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Seasonal Population Dynamics, Spatial Distribution and Parasitism of *Aphis gossypii* on *Hibiscus rosa-chinensis* in Khuzestan, Iran

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ABSTRACT
Aphis gossypii is major pest of *Hibiscus rosa-chinensis* in Khuzestan province, Iran. Seasonal population dynamics, spatial distribution and parasitism of the aphid were investigated during 2008-2010. The aphid population was monitored by leaf count and yellow sticky trap sampling methods. *A. gossypii* observed during moderate temperature months of year (October to April) in Khuzestan condition. The aphid migrates from weeds to *H. rosa-chinensis* in beginning of November. Density peak of *A. gossypii* was recorded during January to February. Yellow sticky trap was suitable sampling tool that could monitor early infestations of the plant by *A. gossypii*. Spatial distribution pattern of the aphid was determined by Taylor's power law. Spatial distribution of the aphid was aggregated on the plant. Parasitism percentage of the aphid by Aphidiidae wasps, especially during January to April, was high. Reduction of insecticide application during the parasitoid activity peak could be useful to the parasitoids conservation.

Key words: Cotton aphid, tropical hibiscus, seasonal population dynamics, spatial distribution, Aphidiidae

INTRODUCTION
Tropical Hibiscus, *Hibiscus rosa chinensis* L., is one of the widely distributed ornamental plant in the urban green landscape of tropical and subtropical regions such as Khuzestan province, Iran (Sher *et al.*, 2002). This plant severely infested with Cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) (Yarahmadi *et al.*, 2011). *A. gossypii* Glover, is cosmopolitan pest that could colonizing more than 600 host plants in tropical, subtropical and warm temperature regions (Blackman and Eastop, 2000). The aphid feeds on the underside of leaves and sucking out plant sap (Karim *et al.*, 2001a). High population of the aphid can reduce the vigor of the host plant and making it susceptible to other pests. The honeydew that the aphid excretes reduces aesthetic value of ornamental plants due to the development of sooty mold on leaves and flower surfaces (Quisenberry and Ni, 2007). Moreover, the sooty mold reduces plant growth and blossom causing photosynthesis reduction. The aphid feeding on blooms causes malformation of the *H. resa-chinensis* flowers (Yarahmadi *et al.*, 2011). *A. gossypii* transmits more than 50 plant viruses (Blackman and Eastop, 2000; Sertkaya and Gulsen, 2005). The aphid was severely parasitized by Aphidiidae such as *Aphidius colemani* Viereck on *H. rosea-chinensis* in Khuzestan province (Yarahmadi *et al.*, 2011). *A. colemani* is a polyphagous solitary endoparasitoid of aphids and

A. gossypii is a highly suitable host for this parasitoid (Perdikis *et al.*, 2004). The parasitoid wasp is a major natural enemy of *A. gossypii* that widely used in biological control of the pest (Elinberg *et al.*, 2000). Information about seasonal population dynamics and spatial distribution of *A. gossypii* and its main natural enemy, Aphidiidae wasps, are essential to development of suitable Integrated Pest Management (IPM) programs based on effective pest control as well as benefit organism conservation. The present study was conducted to determine seasonal population dynamics and spatial distribution of *A. gossypii* and parasitism of it by its main associated natural enemies, Aphidiidae wasps, on *H. rosa-chinensis* in Khuzestan province, South of Iran.

MATERIAL AND METHODS

Experimental design: The experiments were carried out during October 2008 to May 2010 at Dolat Park, Ahwaz Parks and Green Spaces Organization (APGSO), Khuzestan, Iran. The park included 73 *H. rosa-chinensis* plants that were 12-15 years old. No insecticide treatments were applied during trial period. Irrigation and fertilization of the plants were done according to recommendations of horticultural supporting department of APGSO.

Seasonal population dynamics of *Aphis gossypii*: The population densities of *A. gossypii* were monitored weekly using commercial yellow sticky traps (13 by 8 cm) and leaf count methods. Fifteen *H. rosa-chinensis* were chosen and tagged to sampling. To monitor Aphid density, one yellow sticky trap was placed just above the crop canopy of each selected plants for a 24 h period and then collected for counting winged aphids on both sides of it. Positions of yellow sticky trap were randomized in each sampling date.

Each sampling date, starting at the same time, three plants were also randomly selected to leaf counts. Three leaves from different height levels (top, middle and bottom) of the canopy of each selected plant were randomly chosen and transferred to laboratory. In laboratory, the adult and nymph stages of the aphid were counted under stero-microscope.

Efficacy of yellow sticky trap for monitoring the trend of *A. gossypii* population was evaluated by simple correlation analysis for regression between the aphid densities caught on yellow sticky traps and the aphid population that recorded by leaf count method.

Parasitation of *Aphis gossypii* by Aphidiidae wasps: To parasitism evaluation, sampling was performed by leaf count method that mentioned earlier. Number of emerged and none emerged aphid mummies were counted under sterio-microscope to percentage estimation.

Spatial distribution of the aphid and parasitoid wasps: The spatial distribution of the aphid on *H. rosa-chinensis* was evaluated by using the parameters of Taylor's power law. This law describes the regression between logarithm of population variance and logarithm of population mean according to the equation as follows:

$$\text{Log}(S^2) = a+b\,\text{Log}(\bar{X})$$

where, S^2 is the population variance, $\bar{X}$ is population mean, a is the Y-intercept and b is slope of regression line. This equation can transform as follows:

$$S^2 = a\bar{X}^b$$

where, a is the antilogarithm of a and constitutes a scaling factor depending on the sampling unite and b is an index of organism species spatial pattern with b<1, b = 1 and b>1 indicating uniform, random and aggregated spatial pattern, respectively (Southwood, 1978; Tomanovic *et al.*, 2008). Also, Correlation coefficient (r) was calculated to goodness of fit of Taylor's power law. Two tailed t-test at n-2 df was conducted to determine if slope and correlation coefficient values of the regression relation different significantly from 1 and 0, respectively (Snedecor and Cochran, 1980).

