

Encarsia Wasp, a Silverleaf Whitefly Parasitoid (suggested) *Encarsia formosa* Gahan (Insecta: Hymenoptera: Aphelinidae)¹

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Introduction

Encarsia formosa Gahan (Hymenoptera: Aphelinidae) (Figure 1) is a small, parasitoid wasp that attacks several species of whiteflies. It is one of the most commercialized natural enemies and used worldwide in controlled production systems (greenhouses and nurseries) for biological control of whiteflies on ornamentals and vegetables (Hoddle et al. 1998). The earliest record of *E. formosa* parasitic activity was observed in 1926, when an English tomato grower observed black pupae among greenhouse whitefly pupae, *Trialeurodes vaporariorum* Westwood (Hemiptera: Aleyrodidae) on the leaves (Figure 2) and over time observed *E. formosa* emerging from these pupae.

In England, *E. formosa* was first used commercially a year later to control *T. vaporariorum* in hothouses (Speyer 1927), and by the 1930's, *E. formosa* had emerged as a successful commercialized natural enemy for whiteflies and was sold to nurseries both within and outside of Europe (Van

Lenteren and Woets 1988). With the growing popularity of synthetic chemical insecticides after World War II, biological control methods became less common, and the demand for the parasitic wasps declined substantially. However, reports of insecticide resistance development among pest insects in the following decades brought biological control methods back into vogue.



Figure 1. *Encarsia formosa* adult searching for a host. Credits: Lance S. Osborne, UF/IFAS

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Figure 2. Whitefly *Bemisia tabaci* nymph parasitized by *Encarsia formosa* wasp.

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Distribution

Encarsia formosa is a cosmopolitan parasitoid with an ambiguous native range (Hoddle et al. 1998). Its similarity to *Encarsia luteola* Howard suggests that this species first emerged in the Western Hemisphere (Hoddle et al. 1998; Polaszek et al. 1992). Current records of its greenhouse usage show that it is widely utilized in various parts of Europe and Russia, and there are excellent prospects for its use in greenhouse production systems in North America and Asia as well, where this species is currently underutilized.

Description

Encarsia formosa is a thelytokous species, where females develop from unfertilized eggs. Males exist but are rare and emerge concurrently with their female counterparts as primary parasitoids. Thelytoky in *E. formosa* is mediated by *Wolbachia* (a genus of sex-determining intracellular bacteria) infections, and while *E. formosa* exhibits mating behavior and males produce sperm, females are unable to be properly inseminated and thus cannot reproduce sexually (Zchori-Fein et al. 1992). Females are typically ~0.6 mm long by 0.3 mm wide, with a black head and thorax and a yellow abdomen (Figure 1). Males are dark in color and may also occur rarely as autoparasites (parasitic on their own species) of female *Encarsia formosa* larvae (Gerling 1966).

Adult *E. formosa* kills its hosts not only by parasitizing the immature stages but also via host feeding (Dai et al. 2012). Adult *E. formosa* feed on immature whiteflies by piercing the host's cuticle with their ovipositor (Figure 3) and then consuming the hemolymph through the wound (Figure 4) ultimately killing the host. Although *E. formosa* feeds on all the immature whitefly stages except the eggs, their

preferred host stage may vary depending upon prey species. Pupae and 2nd instar nymphs of *T. vaporariorum* are the preferred stage for feeding, whereas in *Bemisia tabaci* Genadiusthe pupae and nymphal instars are equally preferred (Hoddle et al. 1998). The size of the adult parasitoid has not been shown to vary by the host stage parasitized but may influence immature development time (Hu et al. 2003). Adult female *E. formosa* oviposit (lay eggs) singly into the sessile immature stages (older than crawler stage) of *B. tabaci*, but prefer to parasitize the 3rd, 4th and pre-pupal nymphal stages. The most reliable sign of a parasitized *T. vaporariorum* nymph is the change in color from clear or translucent to black, which occurs about two weeks after parasitism. This dramatic color change does not occur in parasitized *B. tabaci*. Whitefly nymphs which have been previously probed for feeding are not used for parasitism and vice-versa (Hoddle et al. 1998).



Figure 3. *Encarsia formosa* adult female inserting its ovipositor in a whitefly nymph.

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Figure 4. Host feeding of a *Bemisia tabaci* nymph by an adult *Encarsia formosa*.

