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Host Searching Behavior of Ganaspidium utilis (Beardsley) (Hymenoptera: Eucoilidae) on Liriomyza trifolii (Burgess) (Diptera: Agromyzidae) 【Scientific note】

隆盾癭蜂對非洲菊斑潛蠅寄主之搜尋行為【科學短訊】

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Abstract

Host searching behavior of Ganaspidium utilis (Beardsley) (Hymenoptera: Eucoilidae) was observed when G. utilis females searched and oviposited on the late 2nd or early 3rd instar of Liriomyza trifolii (Burgess) (Diptera: Agromyzidae) larvae in the laboratory. It was observed that G. utilis females used mines made by their hosts as trails to search for their hosts. A G. utilis female was able to discriminate whether or not mines had previously been searched. It was observed that G. utilis females followed a series of fixed action patterns comprised of walking to find a host, holding the antennae upward when a host was accepted, ovipositor probing to determine the suitability of the host and ovipositor penetrating as culmination of the host searching behavior.

摘要

本文初步觀察隆盾癭蜂之寄主搜尋行為，主要以雌性寄生蜂搜尋其寄主非洲菊斑潛蠅2齡末期或3齡初期之幼蟲，以及在其寄主幼蟲上產卵之行為過程。觀察中發現雌寄生蜂利用潛蠅之食痕隧道找尋其寄主昆蟲，同時也發現，寄生蜂似乎可以判別隧道是否已搜尋過。寄主搜尋的固定行為模式包括主要的行為元素有步行尋找寄主位置、觸角高舉表示接受寄主，找到其寄主以產卵管探測，確定寄主適合度，最後以產卵管穿刺產卵，結束寄主搜尋行為。

Key words: Ganaspidium utilis, Liriomyza trifolii, parasitoid, host searching, fixed action pattern

關鍵詞: 隆盾癭蜂、非洲菊斑潛蠅、寄生、寄主搜尋、行為模式

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ABSTRACT

Host searching behavior of *Ganaspidium utilis* (Beardsley) (Hymenoptera: Eucoilidae) was observed when *G. utilis* females searched and oviposited on the late 2nd or early 3rd instar of *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) larvae in the laboratory. It was observed that *G. utilis* females used mines made by their hosts as trails to search for their hosts. A *G. utilis* female was able to discriminate whether or not mines had previously been searched. It was observed that *G. utilis* females followed a series of fixed action patterns comprised of walking to find a host, holding the antennae upward when a host was accepted, ovipositor probing to determine the suitability of the host and ovipositor penetrating as culmination of the host searching behavior.

Key words: *Ganaspidium utilis*, *Liriomyza trifolii*, parasitoid, host searching, fixed action pattern

Introduction

Parasitoid wasps have to find and accept a host to complete their reproductive behavior which culminates with oviposition. Once a parasitoid physically contacts a potential host, it evaluates to determine whether the host is appropriate for use for its offspring's development (Baaren and Nénon, 1996). Host examination and attack may include different steps such as host encounter, antennation (a kind of drumming), probing, ovipositing, and marking (Van Driesche and Bellows, 1996), and different stimuli may be necessary to elicit this chain of behavior. Thus, parasitoids may use movements and vibrations by the host, chemical cues, both internal and/or external to the host, as well as physical features of the host

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such as its size, shape, and texture as clues during host searching (Vinson, 1977; Van Driesche and Bellows, 1996). Aspects of oviposition behavior may be associated with an extreme degree of stereotyping and may tend to be expressed even in the absence of experience (Mowry *et al*., 1989; Papaj, 1993).

Ganaspidium utilis (Beardsley) (Hymenoptera: Eucoilidae) is a solitary, larva-pupal endoparasitoid wasp that was introduced into Hawaii from Weslaco, Texas for the control of *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) (Nakao and Funasaki, 1979). It was successfully established in Hawaii, the Marianas, Tonga, and Guam where it became an important natural enemy of *Liriomyza* spp. (Lai and Funasaki, 1986; Greathead and Greathead, 1992; Johnson, 1993).

In 2003, *G. utilis* was introduced to Taiwan from Hawaii to control *Liriomyza* leafminers. Previous studies have described the biology of *G. utilis* (Petcharat and Johnson, 1988; Kafle *et al*., 2005a). An effective cost benefit method for mass-producing of *G. utilis* has also been developed (Rathman *et al*., 1991), and functional responses of *G. utilis* using *L. trifolii* as the host were reported by Kafle *et al*. (2005b). However, host searching behavior of this parasitoid has not yet been reported. Therefore, the objective of this study was to determine the host searching behavior of *G. utilis* under laboratory conditions using *L. trifolii* as the host.

Using *L. trifolii* larvae as the host and lima beans as the test plant for *G. utilis*

Throughout this study, the same procedures were followed to obtain late 2nd or early 3rd instar *L. trifolii* larvae as test insects**.** Six pairs of *Phaseolus* "Henderson" lima bean plants (with two leaves each) were placed for 6 h in a screen cage containing 50-60 *L. trifolii* adults. After 6 h, lima bean plants were removed from the cage and held for 5 days to allow the *L. trifolii* eggs to hatch and develop into late 2nd or early 3rd instar.

