Notes on the Morphology and Biology of Syneura cocciphila (Diptera: Phoridae)

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Abstract

Herein we provide information on the morphology and duration of the different stages of development of Syneura cocciphila (Coquillett; Diptera: Phoridae), a phorid-fly predator of the Colombian fluted scale Crypticerya multicicatrices Kondo and Unruh (Hemiptera: Monophlebidae). The time from oviposition to adult emergence was 20.04 d. The duration of the different growth stages was as follows: egg 1.38 (±0.18) d; three larval stages combined 4.5 (±0.19) d; prepupa 1.63 (±0.09) d; and pupa 12.53 (±0.12) d. On average, adult females lived 13.23 (±0.77) d and adult males lived 11.13 (±0.61) d under laboratory conditions. S. cocciphila is a common species in the city of Cali, department of Valle del Cauca, Colombia, and is an effective biological control agent of the scale insect pest C. multicicatrices. This is the first detailed study on the biology of S. cocciphila.

Resumen

Se presenta información sobre la morfología y la duración de los diferentes estados de desarrollo de Syneura cocciphila (Coquillett; Diptera: Phoridae), un mosco depredador de la cochinilla acanalada de Colombia Crypticerya multicicatrices Kondo y Unruh (Monophlebidae Hemiptera). El tiempo de duración desde la oviposición hasta la emergencia de los adultos fue 20,04 días. La duración de los diferentes estados fueron las siguientes: Hueve 1,38 (± 0,18) días; total de los tres estados larvales 4,5 (± 0,19) días; prepupa 1,63 (± 0,09) d; y pupa 12,53 (± 0,12) días. En promedio, las hembras adultas vivieron 13,23 (± 0,77) días y los machos adultos vivieron 11,13 (± 0,61) días en condiciones de laboratorio. S. cocciphila es una especie común en la ciudad de Cali, en el departamento del Valle del Cauca, Colombia, y es un agente de control biológico efectivo del insecto escama plaga C. multicicatrices. Este es el primer estudio detallado sobre la biología de S. cocciphila.

Key words: life cycle, biological control, natural enemy, scale insect, predatory fly

Crypticerya multicicatrices Kondo y Unruh (Hemiptera: Coccomorpha: Monophlebidae) is a polyphagous insect pest native to continental Colombia that became invasive on the islands of San Andrés and Providencia (Kondo et al. 2014). Ornamental trees such as Hibiscus rosa-sinensis L. (Malvaceae); Malvaviscus sp. (Malvaceae); Ficus spp. (Moraceae); Coconut palm, Cocos nucifera L. (Arecaceae); Indian coral tree, Erythrina variegata L. (Fabaceae); papaya, Carica papaya L. (Caricaceae); among another 95 species of plants, are affected by the Colombian fluted scale on these islands (Kondo et al. 2012). In continental Colombia, C. multicicatrices is not a common pest under natural conditions because natural enemies keep its populations under control. However, this scale insect has been found in high populations in commercial orchards where there is a reduction in the populations of natural enemies due to the use of chemical pesticides (Kondo et al. 2012).

Historically, the use of natural enemies in classical biological control programs has proven to be effective against invasive scale insects. Many natural enemies have been reported for C. multicicatrices, i.e., Anovia punica Gordon (González and Kondo 2014), Delphastus quinquefasciatus Gordon, Diomus seminulus (Mulsant)
(González et al. 2012), Rodolia cardinalis (Mulsant) (Pincho et al. 2015) (Coleoptera: Coccinellidae), Ceraeochrysa sp., Chrysoperla sp. (Neuroptera: Chrysopidae) (Kondo et al. 2012, 2014; Montealegre et al. 2016), and the phorid fly, Syneuia coccipha (Coquillet; Diptera: Phoridae) (Gaimari et al. 2012). S. coccipha belongs to a group of small flies, known as phorids or hump-backed flies. Phorid flies display a wide range of feeding habits (Disney 1994); species may be saprophagous, herbivorous, scavengers, fungivorous, predators, parasitoids or kleptoparasites. Gaimari et al. (2012) reported the larvae of S. coccipha feeding inside the ovisacs of C. multicicatrices. Besides C. multicicatrices, S. coccipha is also known to attack another species of icyrne scale, Icerya purchasi Maskell (Hemiptera: Monophlebiidae) (Autfuor 1923, Gaimari et al. 2012). Furthermore, Giomperlik (2010) reported S. coccipha collected from specimens of Crypticeria gemstae (Hempel), an invasive species in Puerto Rico. In that study, Giomperlik (2010) also reported that S. coccipha was at least in part responsible for significant reductions in the prevalence of C. gemstae in Barbados and Florida, together with the coccinellid beetle Anoeca circumlusa (Gorham). The larvae of many phorid species are parasitoids or specialist predators and may be useful as biological control agents. Therefore, S. coccipha has a potential to be used as a natural enemy of the invasive fluted scale C. multicicatrices, as part of a biological control program. The objective of the present study was to generate baseline information on the biological and morphological aspects of S. coccipha under laboratory and field conditions, in order to find management options for C. multicicatrices which has become an urban pest in various cities of Colombia.

