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Suitability of three aphid species for *Aphidius gifuensis* (Hymenoptera: Braconidae): Parasitoid performance varies with hosts of origin

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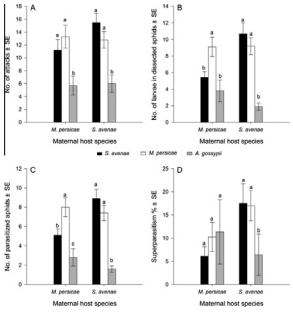
HIGHLIGHTS

- *Aphidius gifuensis* was able to parasitize *Sitobion avenae, Myzus persicae* and *Aphis gossypii*.
- The parasitoids did not develop as well in *Aphis gossypii* as in the other two aphid species.
- Fewer mummies were produced on *Sitobion avenae* when *Myzus persicae* was the maternal host.

GRAPHICAL ABSTRACT



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ABSTRACT

Oviposition behavior and offspring fitness of the parasitoid *Aphidius gifuensis* (Ashmead) were compared on three aphid species, *Sitobion avenae* F., *Myzus persicae* (Sulzer), and *Aphis gossypii* Glover using wasps collected from both *S. avenae* and *M. persicae*. *A. gifuensis* produced more mummies and adults on *S. avenae* and *M. persicae* than on *A. gossypii* regardless of the host of origin. Mummy production was influenced by attack rate and percentage of aphids superparasitized. The F_1 generations from *S. avenae* and *M. persicae* were more female-biased and wasps were larger than those from *A. gossypii*. Although there were significant differences in development time of *A. gifuensis* in the three aphid species, the difference was generally shorter than one day. Fewer mummies were produced when *A. gifuensis* was transferred between *S. avenae* and *M. persicae*, but no significant difference was observed in emergence rate, percentage of female offspring, or body size. The effects of host species on *A. gifuensis* female performance and offspring fitness are discussed, along with the potential for using *A. gifuensis* to control *M. persicae* and *A. gossypii*.

1. Introduction

Aphid parasitoids are important components of in biological control of aphid populations in a variety of crop systems, and the successful use of these parasitoids depends on factors such as their host selection behavior and physiological adaptations to their hosts, including host recognition, host acceptance and host suitability (Rehman and Powell, 2010). For example, once a female parasitoid encounters a potential host, she palpates the host surface with her antennae and probes with the ovipositor to assess host suitability (Hailemichael et al., 1994).

Host acceptance and suitability are influenced by several factors, including host species (Vinson, 1976; Rehman and Powell, 2010). Suitability varies among host species due to difference in quality and quantity of nutrition (host size), and host immunity. Some parasitoids attack several host species in the field, but a preference may exist for certain species. Ode et al. (2005) tested the performance of *Aphidius colemani* Viereck on four aphid species,

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Aphis gossypii Glover, *Myzus persicae* (Sulzer), *Rhophalosiphum padi* (L.), and *Schizaphis graminum* (Rondani) and found that *R. padi* is the least preferred host of *A. colemani*. Host species influences the oviposition behavior of female parasitoids and the fitness of their offspring (Häckermann et al., 2007), e.g., development rate, survivorship, sex ratio and body size. *Aphidius ervi* Haliday reared from *Acyrthosiphon pisum* Harris had a shorter pre-adult period and bigger body size than those from *Sitobion avenae* F. (Daza-Bustamante et al., 2003). This may be because *A. pisum* is larger in size and can offer more nutrition for immature growth and development. Another braconid, *Psyttalia cosyrae* (Wilkinson), accepts six dipteran fly species, but acceptance and larval survivorship vary among them (Mohamed et al., 2003).

Parasitoids usually prefer the host species from which they are reared (Michaud, 1996; Storeck et al., 2000; Ohta and Honda, 2010; Rehman and Powell, 2010). This specialization may cause poor performance in other hosts. *A. ervi* from different populations have obviously different host ranges (Pungerl, 1984). Cameron et al. (1984) transferred *A. ervi* from *A. pisum* to *Microlophium carnosum* (Buckton) without success. However, *A. ervi* was successfully transferred from *A. pisum* to *S. avenae* although significantly fewer mummies were produced from the new host (Daza-Bustamante et al., 2003). The abilities of *A. ervi* and *Aphidius rhopalosiphi* De Stefani-Perez to transfer among different host species were also examined by Powell and Wright (1988). Results reflect the importance of the host of origin for parasitoid performance. This phenomenon may be caused by long term associations between the parasitoid and its host that lead to the evolution of host specificity.

Banker plant system is a natural enemy delivery system which directly or indirectly provides food, host or prey to natural enemies that are implemented in a particular crop and production system (Frank, 2010). Use of parasitoids to control pests in banker plant systems has been extensively studied. The success of the banker plant method depends on the persistence of natural enemies after release. Thus, the ability of parasitoids to switch between pests and alternative hosts can be essential (Powell and Wright, 1988; Ode et al., 2005).