Rearing of *G. utilis*

Ganaspidium utilis parasitoid wasps used in this study were obtained from a laboratory culture which fed on the larvae and pupae of *L. trifolii* as the host insect. A *L. trifolii* colony was maintained in the laboratory using the methods described by Rathman *et al*. (1991). *Ganaspidium utilis* was reared using the method described by Petcharat and Johnson (1988). Stems of *L. trifolii* infested bean plants (with two leaves each) were cut immediately above the roots and placed in a 200-ml flask filled with water. A honey-water solution (25%) was sprayed on the lima bean leaves as a food source for the adult parasitoids. Plants were exposed to *G. utilis* for 24 h and then removed. The leaves were cut at the base and kept in closed plastic containers to allow the *L. trifolii* larvae to pupate. Leafminer puparia were collected and held in a Petri dish (9 cm in diameter) until the *G. utilis* adults began to emerge. Parasitoid adults were returned to the oviposition cages for either culture maintenance or subsequent studies.

Observing host searching behavior

A preliminary investigation showed that paralyzation and oviposition by *G. utilis* occurred at almost the same time as the parasitoid inserted its ovipositor into a host. The host body normally remained motionless after the ovipositor had been withdrawn. Parasitoid wasps normally paralyzed their host before oviposition.

To observe the host searching and ovipositing behaviors, we estimated the number of hosts for the just-mated females

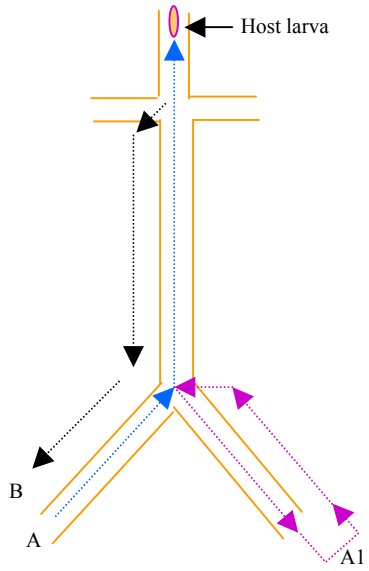

Fig. 1. Host searching track of a *Ganaspidium utilis* female: route A (▶) direct go to target (host larva) along a mine; sometimes, they went indirectly by route A1 (▶) or by route B (▶), because of probing a mine which had previously been probed, and returning to the original starting point.

of *G. utilis*. A leaf containing more than 50 individuals of late 2nd or early 3rd instar larvae of *L. trifolii* was used for each observation trial. Just-mated female parasitoids were introduced into a Petri dish about 1 h after being mated; the dish contained one bean leaf with more than 50 individuals of late 2nd or early 3rd instar larvae of *L. trifolii* as hosts for *G. utilis*. To ensure that this was the first time a female had engaged in host searching behavior, a virgin female and male were confined to a Petri dish until they mated. The food source of the parasitoid wasps was provided by spraying a 25% honey-water solution on the bean leaf. The behavior of *G. utilis* female was observed under a binocular stereo microscope and recorded on a videotape for 30 min during each trail.

These observations were conducted in a laboratory at National Pingtung University of Science and Technology at 25 ± 2℃ and 50 ± 10% RH with photoperiod of 14L: 10D.

In a previous report, a *G. utilis* female used its antennae as a sense organ to follow a host's mines, and then it laid only one egg in each host it encountered (Kafle *et al.*, 2005b). In this study, it was found that the host searching behavior of *G. utilis* females possessed a stereo type as decribed below.

After a *G. utilis* female was introduced to a leaf, it walked all over the leaf's surface (Fig. 3a). During the 30-min observation period, the female searched along the mines (Fig. 3b). The search behavior included antennation and preening of the hind legs and wings (Fig. 3c, d) while walking along the mines with antennae touching the mines; this eventually ended when its ovipositor inserted into a mine containing a *L. trifolii* individual. The mines were found to be attractive to *G. utilis* females. Regardless of whether or not a host larva of *L. trifolii* was present, *G. utilis* females concentrated their searching in areas where mines were present.