Materials and Methods

Sampling Sites and Collection of Specimens

Samples were collected weekly in the city of Cali (03°25′N, 76°31′W, ca 1000 m asl) between February and November 2014. Adult specimens of the Colombian fluted scale, C. multicicatrices were collected by cutting infested branches and twigs of three of its host plants, namely, Caesalpinia pluriosa var. peltrophoroides (Benth.) G.P. Lewis, Pithecellobium dulce (Roxb.) Benth., and Pithecellobium saman (Jacq.) Benth. (Fabaceae). A total of 160 samples of C. multicicatrices were collected in the field in order to collect S. coccipha. Samples were processed at the entomology laboratory of Corpocoa, Palmira Research Station. The infested twigs with C. multicicatrices were cut into smaller pieces and deposited in Petri dishes (each 14.5 cm in diameter) and marked with the following collection data: place of collection, geographical coordinates, altitude, collection date, name of the collector, and the plant host name. Most specimens of C. multicicatrices did not show symptoms of predation by S. coccipha, since most of the predation occurred inside the ovisacs. However, occasionally, some specimens were damaged and were assumed to have been fed by S. coccipha or other predators. The phorid flies, S. coccipha were collected daily in order to carry out the observations needed for the biological and morphological studies.

Biological Studies of S. coccipha

Duration and Description of the Stages of Development of the Phorid Fly S. coccipha

Observations on the biology of S. coccipha were conducted under laboratory conditions at a temperature of 26.6 ± 1.5°C and relative humidity 62.8 ± 6.17%, under natural light conditions, 12:12 (L:D) h. Adult individuals of C. multicicatrices were collected and dissected daily making a longitudinal cut in the ovisacs, in order to determine the presence or absence of S. coccipha larvae. The obtained larvae were measured at widest point when full stretched and separated in Petri dishes. Daily observations were made to determine the duration of the stages of development, until the emergence of the adult. In order to determine the development of egg to larva of S. coccipha, five breeding cages, each 90 cm high × 70 cm wide × 70 cm long were constructed, in which a plant, Caesalpinia pluriosa var. peltrophoroides or areca palm, Dypsis lutescens (H. Wendl.) Beentje and J. Dransf. (Areaceae) infested with adults of C. multicicatrices was introduced. Adults of C. multicicatrices were obtained from a parasitoid-free breeding stock kept in confinement conditions in a greenhouse. Subsequently, five cotton balls were dampened with a mixture of water (10 ml), honey (3 ml) and pollen (4 g) and hung from the cage ceiling as a food source for the adult phorid flies. Copulating pairs of S. coccipha were collected in the field, and were released in each breeding cage so they would oviposit on individuals of C. multicicatrices. Twenty-four hours after the release of the pair of phorid flies, half of the fluted scales were removed, with the remaining scales removed after 48 h. The scale insects removed in each occasion (after 24 h and 48 h, respectively) were dissected under a stereo-microscope in order to locate freshly laid eggs. Eggs were monitored daily in order to determine the development time (days) of eggs and larvae of S. coccipha.

Morphological Studies

Individuals of S. coccipha were dissected in order to describe their morphology and to determine the differences between males and females. The taxonomic key to genera of Brown (2010) was used to identify the specimens as Syneuia, corroborated by the key of Brués (1903), and S. coccipha was determined using the key of Prado (1976) and comparing the descriptions among the known species of Syneuia. It is noteworthy that S. coccipha is the only species in the genus with a hairy mesopleuron.

Longevity of Adults

Individuals of S. coccipha were isolated in glass vials that were used as breeding chambers. A cotton ball moistened with the mixture of water, honey and pollen was placed inside the glass vial for hydration and feeding of the phorids. From the samples collected in the field, 30 newly emerged males and females of S. coccipha were obtained, respectively, which were individually placed in each flask. With the information obtained, the adult life time of S. coccipha was estimated under laboratory conditions.