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Biology

Female *E. formosa* find suitable hosts for oviposition via fly-and-walk sequences or “roaming”, which is mediated by complex visual and chemical cues (Guerrieri 1997). Female *E. formosa* lay 8-10 eggs per day, although this rate slows as the females age. Females lay a single egg per whitefly. On *B. tabaci*, it was found that *E. formosa* larval development times varied based on the prey instar parasitized, and their development time was less when parasitizing older instars (Hu et al. 2003; Liu et al. 2016). Depending on the prey species, host plant, and the whitefly instar parasitized, development from embryo to adult can take 14 - 25 days (Hoddle et al. 1998; Hu et al. 2003). Environmental temperature can greatly influence their life cycle parameters; for instance at 30°C, developmental time from egg to adult can take about 10 days; however, at 18°C it can take as long as 40 days (Osborne and Ehler 1981). The optimal temperature for development and parasitism rates is about 27°C. *Encarsia formosa* females live for approximately 12 days and can lay 59 eggs during this time with *T. vaporariorum* as a host (Hoddle et al. 1998).

Hosts

Information on *Encarsia formosa* habitat and associated plants is restricted almost exclusively to greenhouse settings. Economically important crops on which this parasitoid is mostly used are as follows: tomato, cucumber, eggplant, cotton, tobacco, strawberry, and poinsettia (Hoddle et al. 1998). *Encarsia formosa* can attack > 15 species of whitefly among which *T. vaporariorum* and *B. tabaci* are of the greatest economic concern to the greenhouse producers. *Encarsia formosa* has also been observed parasitizing other whitefly species including solanum whitefly (*Aleurotrachelus trachoides* Back), honeysuckle whitefly (*Aleyrodes loniceriae* Walker), cabbage whitefly (*Aleyrodes proletella* L), iris whitefly (*Aleyrodes spiraeoides* Quaintance), citrus whitefly (*Dialeurodes citri* Ashmead), *Aleuroglandulus malangae* Russell and *Dialeurodes chitenden* Laing (Polaszek et al. 1992).

Economic Importance

During their lifespan, adult *Encarsia formosa* can kill about 95 *T. vaporariorum* nymphs by ovipositing an average of five eggs per day and feeding on three nymphs per day (Hoddle et al. 1998). A recent study suggested *E. formosa* can consume approximately ten 1st - 2nd instar, or five 3rd - 4th instar *B. tabaci* over a 48 hour period (Zang and Liu 2008), and their host feeding potential can be enhanced by depriving them of food before release (Zang and Liu 2010).

Depending upon the target crop, *E. formosa* can be commercially applied in greenhouses using inundative (mass release of natural enemies for immediate pest control, where establishment is not expected) or inoculative (small releases made when pest populations are low and natural enemies are expected to establish) release strategies. In commercial ornamental production where there are low whitefly damage thresholds and a zero-tolerance policy for items to be exported, inundative releases of *E. formosa* are considered the preferred mode for whitefly control. The inoculative releases of *E. formosa* can be done by any of the methods tested in the past, which include the “pest in first approach” and “dribble method.” As the name suggests, “the pest in first approach” method involves releasing adult whiteflies into the greenhouse before releasing *E. formosa*. The objective here is the successful establishment of the parasitic wasp population in the production system. However, for obvious reasons of needing to release pests into the production system, this method is not widely employed by the growers. The “dribble method” involves releasing *E. formosa* at low rates in anticipation of an arriving whitefly population which will continue until parasitized black whitefly nymphs are observed.

It is difficult to make a general recommendation on the number of parasitoids needed to be released by growers for effective whitefly control, as it depends on many factors including target host plants, greenhouse temperature, whitefly species, and the level of whitefly infestations (Osborne and Ehler 1981). However, depending upon the availability of parasitoids and the cost of their release, it would be best to release an equal number of parasitoids for each whitefly adult. It is worth mentioning that since most of the chemical insecticides can have a negative impact on *E. formosa* populations, parasitoids should be released at least two weeks post application of the insecticides. For optimal results, it is important to follow general cultural practices such as removal of alternate hosts (weeds, plants, cuttings) of the whiteflies from the greenhouse before releasing parasitoids. In the United States, *Encarsia formosa* is commercially sold by multiple vendors of beneficial organisms.

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