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Encarsia citrina (Crawford) (Hymenoptera, *Aphelinidae*), a parasitoid of *Unaspis citri* (Comstock) and *Lepidosaphes beckii* (Newman) (Homoptera, Diaspididae) in citrus orchards of São Miguel island (Azores)

A. O. SOARES, R. B. ELIAS y H. SCHANDERL

En dos parcelas de naranjo, var. Valencia late, se ha estudiado durante 1995 y 1996 la variación estacional de la abundancia y parasitismo activo de *Encarsia citrina* (Crawford), en relación a la estructura poblacional de sus hospederos, la cochinilla nevada de los cítricos, *Unaspis citri* (Comstock), y la serpeta gruesa, *Lepidosaphes beckii* (Newman). Se ha determinado la proporción anual del parasitismo en relación a los estadios de desarrollo de las poblaciones de los cóccidos diaspinos.

E. citrina es un endoparásito que contribuye de forma acusada para el control biológico de las poblaciones de las cochinillas, disminuyendo la proporción de inmaduros en *U. citri* y de los machos de *L. beckii.*

La actividad del vuelo y de la puesta es máxima en primavera y verano, siendo la proporción del parasitismo activo, en *U. citri,* mas baja en verano y elevada en las otras estaciones. Con respecto a *L. beckii,* se observan las más elevadas actividades en verano y primavera. El parasitismo y abundancia estacional de *E. citrina,* dependen de la presencia de los estados de desarrollo susceptibles de ser parasitados y de las condiciones abióticas del habitat.

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Palabras clave: Cítricos, parasitismo, diaspinos, parasitismo activo, *Encarsia citrina, Unaspis citri, Lepidosaphes beckii.*

INTRODUCTION

In São Miguel island, 23 species (of 11 families) of phitophagous insects, are known (CARVALHO *et al.,* in press). Among them, *Lepidosaphes beckii* (Newman) and *Unaspis citri* (Comstock), have the highest values of abundance, representing about 80% of the total frequency of Homoptera Coccoidea. They are also the most constant species in São Miguel (Soares, 1995). Chemical treatments are regularly applied, due to the absence of predators and the reduced abundance of parasitoids. However parasitoids have the main role in the biological control of armored scales insects.

The genus Unaspis was recorded for the first time in São Miguel at the beginning of the century, and was considered at the time as one who caused great damage to citrus (BENSAÚDE, 1927). *Encarsia citrina* (Crawford) is one of its natural enemies. This is a uniparental species, primary and solitary endoparasitoid of young stages of armored scale insects (VIGGIANI, 1990). *E. citrina* is one of the most poliphagous aphelinid species, and can be found parasitising *Aonidiella aurantii* (Maskell), *Lepidosaphes beckii*

(Newman), *Aonidia* (Targioni-Tozzetti), *Aulacaspis* sp. (Cockerell), *Chionaspis* sp. (Signoret), *Dynaspidiotus* sp. (Thiem & Gerneck), *Parlatoria* sp. (Targioni-Tozzeti), *Quadraspidiotus* sp. (MacGillivray), among others (NASCA *et al.*, 1981; PRINSLOO, 1984; VIGGIANI, 1990). In the Mediterranean basin, it is refered as a parasitoid of *L. beckii* and *Chrysomphalus dictyospermi* (Morgan), although it has never been observed in Portugal (CARVALHO, 1990).

The most important natural enemy of *L. becki* is *Aphytis lepidosaphes* (Compere). Its origins are in South and Oriental Asia (AVIDOV & HARPAZ, 1969), and is well adapted to the Azorean ecosystems. In São Miguel *A. lepidosaphes* has contributed to reduce *L. beckii* populations, mainly in the spring and beggining of the summer, with levels of parasitism above 30% (SOARES, 1995). During our work *E. citrina* was also found parasitising *L. beckii.*

Bioecology of *Encarsia citrina*

A minute aphelinid species with a little less than 0,5 mm in length. Wings hyaline except for the area beneath the marginal vein of the fore wing, wich is infuscated forming a broad, dark band across the wing blade. The fore wing as a long marginal fringe (PRINSLOO, 1984), and a glabrous area beneath the stigmal vein (VIGGIANI, 1990) (fig. 1). Antenna with eight slender segments, the club segments not clearly different from those of the funicle (fig. 2). Ovipositor hardly protruding at the apex of the abdomen and tarsi five-segmented (fig. 3). Head and thorax dark yellow, the abdomen is blackish brown in contrast (PRINSLOO, 1984).

