Parasitization of the Potato Aphid, *Macrosiphum euphorbiae* (Thomas), by *Aphelinus asychis* Walker in Greenhouses in India[1]

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ABSTRACT The potato aphid, *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae), with over 200 known host plants pecies, is one of the most problematic aphids in protected environments worldwide. This study reports for the first time the presence of *Aphelinus asychis* Walker (Hymenoptera: Aphelinidae), a major parasitoid of *M. euphorbiae*, in greenhouses in Himachal Pradesh, India. Percent parasitism by *A. asychis* ranged 2.1–39.3%, reaching its maximum in late November. These findings suggest that *A. asychis* may be released in augmentative biological control program against *M. euphorbiae*, which would help reduce pesticide use in Indian vegetable production greenhouses.

KEY WORDS *Aphelinus asychis*, aphid, *Macrosiphum euphorbiae*, biological control

Protected cultivation is the most intensive method of crop production. Its chief benefit is the protection it affords plants against adverse environmental conditions. Protected crops also provide stable, favorable microclimates for development of pest populations, which often limit the success of this crop production system (Sood 2010). The greenhouse whitefly, *Trialeurodes vaporariorum* Westwood (Hemiptera: Aleyrodidae); the green peach aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae); spider mites, *Tetranychus* spp. (Trombidiformes: Tetranychidae); the potato aphid, *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae); the serpentine leaf miner, *Liriomyza trifolii Burgess* (Diptera: Agromyzidae); and the noctuid, *Spodoptera litura* F. (Lepidoptera: Noctuidae) are the major pests of protected vegetable crops (tomato, *Lycopersicon esculentum* (Mill); bell pepper, *Capsicum annuum* L.; and cucumber, *Cucumis sativus* L.) in India (Sood 2010, Gavkare 2012).

Macrosiphum euphorbiae is noteworthy among pests of greenhouse-grown vegetables because it causes heavy economic losses in tomato (van Schelt & Wäckers 2003, Bueno 2005, Aragón et al. 2007). Populations often increase rapidly on tomatoes grown for processing (Walker et al. 1984). In addition to reducing plant growth, producing copious amount of honeydew, and promoting the growth of sooty mold, aphids are highly efficient in virus transmission

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(Fereres et al. 1993, Fernández-Calvino et al. 2006, La-Spina et al. 2008). Walgenbach (1997) determined that large aphid populations cause significant fruit quality and yield losses in tomatoes intended for fresh markets. Aphid feeding also cause defoliation, which leads to sunscald that reduces fruit quality. Other damage can occur from feeding by other hemipterans, which are attracted to high aphid populations and use the fruits as alternate food sources (Walgenbach 1997). In addition, some *M. euphorbiae* populations may be resistant to carbamates, pyrethroids, and organophosphates (Foster et al. 2002, 2007).

Biological control of aphids of Macrosiphini, such as *M. euphorbiae*, has been implemented primarily using the parasitoid *Aphidius ervi* (Haliday) (Hymenoptera: Aphelinidae) (Malais & Ravensberg 2003), but complete control is not always achieved. Few studies have selected and evaluated natural enemies of aphids of Macrosiphini. Augmentative releases of hymenopteran parasitoids in greenhouses has been used in different parts of the world (van Lenteren 2000, Wei et al. 2005, Sanchez et al. 2010). Hymenopteran parasitoids of *M. euphorbiae* are not known under greenhouse conditions in India. The present study was undertaken to determine the abundance and diversity of hymenopteran parasitoids attacking *M. euphorbiae*, and their impact on the population dynamics of this pest, under greenhouse conditions in India.

Materials and Methods

This study was conducted in a crop of tomato (var. 'Solan Lalima') that was grown in a greenhouse at the experimental farm of the Department of Entomology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry (UHF), Nauni, Solan, Himachal Pradesh, India (30.01 N latitude, 77.00 E longitude) in 2014. Thirty *M. euphorbiae*-infested tomato plants (8–9 weeks old) were tapped over white paper, and 50 aphids that dropped from the leaves, branches, and twigs were randomly collected and separated on the basis of mummified vs. live aphids at weekly intervals from 20 October to 22 December 2014. Both mummified and live aphids were kept in separate Petri dishes under laboratory conditions (25°C and 75 ± 5% RH) in the Postgraduate Laboratory, Department of Entomology, UHF.

Emerged parasitoids were collected and preserved individually in 90% alcohol. The parasitoid specimens were identified at 5×–18× magnification under stereomicroscopes (Nikon SMZ745T, Nikon digital sight DS-Fi1, Japan) using the keys in Japoshvili & Karaca (2009). Morphometric observations of the parasitoids were carried out using an ocular micrometer calibrated with a stage micrometer. Hyperparasitoids that emerged also were collected and identified.

