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Host-finding and oviposition behaviour of *Cheiropachus quadrum* (F.) (Hym.: Pteromalidae), a parasite of olive bark beetles (Col.: Scolytidae)

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The host-finding and oviposition behaviour of the parasite of olive bark beetles (Col.: Scolytidae) *Cheiropachus quadrum* (F.) (Hym.: Pteromalidae) was investigated. Twenty three adult female parasitoids, placed in cages with host larva infested olive logs, were observed for three hours each in the laboratory. The parasitoid spent 43 % of the time resting, 37 % searching for hosts and 20 % ovipositing and feeding. Oviposition and feeding can be divided into different categories: antennation, drilling, piercing, inserting and oviposition and/or feeding sensu stricto. In relation to these, a diagram with transition probabilities has been drawn up. Oviposition (84 %) occurs on most host. Sixteen per cent of the time the host is used only for feeding.

Keywords: Host-finding, oviposition, *Cheiropachus quadrum* (F.), bark beetles, olive, biological control

INTRODUCTION

Cheiropachus quadrum (Hym: Pteromalidae) is a common parasitoid of several scolytids and also various weevils (DAHLSTEN, 1982). In our area of study (the Southern Iberian Peninsula) it attacks two olive bark beetle pests, *Phloeotribus scarabaeoides* (BERNARD) and *Hylesinus varius* (F.) (Col: Scolytidae). Adults of both bark beetles overwinter on living olive trees in which they excavate overwintering and feeding galleries. In spring the adults disperse from the feeding sites to reproduce in cut logs where the females excavate subcortical reproduction galleries (GONZALEZ, 1990; LOZANO & CAMPOS, 1996)

Whilst developing in the cut logs, larvae of these scolytids are attacked by several hymenopteran parasitoids, of which *C. quadrum* is one of the most effective at reducing host numbers (CAMPOS & LOZANO, 1994). This suggests the possible use of this pteromalid for biologicol control.

The parasitoid is a solitary ectoparasite, which deposits its egg on the host larva's surface by piercing the bark. The parasitoid larva develops at the expense of the scolytid larva (DOMINGUEZ GARCIA-TEJERO, 1953). Besides oviposition, host larvae are used by adult female parasitoids for feeding (LOZANO, 1993). Host-feeding supplies the females with proteinaceous materials for continued egg production (BARTLETT, 1964; JERVIS & KIDD, 1986). Previously work on other aspects of the biology of *C. quadrum* such as longevity, fecundity, preference for different stages of host, sex ratio, competition, etc., have been realised (MENDEL, 1986; CAMPOS & GONZALEZ, 1991; MILLS *et al.*, 1991; CAMPOS & LOZANO, 1994).

The aim of the present paper is to contribute to the knowledge of the host-finding and oviposition behaviour of *C. quadrum*.

MATERIAL AND METHODS

Parasitoids were obtained from a laboratory reared colony (CAMPOS & LOZANO, 1994). Adult parasitoids were placed in eight transparent cages measuring 30 cm x 20 cm x 7 cm with olive logs infested in the field with *P. scarabaeoides* larvae. The average level of infestation of the logs was 5.9 maternal galleries per dm^2 (S.D.: 2.7) and they were used in the experiments when most of the progeny were larvae. The thickness of bark of the logs measured around 1 mm. The number of adult female parasitoids per cage was variable, with an average of 3.6 females (S.D.: 4.8 females). Every female observed was fertilised and had emerged in the last 24 hours beforehand. Thus, maximum age of the females was 1 day.

Twenty three observations were made, in each of which, the distinct activities of one different adult female parasitoid was followed during three hours at 22° C and with white artificial light. The observations were made just after the parasitoids were released in the cages. The bark was removed to check for eggs. The time spent in each activity or phase of behaviour was recorded as well. Each observation was made directly or using a video camera.

RESULTS

We can divide the behavioural activity of *C. quadrum* females into three distinct categories:

Resting

The parasitoid stays quiescent on the wall of the cage or on the surface of the log. 43 % (C.V.: 17.7) of the observed time is spent in this phase.

Host searching

The parasitoid walks on the surface of the log touching it with its antennae searching for places where the host can potentially be found (patches). Sometimes, perhaps when the parasitoid finds a patch, a change in searching behaviour might be observed. Such changes are a decrease in walking speed, an increase in the rate of turning, an alteration in the position of the antennae and an increase in the amount of time spent standing still. 37 % (C.V.: 21.6) of the observed time is spent in this phase.

