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DEFENSIVE BEHAVIOUR OF THE LONGTAILED MEALYBUG *PSEUDOCOCCUS LONGISPINUS* (TARGIONI TOZZETTI) (HEMIPTERA: PSEUDOCOCCIDAE) AGAINST THE BROWN LACEWING *SYMPHEROBIUS FALLAX* NAVAS (NEUROPTERA: HEMEROBIIDAE).

ABSTRACT

DEFENSIVE BEHAVIOUR OF THE LONGTAILED MEALYBUG *PSEUDOCOCCUS LONGISPINUS* (TARGIONI TOZZETTI) (HEMIPTERA: PSEUDOCOCCIDAE) AGAINST THE BROWN LACEWING *SYMPHEROBIUS FALLAX* NAVAS (NEUROPTERA: HEMEROBIIDAE).

The defensive tactics of 2nd- and 3rd-instar nymphal and adult *Pseudococcus longispinus* (Targioni Tozzetti) against larval *Sympherobius fallax* Navas were studied. When attacked by 1st- and 2nd-instar predators, these three mealybug stages were able to secrete ostiolar fluids which spread and hardened on the mouthparts of the predators; 1st-instar mealybugs appeared to be unable to secrete ostiolar fluids. Adult mealybugs also successfully defended themselves against 1st-instar predators by simply pushing them away with their cerarial wax fringe. Of the lacewing stages, 3rd-instar *S. fallax* larvae were the most successful at overcoming the defense tactics of *P. longispinus.*

Key words: lacewings, Chrysopidae, *Chrysoperla carnea*, behavioural defence, morphological defence, potato sprouts, haemolymph.

INTRODUCTION

Adult female longtailed mealybug, *Pseudococcus longispinus* (Targioni Tozzetti), is a typical mealybug but has a particularly well-developed fringe of long, waxy filaments around the margin of the body associated with the cerarii, the hindmost two filaments being exceptionally long, so giving this mealybug its common name. As in other mealybugs, it has lateral pairs of transverse slit-like ostioles anteriorly, approximately on the head, and posteriorly on the VIth abdominal segment (Plates 1 & 2). When the mealybug is stimulated violently, a globule of fluid appears from one or more ostioles and this hardens quickly on exposure to the air.

Larvae of Neuroptera are usually predators and principally attack aphids, although they can also attack chermids, mealybugs, whiteflies and occasionally diaspidid scale insects (Clausen, 1972). Lacewings are widely distributed in both natural and agro-ecosystems in many parts of the world. Two families in particular, the Chrysopidae and Hemerobiidae, have attracted considerable attention as potential biological agents of small arthropod pests, both in the field and under glass. However, only a few species are widely distributed and have been seriously considered as biocontrol agents (New, 1975). One of these is the brown lacewing, *Sympherobius fallax* Navas (Hemerobiidae), where the adults are small and brown in colour, as the name indicates. The antennae are almost as long as the wings and tend to be held forwards. These insects are heterometabolous. Unlike the adults, the larvae have powerful mouthparts with which to suck fluids when inserted into the body of their prey. The adults have chewing mouthparts, are predatory and feed on similar food to the larvae.

Herbivorous insects vary enormously in their defensive behaviour against entomophagous insects. The anti-predatory mechanisms mostly involve behavioural and morphological defences (Gross, 1993) and thus, in the aphids, the tube-like cornicles (also known as siphunculi) have evolved as defensive structures which secrete a waxy fluid when the insect is alarmed. This has two functions: it contains an alarm pheromone and, on contact with a predator or parasite, the waxy fluid can dry quickly, incapacitating the enemy. Dixon (1958) observed that, if the larva of the coccinellid *Adalia decempunctata* (L) was smaller than the aphid (*Macrosiphum evansi* (Theobald)) it was attacking and seized an appendage, the aphid could escape by pulling the appendage free. However, if the coccinellid larva and aphid were about the same size, the aphid could escape if the cornicle nearest the appendage swung over and placed a drop of waxy liquid on the coccinellid's head where the wax could spread over the mouthparts and solidify. Similar observations were made by Canard & Principi (1984) with lacewing larvae, which died after their mouthparts had been smeared with cornicular fluid. Chrysopid larvae can also cause other escape reactions in aphids, which may drop off the plant in response to the presence of a larva of *Chrysoperla carnea* (Stephens) (Arzet, 1973). Perhaps similar behaviour occurs when mealybugs are attacked by natural enemies, as Williams (1978) considered that the posterior ostioles of mealybugs may be homologous with the cornicles of aphids.