Percent parasitism (*PP*) was calculated using the formula $PP = (M \times 100)/N$, where M is the number of parasitized aphids and N is the total number of live and parasitized aphids collected. The percent of plants damaged by *M. euphorbiae* (*PD*) was calculated using the formula $PD = (B \times 100)/a$, where B is the number of infested plants and a is the number of samples studied (Khadzhibeili 1983). A simple correlation between percent parasitism and percent plants damaged was calculated with Excel® (Microsoft, Redmond, WA) (Gomez & Gomez 1984).

Table 1. Percent plants damaged (±SEM) caused by *M. euphorbiae* and percent parasitism by *Aphelinus asychis* on each sampling date on tomato grown under greenhouse condition in Solan, Himachal Pradesh, India, from 20 October to 22 December 2014.

Sampling date	% Plant damage	% Parasitism
20 October	46.7 ± 9.8	2.1 ± 0.7
27 October	36.1 ± 7.4	14.9 ± 2.7
03 November	32.7 ± 6.8	26.5 ± 4.9
10 November	27.2 ± 5.6	35.9 ± 6.8
17 November	20.9 ± 4.5	37.9 ± 7.1
24 November	18.9 ± 3.9	39.3 ± 7.9
01 December	16.8 ± 3.1	27.9 ± 5.7
08 December	10.1 ± 2.9	15.1 ± 2.1
15 December	4.9 ± 1.2	6.6 ± 1.7
22 December	2.1 ± 0.7	2.9 ± 0.9

Results and Discussion

Aphelinus asychis was the only primary parasitoid species reared from the *M. euphorbiae* collected in this study. The parasitized mummies were first observed in the fourth week of October, and parasitism increased until 24 November 2014 (Table 1). Adult *A. asychis* collected in this study were tiny black wasps with an average length of 1.50 ± 0.65 mm and width of 0.54 ± 0.15 mm. The parasitoids were brachypterous, and the length of forewings was 1.02 ± 0.96 mm. The gaster was reddish-yellow and the legs were extensively infuscated and reddish in color.

The parasitism rate increased gradually from 2.1% on 20 October 2014 to a peak of 39.3% on 24 November 2014 (Table 1). The parasitism rate then gradually decreased, reaching 2.9% on 22 December 2014. The decline in percent parasitism is perhaps due to a reduction of the aphid population, decreasing ambient temperatures, or hyperparasitism by *Alloxysta* spp. (Hymenoptera: Figitidae), which was collected in this study. *Alloxysta* spp. also has been reported as a hyperparasitoid of *Aphidius colemani* and *A. asychis* parasitizing *M. persicae* (Grasswitz & Reese 1998, Gavkare et al. 2014).

Plant damage decreased gradually from 20 October to 22 December 2014 (Table 1). However, the aphid population decreased after the parasitoids appeared. The percentage of plants damaged decreased from 46.7% on 20 October, to 18.9% on 24 November, and finally to 2.1% on 22 December 2014. The decrease in the percentage of plants infested by *M. euphorbiae* was likely due to the impact of *A. asychis*, because no other natural enemies were active during this period. However, a significant correlation was not observed between percent plants damaged and percent parasitism ($R = 0.062$).

Aphelinus asychis was first recorded during a survey of natural enemies of aphids in India (Rameseshiah & Dharmadhikari 1969) and its taxonomic position was established later (Hayat 1980). The present study is the first report of parasitisation of *M. euphorbiae* by *A. ascychis* under greenhouse conditions in India. Gavkare et al. (2014) also collected *A. asychis* from *M. persicae* infesting

C. annuum under greenhouse conditions in India. Augmentative releases of *A. asychis* have been used against *M. euphorbiae* in different parts of the world (Wei et al. 2005, Sanchez et al. 2010). Tatsumi & Takada (2005) assessed the potential of this parasitoid as a biological control agent against three aphid species, *A. gossypii, M. persicae,* and *M. euphorbiae* in Japan. They (Tatsumi & Takada 2005) concluded that *A. asychis* could be an effective biological control agent against *M. euphorbiae*. However, there is no published record of this parasitoid on *M. euphorbiae* in a greenhouse environment in India before this study. The present record of these parasitoids of *M. euphorbiae* under greenhouse conditions is an important piece of information in developing biological control strategy for this aphid. Further studies are required to develop methods for mass rearing and release techniques in tomato production in Indian greenhouses.

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