Oviposition and feeding

This phase stretches from host location by a female parasitoid for oviposition and/or feeding until when the host is left. It can be subdivided into different periods: antennation, drilling, piercing and inserting, feeding, preening and oviposition. Fig. 1 shows these categories. Time spent by the parasitoid in this phase corresponds to the remaining 20 % (C.V.: 45.5) of the observed time. The average time of only one category is 46.0 min (S.D.: 16.1 min).

Antennation: When a larva host is located under the bark, the parasitoid stays at this point drumming it rapidly with its antennae. Time spent: 12.8 min (S.D.: 9.7 min).

Drilling, piercing and inserting: After antennation the parasitoid may leave to search another place. However, most of the time (80 %), it starts to drill the bark with the ovipositor in the same area. Sometimes (43 %), drilling is not continuous

and is interrupted by antennation periods. Mostly the parasitoid pierces the bark until the ovipositor is inserted next to the host larva. Only in a few cases, after drilling and antennation did *C. quadrum* leave the host. Time spent piercing the bark was 26.6 min. (S.D.: 12.6 min.)

Oviposition: Once the ovipositor is placed next to the host larva, the parasitoid has two options: oviposition (53 %) or feeding (47 %). In relation to oviposition, only one egg is laid on the larva, which stays immobile. According to STRAND (1985) this immobility is because the parasitoid injects paralysing substances into the host larva just before placing the egg. When the egg is laid, the abdomen of the females is strongly contracted for 3–4 seconds. After oviposition the host is left by the female adult parasitoid.

Feeding: In this case, the parasitoid pierces the larva with the ovipositor and immediately removes it. In this way, fluids from the body of the larva come out through the capillary tube formed by the ovipositor at the surface of the bark, where they are consumed by the parasitoid during an average time of 3.8 min. (S.D.: 2.2 min.). When we removed the bark after feeding (n = 5), the parasitized larva was living.

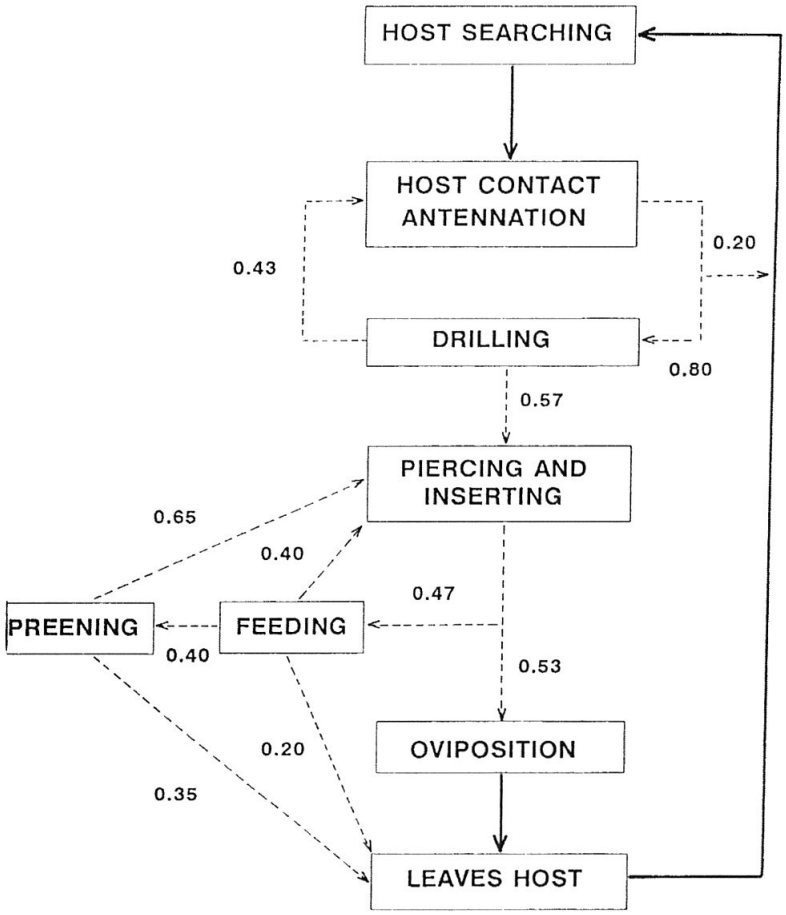

Fig. 1. The behaviour pattern of *C. quadrum* females from host location for oviposition and/or feeding until when the host is left. The numbers indicate the probabilities to choose a particular route. ——— invariable paths, – – – – alternatives.