The purpose of these observations was to look at the defence mechanisms of *P. longispinus* when attacked by various larval stages of *S. fallax* and to see how these were overcome by the lacewing larvae.

MATERIALS AND METHODS

The defence behaviour of 2^{nd}- and 3^{rd}-instar nymphs and adult *P. longispinus* was tested against 1^{st}-, 2^{nd}- and 3^{rd}-instar larvae of *S. fallax*. *P.*

longispinus and *S. fallax* were kept in cultures maintained on sprouting potatoes at about 27°C and 65% r.h. Prior to each trial, the larvae of *S. fallax* were starved by keeping them singly in 5ml glass vials for 24h. The three stages of *P. longispinus* were tested separately against each lacewing larval instar. The defensive behaviour of *P. longispinus* was studied against a background of green paper within a small cage. These cages were made of three pieces of perspex-glass, measuring 75x38x8mm; the middle piece of perspex had a 25mm diam. hole in the centre and this was sandwiched between the other two pieces. Ten mealybugs of a specific stage were offered at a time in the central cavity to a single larva of each stage of *S. fallax*. The behaviour of the predator and host were observed under a stereo-microscope for 20-90 mins from the time of introduction of the mealybugs into the arena. This was repeated at least 10 times for each *S. fallax* stage. The main purpose was to observe the defensive tactics of *P. longispinus* against the predatory larvae and, therefore, any feeding by *S. fallax* larvae was ignored. The results are based on individual observations on different nymphal stages of *P. longispinus* and no actual data were recorded. All these observations were made at about 26°C, 65% r.h. and 7.5 watts/m^2 light intensity. An S.L.R. camera fitted on a stand was used to take photographs *in situ*.

RESULTS AND DISCUSSION

When a *S. fallax* larva encountered a longtailed mealybug, the mealybug did not present herself as an easy target to the predator, but utilised her morphological and behavioural abilities to the maximum to defend herself. On contact with a larva of *S. fallax* of any age, 3^{rd}-instar and adult mealybugs raised the posterior end of their abdomens. This behaviour is similar to that when a male *P. longispinus* approaches a female and may be a signal that the female is ready for mating. Because all *S. fallax* larvae attacked *P. longispinus* from behind, the raising of the abdomen provided an apparently easy access to the underside of the abdomen. When a *S. fallax* larva began its attack (by grabbing at the underside of the mealybug's abdomen with its mandibles), the mealybug tried to get rid of the predator by one of the following ways:

a) Escape. This was generally successful with 3^{rd}-instar mealybugs when attacked by 1^{st}- and 2^{nd}-instar *S. fallax*. Occasionally, the lacewing larva could be found still chasing an escaping mealybug, even 24h later.

b) Pushing the lacewing larva away. This was accomplished by the fringe of waxy filaments at each cerarius and by moving or twisting the abdomen.

Adult *P. longispinus* were always successful in pushing 1st-instar *S. fallax* larvae away, even after being attacked for 24h. However, this tactic by adult mealybugs was not successful against 3rd-instar *S. fallax* and was only partially successful against 2nd-instar larvae.

c) Ostiolar fluid secretion. Second- and 3rd-instar nymphs and young adult *P. longispinus* secreted shiny droplets of a waxy fluid from their posterior ostioles when attacked (1st-instar nymphs, and reproducing and spent females were never seen to produce droplets). The larvae of *S. fallax* always attacked the mealybugs from behind, close to the posterior ostioles. The ostiolar fluid solidified quickly in air (15 to 45 secs, depending on the size of the droplet). If the mealybug was lucky and the predator was not been able to grab it successfully, then the predator sometimes came into contact with the ostiolar fluid, which stuck to its mouthparts, solidified and caused death by starvation. Similar phenomena were observed by Dixon (1958) when larvae of the coccinellid *A. decempunctata* attacked the aphid *M. evansi*, and by Canard & Principi (1984) when chrysopid larvae attacked aphids. If a *S. fallax* larva was successful in grabbing a mealybug, the latter kept on secreting ostiolar droplets until the whole reserve of the fluid was exhausted, each successive droplet being smaller than the last. The available fluid appeared to be exhausted after 6 or 7 droplets had been produced. After 24h, most of the 1st-instar *S. fallax* were found to be victims of ostiolar fluid from adult female *P. longispinus*, but most 3rd-instar *S. fallax* successfully escaped from the ostiolar fluid of 3rd-instar nymphs and adult *P. longispinus*.