Aphidius gifuensis (Ashmead) is a solitary koinobiont endoparasitoid that has been used as a biological control agent against *M. persicae* in China and Japan (Ohta et al., 2001; Yang et al., 2009a, 2011). Yang et al. (2009b) successfully mass-reared and released *A. gifuensis* to control *M. persicae* on tobacco in Yunnan, China. *A. gifuensis* was effective against *M. persicae* on vegetables (Ohta et al., 2001). Ohta and Honda (2010) tested the performance of *A. gifuensis* on six aphid species and their results suggested that *Sitobion akebiae* (Shinji) was suitable as an alternative host for *A. gifuensis* in a banker plant system to control vegetable aphids *M. persicae* and *Aulacorthum solani* (Kaltenbach). *A. gifuensis* was also documented to parasitize *A. gossypii*, *S. avenae* and *Lipaphis erysimi* (Kaltenbach) in China (Yang et al., 2009a).

To assess the potential of *S. avenae* as an alternative host for *A. gifuensis* in a banker plant system, we measured the oviposition behavior and developmental performance of *A. gifuensis* on three aphid species, *S. avenae*, *M. persicae* and *A. gossypii*. We also assessed the host-switching ability of *A. gifuensis* and its potential for the control of *M. persicae* and *A. gossypii* in greenhouses.

2. Materials and methods

2.1. Insects and plant cultures

Three aphid species, *S. avenae, A. gossypii and M. persicae* were collected in May 2011 in Yangling, Shannxi, China. Colonies of the three aphid species were reared on winter wheat, pepper and cucumber, respectively. These host plants were grown in 10 cm diameter plastic pots that filled with soil mix (peat moss: perlite = 3:1). *A. gifuensis* was collected from *M. persicae* mummies in August 2011 in the same location and reared on *S. avenae* and *M. persicae*, respectively.

For the experiments, only second and third instar nymphs of the three aphid species were used as hosts for the parasitoids because these two instars are most preferred by several aphid parasitoids (Bi and Ji, 1994; Ohta et al., 2001; Ohta and Ohtaishi, 2004; Ohta and Honda, 2010). *A. gifuensis* mummies from each colony were collected and individually isolated in gelatin capsules. Mummies were examined daily for adult emergence. As soon as the adults emerged, they were sexed. One female and one male were paired and held in a gelatin capsule with 10% honey solution for 24 h. We have observed that the male and the female normally mate a few hours after they were paired. The females were used in the experiments. All the experiments were conducted in air-conditioned insectaries under the following conditions: 25 ± 2 °C, 60 ± 10% RH, and a photoperiod of 16:8 (L:D) h.

A. gifuensis originally reared from *S. avenae* or from *M. persicae* are referred to as *A. gifuensis-SA* and *A. gifuensis-MP*, respectively, throughout this paper.

2.2. Parasitism of alternative aphid species

To measure performance of *A. gifuensis* on the three aphid species, we exposed female parasitoids of *A. gifuensis-SA* and *A. gifuensis-MP* to each of the three aphid species. Thus, there were six treatments (two maternal host species × three offered host species). Plant seedlings with two hundred second or third instar aphid nymphs were introduced into a plastic cage (13 cm in diameter and 30 cm in height) with screen mesh caps. After the aphids settled, five mated females of *A. gifuensis* were introduced into each rearing cage. The parasitoids were removed after 8 h, and the aphids were maintained under the same conditions. Eight days after treatment, mummified aphids in each cage were collected and counted in Petri dishes, and checked every 12 h thereafter. Emergence date and sex of all emerging wasps were recorded. Thirty newly emerged females were randomly selected, and the lengths of body and hind leg tibiae (HLT) were measured. The sex ratio was expressed as the proportion of females in offspring. Each treatment was replicated eight times.

2.3. Oviposition performance of *A. gifuensis* on alternative aphid species

Since parasitism rate alone does not distinguish between host acceptability for oviposition and suitability for development, we examined the host searching and oviposition behaviors of individual female parasitoids. Individual mated females were released into a Petri dish (9 cm in diameter and 1.5 cm in depth) containing 20 s or third instar aphids on a leaf of an appropriate host plant. Each parasitoid was continuously monitored using a digital CCD camera (LX-IR920Y, 1/3" SONY 700TVL, Japan) for 30 min, and 30 parasitoids were observed for each treatment. The number of attacks was tallied as the number of times the female probed an aphid with her ovipositor. All observations were made from 10 am to 4 pm. The aphids were dissected after two days, and the number of parasitized aphids, superparasitized aphids, and number of parasitoid larvae were recorded.

2.4. Data analysis

All data were analyzed using the Statistics package SPSS v. 19.0 (SPSS, 2010). Significant difference detected in the parameters of *A. gifuensis* that originated from the same host species and later evaluated on the three aphid species were analyzed using one-way