When an unparasitized host larva was encountered, a *G. utilis* female responded by attempting to insert its ovipositor into the host larvae. The larva responded by moving vigorously and irregularly and further withdrawing back into the mine. Once a *G. utilis* female located a host larva, she stepped on the larva, inserted her ovipositor into the host body and allowed it to remain in the host body until the following behavior was finished. The *G. utilis* female was observed to insert and push its ovipositor deeply into the host body. The first ovipositor insertion rendered *L. trifolii* larva motionless (Fig. 3e). When the *G. utilis* female ceased its movement, the host moved less and less until its body eventually relaxed and became motionless. This indicated that the host larva had been paralyzed by the

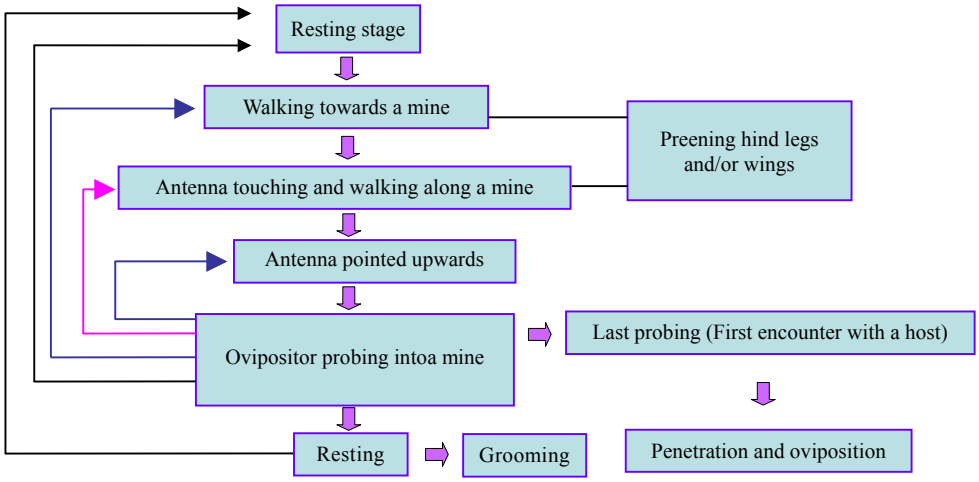

Fig. 2. Sequence diagram of host searching behavior of *Ganaspidium utilis* females.

parasitoid wasp.

An egg was laid when the female bent her abdomen (Fig. 3f). After the *G. utilis* female withdrew its ovipositor from the paralyzed host body, it continued searching along the mine for the next host.

When a *G. utilis* female encountered a parasitized host that was motionless, the searching continued along with the mine without stopping. Sometimes the host larva did not readily recover from paralysis and it was noted to respond to the piercing of the *G. utilis* female's ovipositor by vigorously moving its body. In such a case, the *G. utilis* female continued to parasitize that host. However, a parasitized host that remained active was often rejected by a *G. utilis* female after an encounter.

Ganaspidium utilis females use the serpentine mines made by *L. trifolii* larvae as cues for locating host larvae for parasitization. It is very common in parasitic insects for visual contact to be insufficient to locate their hosts. *G. utilis* females used their antennae during host searching as setae on the antennae and tarsi are generally considered sense organs (Chapman, 1998). It is possible that a *G. utilis* female uses her antennae to track the host larvae and to discriminate unparasitized larvae from parasitized ones.

The ovipositor plays an important role in host searching and determining host acceptability by *G. utilis* females. Vinson (1984) and Chapman (1998) reported that the ovipositor is an important chemical receptor organ of parasitoids. Hawke *et al.* (1973) reported that parasitoids use sensilla on the ovipositor to locate hosts and discriminate parasitized from unparasitized hosts. van Alphen and Drijver (1985) reported that a parasitoid shows little walking and intensive probing in substrates that contain hosts.

Preening was observed in *G. utilis* females (Fig. 3c, d). Karamaouna and Copland (2000) reported that preening is a nonfunctional, stereotyped action initiated by parasitoids when actual conflict occurs (Fig. 2). Because *G. utilis* females used mines as cues, the mine pattern was very important in the host search process. The more the mines crossed one another the greater the possibility that *G. utilis* females would find a host (Fig. 1). Kato (1984) thought that crossing mines prolonged the time it took for a *G. utilis* female to locate a host because the *G.*

Fig. 3. Host searching behavior of *Ganaspidium utilis* females: (a) traveling towards a mine of *L. trifolii* larva, (b) probing and trailing along the mine, (c) preening of the hind legs, (d) preening of wings while searching, (e) first encounter with a *L. trifolii* larva, and (f) oviposition into a *L. trifolii* larva.

utilis female would have to choose one of the tracts at a branching point. Once it chose a tract and searched it once, it would spend time walking back along the same tract to the branching point (Fig. 1). Further studies are needed to determine additional attributes of *G. utilis,* including search ability, mutual interferences and dispersal to aid in the assessment of its effectiveness against *Liriomyza* leafminers on commercial crops in Taiwan.

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摘 要

本文初步觀察隆盾癭蜂之寄主搜尋行爲，主要以雌性寄生蜂搜尋其寄主非洲菊斑潛蠅 2 齡末期或 3 齡初期之幼蟲，以及在其寄主幼蟲上產卵之行爲過程。觀察中發現雌寄生蜂利用潛蠅之食痕隧道找尋其寄主昆蟲，同時也發現，寄生蜂似乎可以判別隧道是否已搜尋過。寄主搜尋的固定行爲模式包括主要的行爲元素有步行尋找寄主位置、觸角高舉表示接受寄主，找到其寄主以產卵管探測，確定寄主適合度，最後以產卵管穿刺產卵，結束寄主搜尋行爲。

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