When 2nd-instar *S. fallax* had successfully pierced an adult mealybug, the latter would still try to escape and would continue to secrete ostiolar globules. On some occasions, one of these globules would engulf the predatory larva, resulting in it becoming stuck to the mealybug. On these occasions, the mealybug could be found walking about with the dead lacewing larva still attached to its posterior end, especially when the mealybug was large and the *S. fallax* larva was an early instar.

Some observations were also made on the source of the ostiolar fluid. It is considered here that it may be modified haemolymph because, when a mealybug was pricked with a needle, the body fluids exuded as droplets and solidified in the same way as the droplets from the ostioles (i.e. in 15-45 secs). The main difference was that the ostiolar fluid was clear and colourless while the haemolymph was opaque and buff-coloured.

Of the two stages of *P. longispinus* studied, it was the adult stage which was most capable of defending itself, whilst the 2nd-instar nymphs were the most vulnerable. Similarly, the 3rd-instar *S. fallax* was the most active in escaping from the ostiolar fluids produced by *P. longispinus,* while the 1st-instar was the least successful.

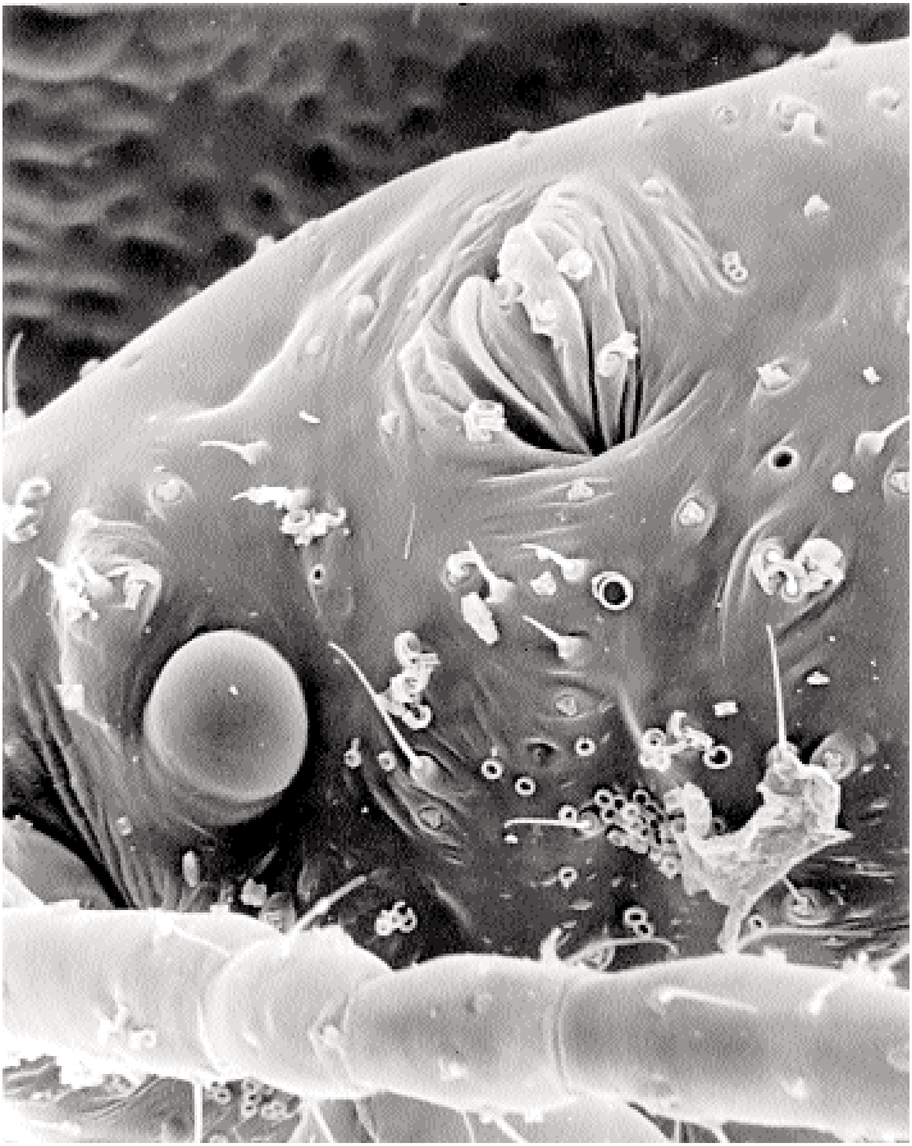

Plate 1: Scanning electron microscope study of anterior ostiole of *Pseudococcus longispinus*. x840

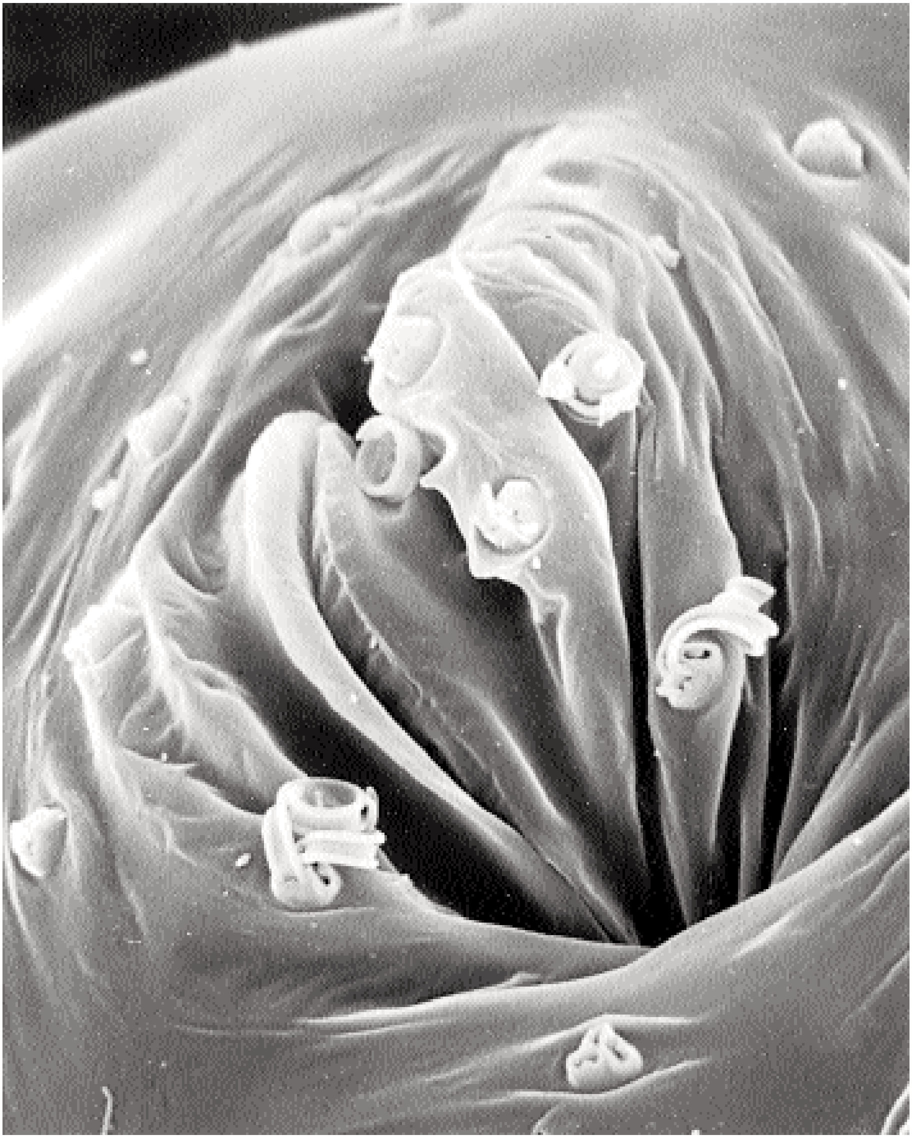

Plate 2: Scanning electron microscope study of anterior ostiole of *Pseudococcus longispinus*. x2500.

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