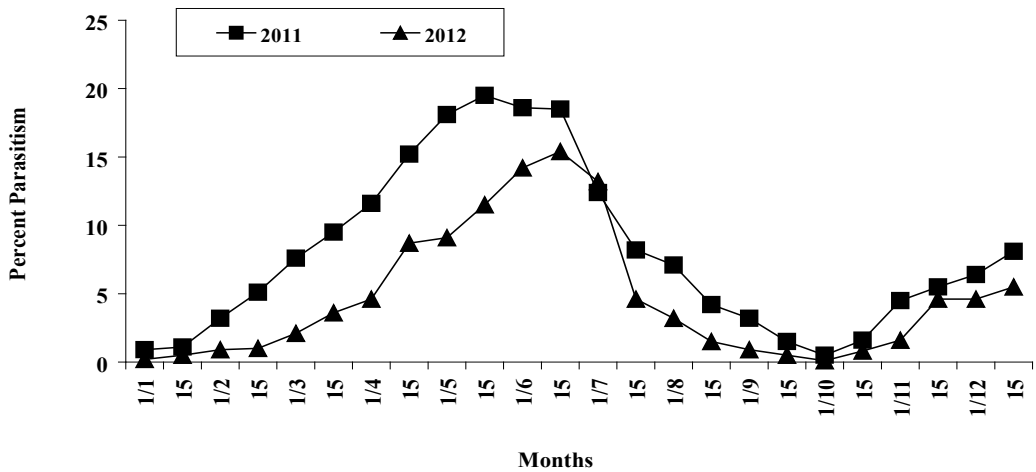

Fig. (4). Percent parasitism of *Aonidiella aurantii* infesting citrus in El-Minya governorate by *Encarsia lounsburyi* during 2011 and 2012

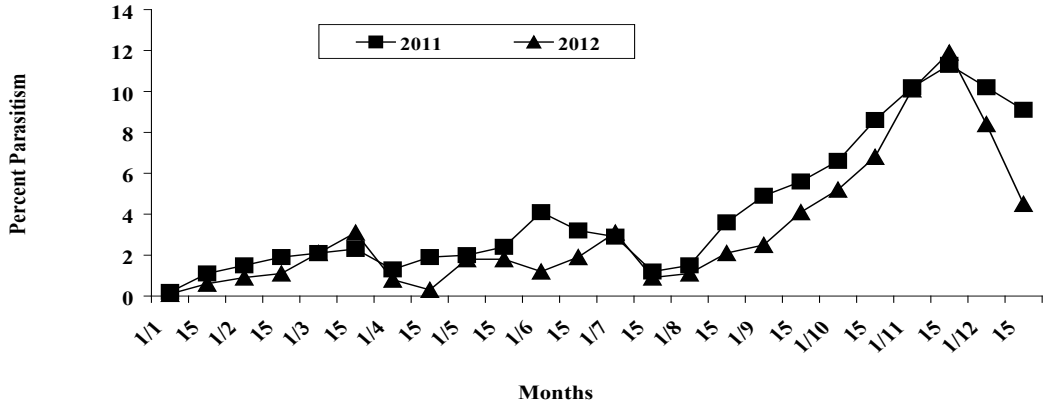

Fig. 5. Percent parasitism of *Lepidosaphes pallida* infesting mango in Sharqiya governorate by *Encarsia perniciosi* during 2011 and 2012

parameters were not significant (b = 0.66, 0.59 and 0.42 respectively for 2011; b = 0.61, 0.58 and 0.42 respectively for 2012).;

Role as a biological control agent. This parasitoid was collected and studied for the first time during the present work.

Conclusions

These results indicate that at least some *Encarsia* species are affected by weather factors. The maximum parasitism rates occurred during May, November and December, when the temperatures ranged between 15 and 27ºC and the relative humidity between 50 and 65%. It is concluded that *Encarsia* is most active during periods of mild temperature and moderate relative humidity.

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