Occasionally (20 %), directly after feeding, the host is abandoned. However, more commonly the parasitoid inserts again the ovipositor (40 %), but this time to oviposit. Usually (40 %), before leaving or inserting the ovipositor, it preens its antennae and buccal cavity for 2.8 min. (S.D.: 1.3 min.).

DISCUSSION

Parasitoids spend a significant proportion of the observed time searching for patches where the host can be found. In general, insect parasitoids locate the host following some stimulus such as the sound produced by the host larva (CADE, 1975) and the odours associated with the host's environment (VINSON, 1976). According to VAN ALPHEN & VET (1985) the latter is more common. For bark beetle parasitoids, olfactory cues are probably more important.

It has been observed that when a patch is found by a parasitoid, the time which the parasitoid spent in the patch depends on different factors such as: the parasitoid's previous experience, its egg load, patch kairomones concentration, encounters with parasitized or unparasitized hosts, or the timing of inter- or intraspecific encounters with either the individuals or traces of their presence (VAN ALPHEN & JERVIS, 1996). Some parasitoids are known to defend patches of hosts against conspecific and heterospecific intruders. This behaviour serves both to prevent competing females from ovipositing in hosts not already attacked by the defending female (WAAGE, 1982) and to ensure that hosts already parasitized are not superparasitized by competitors (VAN ALPHEN & VISSER, 1990). MILLS *et al.* (1991) points out that aggressive encounters between *C. quadrum* individuals are frequent. *Cephalonomis stephanoderis* BETREM (Hym.: Bethylidae), a parasitoid of the scolytid *Hypothenemus hampei* (FERRARI), recognizes a marking pheromone deposited in the host during the oviposition which enables female parasitoids to also avoid self and conspecific superparasitism (BARRERA *et al.*, 1994).

Fig. 1 shows that the adult female *C. quadrum* oviposits without feeding in 53 % of the hosts, feeds without ovipositing in 16 % (0.16 = (0.47·0.20) + (0.47·0.40·0.35)) of the hosts and both oviposits and feeds in 31 % (0.31 = (0.47·0.40) + (0.47·0.40·0.65)) of the hosts. Thus, these results indicate that *C. quadrum* mainly oviposits (84 %) on its hosts and feeds (47 %) on almost half of them.

In general, as there are many synovigenic parasitoids, which exhibit host-feeding behaviour (JERVIS & KIDD, 1986), the decision either to host-feed or to oviposit should depend on the immediate gain from oviposition, weighed against the future gain from host-feeding, which in turn depends on the parasitoid's internal state, its age, host availability and host stage (JERVIS & KIDD, 1986, KIDD & JERVIS, 1991; VAN ALPHEN & JERVIS, 1996). Models developed by CHAN & GODFRAY (1993) predict that the decision to host-feed versus oviposit depends on the parasitoid's egg load. However, this theoretical prediction has not been supported empirically (ROSENHEIM & ROSEN, 1992).

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RÉSUMÉ

Comportement de localisation de l'hôte et d'oviposition de Cheiropachus quadrum (F.) (Hym.: Pteromalidae), un parasite des scolytes de l'olivier. – Le comportement de localisation de l'hôte et d'oviposition du parasite des scolytes de l'olivier (Col.: Scolytidae) (Hym.: Pteromalidae) ont été étudiés. Vingt-trois femelles parasitoides adultes ont été observées au laboratoire, dans des boîtes contenant des tronçons d'olivier infectés avec des larves de l'hôte, pendant trois heures. Le parasitoide dédie 43 % de son temps au repos, 37 % à la recherche de l'hôte, 20 % à l'oviposition et à la nourriture. Ces deux derniers processus peuvent être divisés en des catégories différentes: localiser avec les antennes, traverser, insérer et ovipositer et/ou se nourrir sensu stricto. En relation avec ces processus on a proposé un schéma avec les probabilités de suivre une voie. La plupart des fois l'hôte est oviposité (84%). Le 16 % restant, l'hôte est parasité seulement pour la nourriture.

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