The larval stages, apparently three in all Aphelinidae, are very similar in shape and structure. In the endoparasitoids there is a reduction in the mandible, and sometimes in the respiratory system (VIGGIANI, 1984). The larvae are fusiform, light translucid. The pupae are dark brown, with a listed abdomen. When adult the parasitoid emerges from its host by a hole in the cover of the mummy (fig. 4).

The present paper aims to record the presence of *E. citrina* for the first time in Azores islands and to describe seasonal variation of the abundance and active parasitism, in relation to the population structure of the hosts, *L. beckii* and *U. citri*. It pretends also to determine the annual proportion of parasitism in the different developmental stages of *L. beckii* and *U. citri.*

MATERIAL AND METHODS

Two citrus orchards with *Citrus sinensis* var. *Valencia late* were selected, in two locations of São Miguel. This selection was based on the fact that those orchards presented high population levels of *U. citri* in location 1 (Ribeira-chã) and *L. beckii* in location 2 (Ginetes). The trees, with approximately 20 years, were in full production.

To follow the seasonal abundance of *E. citrina,* two cromotropic traps were installed, with 2 weeks interval, on each location during 1995, with a month interval, for the first 5 months of 1996. These traps consisted of a glass plaque with 20 × 10 cm. Under the plaque, a yellow lustred paper, was mounted. A sticky substance (of the type «*Tanglefoot*») was spread over the glass.

In order to determine the active parasitism rate and to evaluate the population structure, 60 one year old leaves (5 of each quadrant on 3 trees) were collected, periodically as it happened with the traps. The change in the methodology in 1996 was based on the results of the previous year and those of SOARES (1995), in which was verified that the levels of abundance and active parasitism were low during the first months of the year.

To calculate active parasitism rate we followed the methodology of RODRIGO (1993). Thus, we calculated the percentage of parasitised armored scales, on the leaves, that had alife parasitoids in them, over the total number of armored scales susceptible of being parasitised. The leaves were aconditionated after being collected on plastic bags, and

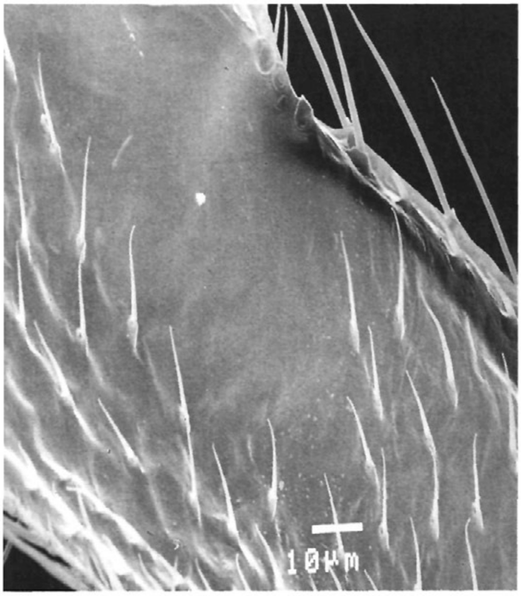

Fig. 1.–Parcial view of the fore wing of *Encarsia citrina,* showing a glabrous area beneath the stigmal vein.

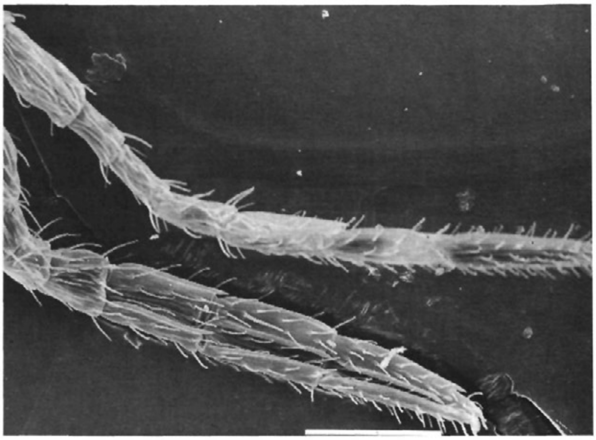

Fig. 2.–Antenna of *E. citrina,* with eight slender segments (antennal formulae 1; 1; 3; 3).