Sex Ratio

Sixty pupae of S. coccipha were separated in Petri dishes obtained from laboratory samples. The pupae were observed daily with the aid of a stereoscope until the emergence of the adult flies. Once all flies had emerged, the sex (male or female) of each individual was identified. The sex ratio data were analyzed using a Chi-square hypothesis test. Data obtained from the duration and measurements of the stages of development of S. coccipha were subjected to descriptive statistics using the statistical program InfoStat version 2008 (INFOSTAT 2008).

Results and Discussion

Duration of the Stages of Development of S. coccipha

According to the results of the trials (Table 1), the egg-to-adult life cycle of S. coccipha has an average duration of 20.04 ± 0.58 d (Fig. 1). Our results differ from those reported by López and Gieschen (1946), where they suggest that a new generation of S. coccipha occurs every 26 d.
The variation in the number of days in the life cycle depends on the environmental conditions in which the experiment is carried out. El-Miniawi and Moustafa (1965) reported that for the phorid fly, *Megaselia scalaris* (Loew 1866) (Diptera: Phoridae) at temperatures of 27°C, for both males and females, egg hatching occurred after 0.7 d, the larval stage lasted 5–7 d in females and 4–6 d in males, the pupal stage lasted 9 d for females and males.

Description of the Stages of Development of *S. cocciphila*

**The Egg**

A total of 15 eggs of *S. cocciphila* were found during the dissections of the ovisacs, out of which only eight hatched. These eggs were evaluated daily and it was found that *S. cocciphila* remains on average in the egg stage for 1.38 (±0.18) d (Table 1) and a range between 1 and 2 d. *S. cocciphila* ovisposits within the ovisac of *C. multicicatrices* (Figs. 1 and 2A). Eggs are white, translucent, ovoid, approximately 0.52 (±0.0037, n = 5) mm long, and 0.21 (±0.002, n = 5) mm wide (Figs. 1 and 2A). The observations were similar to those reported by García et al. (2010) for the species *M. scalaris*, which eggs are whitish and ovoid, measuring 600 × 220 microns. Occasionally, large-size larvae of *S. cocciphila* were found, which measured 0.79 mm long and 0.27 mm wide (±0.02, n = 5), slightly larger than the eggs, which suggests that the time from when the first-instar larva hatches till it becomes a second-instar is very short. According to Disney (1994), eggs of some species of phorid flies hatch between 2 and 4 d. It was more common to find larvid than eggs of *S. cocciphila* inside the ovisacs of *C. multicicatrices*.

**Larva**

Due to the small size of the larvid of *S. cocciphila* and in many cases because of the difficulty of separating them from the internal contents of *C. multicicatrices*, it was not easy to find them. Larvid vermiform (Figs. 1, 2B and C), body composed of 11 segments, with a pair of black, sclerotic, parallel oral hooks, initially white in color, becoming cream-yellow as they grow. Smaller larvae approximately 0.70 mm long by 0.25 mm wide (Fig. 2B), with older larval stages (Figs. 1 and 2C), measuring approximately 2.2 (±0.05, n = 30) mm long by 0.83 (±0.02, n = 30) mm wide. On average, the larval stage (including all instars) lasts 4.5 (±0.19) d (Table 1). According to Clausen (1940), the larvid of *S. cocciphila* is rather robust in form and bears a transverse row of small setae dorsally and laterally on each body segment. Phorids generally go through three larval stages in a period of 8 d before pupating (Disney 1994).

**Prepupa and Pupa**

The larvid of *S. cocciphila* loses mobility and its skin gradually becomes sclerotized as it enters the prepupal stage which lasts 1.63 (±0.09) d (range 1.0–2.0 d) (Fig. 1); then the prepupa transforms into a pupa. Pupae coarctate, elongate oval, brown in color, sclerotized, 1.99 (±0.02, n = 30) mm long, 0.89 (±0.01, n = 30) mm wide, segmentation present, with two prothoracic cornicles present anteriorly (Fig. 2D). The pupal stage can be easily differentiated from the prepupal stage by the presence of the thoracic cornicles which are absent in the prepupa. The pupal stage lasted 12.53 (±0.12: range 10–13) d (Table 1).

Table 1. Duration in days of the different stages of development of *Syneura cocciphila* under laboratory conditions (26.6 ± 1.5°C; RH: 62.8 ± 6.17%)

| Developing stages of *S. cocciphila* | Mean ± MSE | Range |
|--------------------------------------|-----------|-------|
| Egg (n = 8)                          | 1.38 (±0.18) | 1–2   |
| Larva (n = 8)                        | 4.5 (±0.19) | 4–5   |
| Prepupa (n = 30)                     | 1.63 (±0.09) | 1–2   |
| Pupa (n = 30)                        | 12.53 (±0.12) | 10–13 |
| Total (egg - adult)                  | 20.04 (±0.58) | 16–22 |

*Values in parentheses next to the means indicate the mean standard error (MSE).*

![Fig. 1. Life cycle of *Syneura cocciphila* under laboratory conditions (26.6 ± 1.5°C; RH: 62.8 ± 6.17%). Photos: K. Muñoz.](image-url)
to emerge, whereas puparia that had well-developed thoracic cornergles normally emerged, supporting the observations of Folgarait et al. (2005).