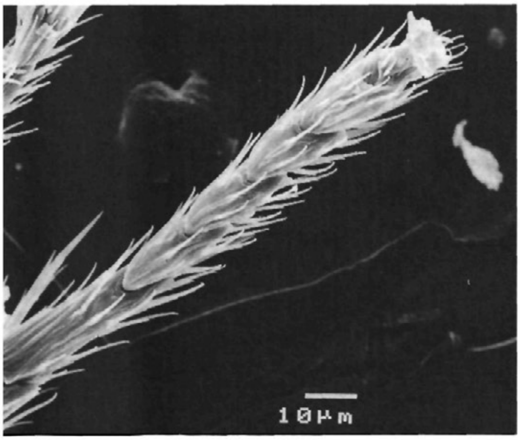

Fig. 3.–Tarsi of *E. citrina,* with five segments.

Fig. 4.–Young female of *Unaspis citri* with an exit hole made by *E. citrina.*

kept under low temperatures. The observations were made in the next 48 hours.

To evaluate population structure, hosts were counted by developmental stage (larvae, young females, adult females, prepupae, pupae and adult males). The presence or absence of the parasitoid, in those stages, was registered.

In order to study some specific characteristics of *E. citrina,* adult individuals were examined with a SEM-JSM-5410. Prior to scanning electron microscopy the specimens were washed in two solutions of ethanol 100% and one of ethanol/acetone 50:50, acetone 100% and hexamethyldisilane, 20 minutes in each of them.

RESULTS AND DISCUSSION

Seasonal abundance of *Encarsia citrina*

In figures 5 and 6, values of seasonal abundance and active parasitism in locations 1 and 2, are given.

In location 1, the higher values of abundance occurred in the end of spring, between May and June 1995, even though considerably lower than those of the second half of August, in which the highest value of abundance was found (1,2 individuals/trap/day). After autumn we observed a great diminution of the population. Those low levels continued until autumn of 1996.

In location 2, and during 1995, the maximum values occurred in the same seasons, with higher values in the first half of June and July (1,8 and 1,7 individuals/trap/day, respectively), and on the second half of August. Once again there was a great diminution of the population levels in 1996.

The flight activity of the parasitoid seams to be related to the population structure of the host, during the year. The absence of stages susceptible of being parasitised contributes to the diminution in the parasitoid abundance. The winter population of *L. becki* and *U. citri,* is mainly composed of adult stages (78% and 40% of the population, respectively), that are not used by the parasitoid, for oviposition. This was verified in field work and in previous works (Soares, 1995). In the winter months the parasitoid is found, like in all Aphelinidae (GAULD & BOLTON, 1988; VIGGIANI, 1984), in the early stages (larvae, prepupae, pupae), in the interior of the host. In the other seasons we can find an heterogeneous population, with a dominance of early stages more suitable to parasitism (VIGGIANI, 1990), mainly due to the appearance of the host generations.

On the other end, we think that reduced flight activity during the winter is also a consequence of abiotic factors (namely, less temperature, more rain fall and wind velocity, and less relative humidity). This also contributes to the lower number of parasitoids captured in the traps. The low population level in 1996 was probably the consequence of the atmospheric conditions registered that winter (figs. 5 and 6). When comparing this winter with the one from 1995, we see that temperature and relative humidity were lower, and that rain fall and wind velocity were higher. As an example, average temperature was 2,4 °C lower, in the winter of 1996. In addition, during 18 days minimum temperatures were lower than 10 °C (the lowest temperature was 6 °C). These conditions may have caused high mortality and a delay in the population development of parasitoid and host, with a reduction on the population levels in the following months.

Seasonal variation of active parasitism

During 1995, on location 1, the higher values of active parasitism occurred in spring and autumn (13,5 and 12,5%, respectively), with the higher values taking place in the first half of April (35,85%) and November (22,1%) (fig. 5). This is related with the beginning of the generations and the presence of stages suitable for parasitism, since the end of spring until the beginning of autumn. The high values observed in autumn went on until the winter of 1996, with an average parasitism of 13,7%. In spring and summer parasitism diminished considerably, showing a tendency to increase only in the end of the year.

In both years parasitism occurred mainly in second instar larvae (47% in 1995 and 71,6% in 1996) (fig. 7). These observations are in agreement with those of Viggiani (1990).

In location 2, parasitism occurred almost exclusively, in prepupae of *L. beckii.* The higher average values (3,2 and 6,6%) were found, respectively, in spring and summer 1995 (fig. 6), in which the proportion of males in the population, is higher. These are expected results according to SOARES (1995). The higher values of parasitism, were 9,7 and 19,9% respectively in the first half of June and second of July of 1995. If we analyze parasitism, considering only males, we have va-

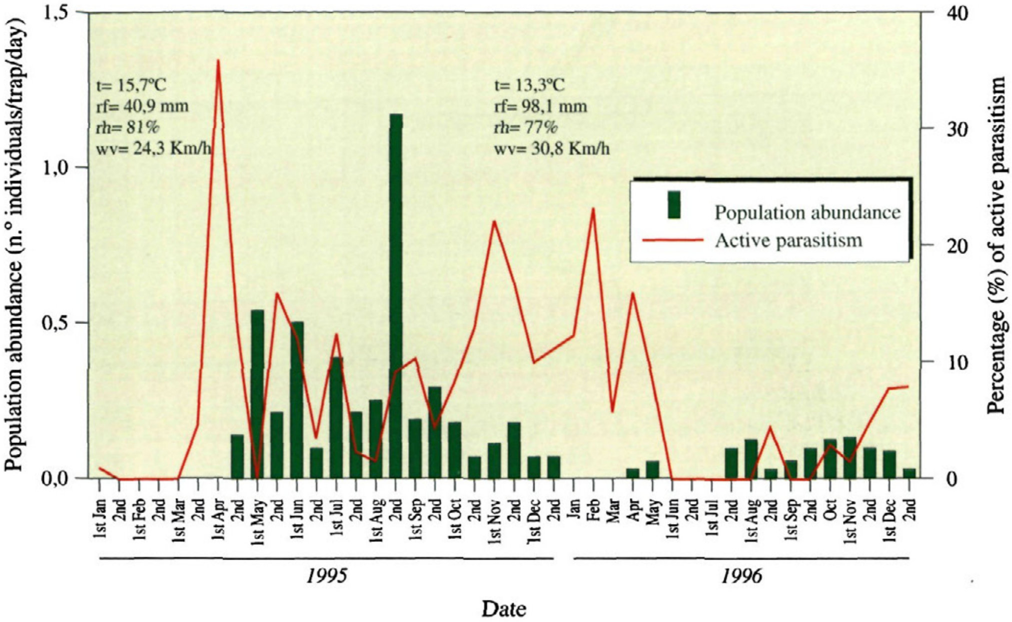

Fig. 5.–Seasonal abundance and active parasitism of *E. citrina*, in location 1. Values of temperature (t), rain fall (rf), relative humidity (rh) and wind velocity (wv), in winter 1995 (average values for the period 01.01.95-31.03.95) and 1996 (average values for the period 01.01.96-31.03.96).