Adults

Male flies (Figs. 1 and 2E) 1.50 mm (±0.060, n = 10) long; female flies (Figs. 1 and 2F) larger, 1.74 mm (±0.032, n = 10) long; adult flies (both males and females), dark-brown to black in color; thorax forming a dorsal hump; head with three horizontal rows of bristles; antennae aristate; mesopleuron hairy; wings well developed, with thick costal and radial veins; legs long, prothoracic coxae yellowish or lighter in color, the rest brownish, posterior femora well developed and laterally flattened, posterior tibia with well-developed spurs. The ovipositor terminates in a T-shaped segment 7. The above observations are corroborated by the keys leading to the diagnosis of the species by Brues (1903), and the diagnosis of the species by Brues (1903).

Adult Longevity

The longevity of individuals of S. cocciphila was studied under laboratory conditions. The adult females of S. cocciphila lived on average 13.23 (±0.77) d (range 7–24) (n = 30) and males lived on average 11.13 (±0.61) d (range 6–19 d) (n = 30).

Studies conducted on the phorid fly, M. scalaris determined that the longevity may vary depending on temperature, i.e., females lived for 7.3 d and males for 17.3 d at 27°C; females lived for 29.9 d and males for 24.8 d at 25°C; and females survived for 51 d and males for 43 d when reared at 15°C (Prawirodisastro and Benjamin 1979).

Sex Ratio

For the sex ratio of S. cocciphila, we counted 31 females and 29 males of a total of 60 individuals that were evaluated. A Chi-square test conducted at a 95% confidence level accepted the hypothesis that suggests that the sex ratio of S. cocciphila is 1 female: 1 male (P < 0.05). This result is similar to that reported by Hussey (1965) for Megaselia halterata, who reported a sex ratio of 1.06 males: 1.00 female. According to Disney (1994), the sex ratio is influenced by temperature.

Behavior of S. cocciphila

Field observations of the predatory fly S. cocciphila were carried out on Caesalpinia pluviosa var. peltrophoroides plants infested with individuals of C. multicicatrices. The copulation of a pair of flies was observed on flight, in which they flew around the plant in circular movements. According to Disney (1994), during mating, phorid males fly in swarms near tree, dancing in the air and can rise up to 2.5 m from the ground. Disney (1994) reports mating time as ranging from 32 s up to 11 min depending on the phorid species.

In the field, a pair of S. cocciphila were observed in copula (Fig. 1) while flying in circles and perching on the leaves of C. pluviosa var. peltrophoroides, infested with C. multicicatrices. This event lasted for a period of 42 s; then the gravid female searched for adults of C. multicicatrices, flew for several seconds over the scale insects, and finally oviposited in one of them. During the oviposition process, the female stayed on the ovisac with its anterior legs stretched forward and performed contraction movements of the abdomen in order to insert its ovipositor into the ovisac of C. multicicatrices, which lasted for several seconds (Fig. 1).

S. cocciphila larvae are good predators of adults and eggs of Crypticerya multicicatrices and could potentially be used as a biological control agent of this scale insect pest. Some species of phorid flies are known to be parasitic on other insects. For example, the phorid fly Pseudacteon litoralis Borgmeier is known to parasitize the fire ant, and has been proposed as a biological control agent of Solenopsis invicta Buren (Porter et al. 1995). According to Gilbert
and Morrison (1997), based on a study of four South American Pseudacteon species, namely, P. litoralis, P. wasmanni (Schmitz), P. tricuspis Borgmeier, and P. curvatus Borgmeier, determined that species of Pseudacteon are highly specific to particular species of Solenopsis ants. In the same manner, S. cocciphila appears to be specific to iceryine scales.

Environmental conditions such as relative humidity and temperature appear to influence the survival of the phorid flies. Rearing of S. cocciphila under laboratory conditions is currently not feasible until we better understand their copulation behavior, which has so far failed to be observed under artificial conditions. It is possible that S. cocciphila requires wide spaces for copulation to occur. Additional studies should be conducted to determine which stimuli induce copulation in S. cocciphila as this is a critical component in the mass rearing of this predatory phorid fly in the future.

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