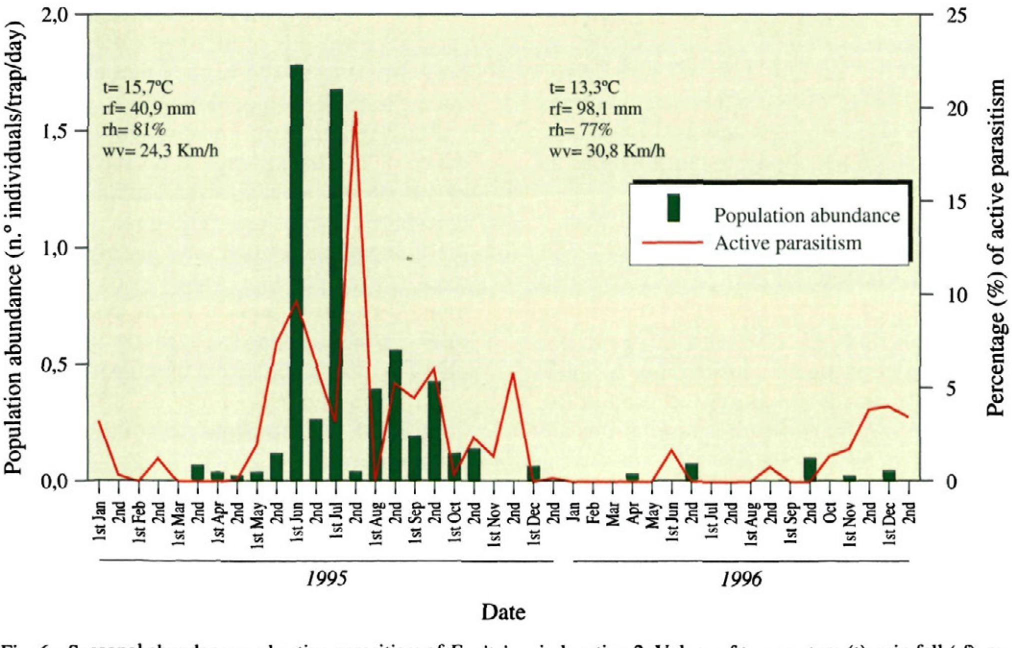

Fig. 6.- Seasonal abundance and active parasitism of *E. citrina,* in location 2. Values of temperature (t), rain fall (rf), relative humidity (rh) and wind velocity (wv), in winter 1995 (average values for the period 01.01.95-31.03.95) and 1996 (average values for the period 01.01.96-31.03.96).

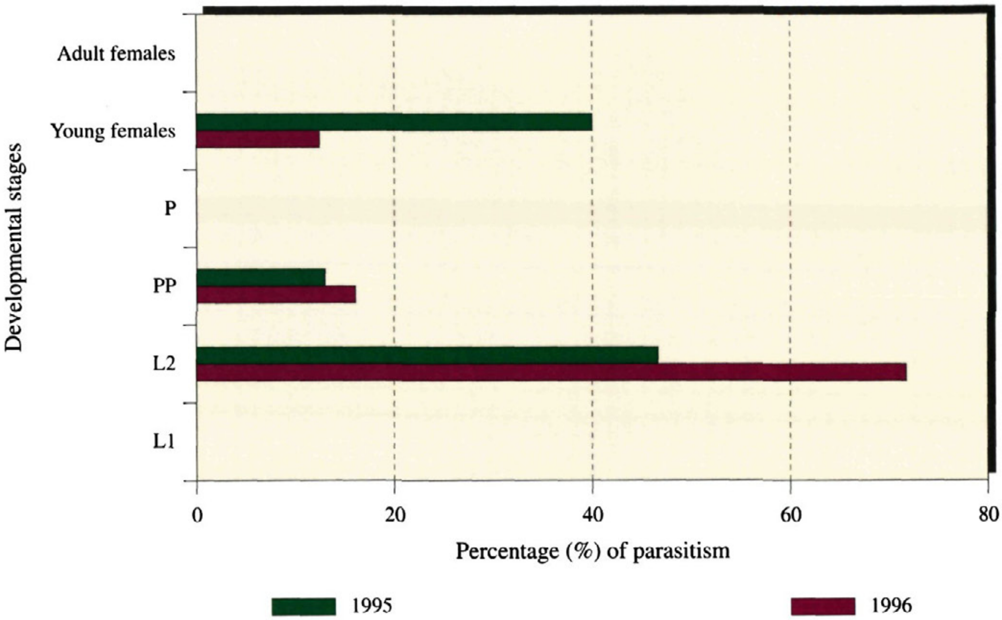

Fig. 7.- Proportion of developmental stages of *U. citri,* parasitised by *E. citrina* (P- Pupae; PP- Prepupae; L2- second instar larvae and L1- first instar larvae).

lues always higher than 10% during most of the spring and summer. As an example, in the second half of July, 63% of males were parasitised by *E. citrina.* Once again, active parasitism was extremely low in 1996. Parasitism occurred mainly on prepupae (100% in 1995 and 96% in 1996) (fig. 8).

CONCLUSIONS

E. citrina has *U. citri* and *L. beckii* as hosts, and contributes considerably to their biological control, lowering the proportion of larvae and males in the populations of *U. citri* of *L. beckii,* respectively.

The highest flight activity and oviposition occurs, for both hosts, in spring and summer.

Active parasitism on *U. citri* is lower in summer, and relatively high in the remaining seasons. This seems to be related to the decrease of larval density during summer, and to the increase in flight activity (which diminishes the percentage of young stages in the population). In *L. beckii,* summer and spring are seasons of high parasitic activity, probably due to the higher percentage of males, in the hosts population.

Active parasitism and population abundance of *E. citrina,* depend on the presence of susceptible stages for parasitism, and on the abiotic conditions. The aggravation of the atmospheric conditions, mainly the decrease of temperature, seems to have an extremely negative impact on the populations of *E. citrina,* causing great losses in the population, and in the levels of parasitism. The population seems to recover, after a few months, if the atmospheric conditions are back to normal.

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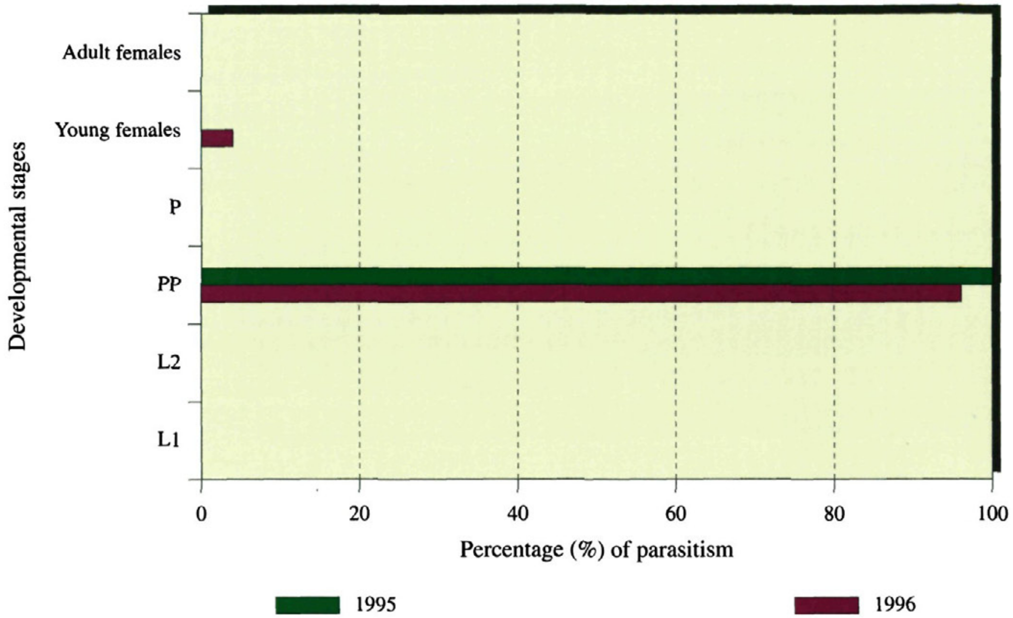

Fig. 8.- Proportion of developmental stages of *L. beckii*, parasitised by *E. citrina* (P- Pupae; PP- Prepupae; L2- second instar larvae and L1- First instar larvae).

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ABSTRACT

SOARES, A. O.; ELIAS, R. y SCHANDERL, H., 1997: *Encarsia citrina* (Crawford) (Hymenoptera, Aphelinidae), a parasitoid of *Unaspis citri* (Comstock) and *Lepidosaphes beckii* (Newman) (Homoptera, Diaspididae) in citrus orchards of São Miguel island (Azores). *Bol. San. Veg. Plagas*, **23**(3): 449-456.

Two citrus orchards were selected, in order to determine seasonal abundance and active parasitism of *Encarsia citrina* (Crawford), in relation to the population structure of the hosts *Unaspis citri* (Comstock) and *Lepidosaphes beckii* (Newman). Annual proportion of parasitism in the different developmental stages of the hosts is also determined.

Encarsia citrina contributes considerably to the biological control of these armored scales, lowering the proportion of larvae and males in the populations of *U. citri* and *L. beckii*, respectively.

The highest flight activity and oviposition occurs in spring and summer and active parasitism on *U. citri* is lower in summer and relatively high in the remaining seasons. In *L. beckii*, summer and spring are seasons of high parasitic activity. Active parasitism and population abundance of *E. citrina*, depend on the presence of susceptible stages for parasitism, and on the abiotic conditions (mainly temperature).

Key words: Citrus, parasitism, armored scale insects, active parasitism, *Encarsia citrina, Unaspis citri, Lepidosaphes beckii.*

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