Data analyses: Pearson's correlation coefficient was calculated to test relationship between population monitored by yellow sticky trap and leaf count methods. All analyses were carried out using the SPSS software version 16 (SPSS Inc., Chicago, USA).

RESULTS

Seasonal population dynamics of *Aphis gossypii*: Population dynamics of *A. gossypii* as monitored by yellow sticky traps and leaf counts first and second periods of the aphid activity were show in Fig. 1 and 2, respectively. The aphid observed on *H. rosa-chinensis* during moderate

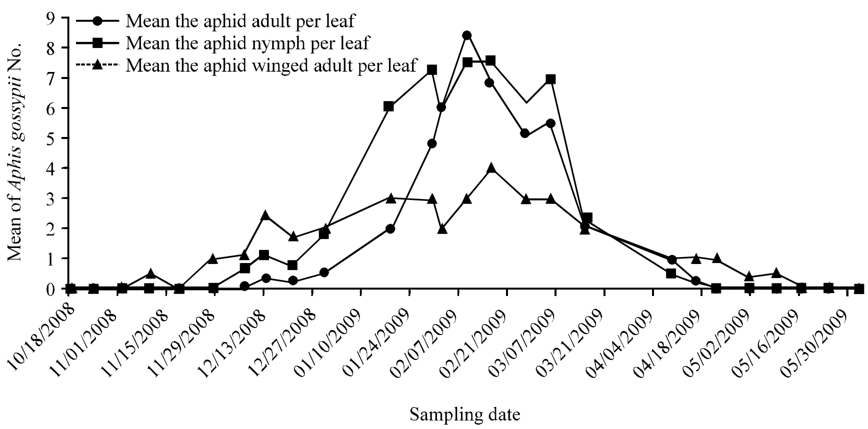

Fig. 1: Seasonal population dynamics of *Aphis gossypii* on *Hibiscus rosa-chinesis* during the first period of aphid activity

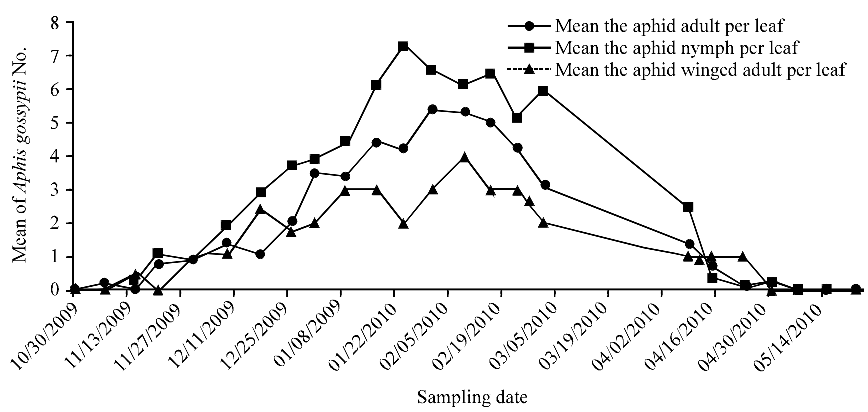

Fig. 2: Seasonal population dynamics of *Aphis gossypii* on *Hibiscus rosa-chinesis* durin the second period of aphid activity

temperature months of year (October to April) in Khuzestan province with tropical weather condition. Population trends as measured using yellow sticky trap and plant leaf count were the same in the both periods.

In the first period of aphid activity (October 2008 to Jun 2009), population densities of *A. gossypii* increased exponentially from 0.35-8.4 adults and 1.09-7.53 nymphs per leaf from 18 October 2008 to 9 February 2009. The population densities of adults and nymphs decreased after 9 and 16 February 2009 as reached 0.26 adult or 0.2 nymph at 16 April 2009. No aphid adults or nymphs were sampled after 16 April in the first period of aphid activity. Winged aphids were captured by yellow sticky trap from 2 November in the first period of aphid activity.

The aphid densities as monitored by yellow sticky trap were slowly increased from 0.1 aphids per trap at 2 November 2008 and reached peak 4 aphids per trap at 16 February 2009. The captured aphids by yellow sticky trap were gradually reduced after 16 February. The aphid populations were seen till 9 May on yellow sticky taps and then disappeared since 16 May 2009.

During the second period of aphid activity (November 2009 to May 2010), the first adults and nymphs were observed at 7 and 15 November 2009 for leaf count and yellow sticky trap sampling methods, respectively. The aphid densities as measured using yellow sticky trap and leaf count methods built up rapidly from November 2009 to February 2010. Peak densities of adult and nymph stages were 5.4 and 7.3 aphid at 1 February and 24 January 2011, respectively. Populations of adults and nymphs as monitored by leaf count method decreased rapidly from 21 January and 1 February to end of sampling period, respectively. When population was monitored using yellow sticky trap, peak density of the aphid was recorded at 9 February 2010. After this time density of *A. gossypii* captured by yellow sticky trap, was dropped. No aphid captured by yellow sticky trap after 23 April 2010.

Regression relationship between densities of *A. gossypii* as monitored by leaf count and yellow sticky trap methods was showed in Fig. 3. Pearson's correlation coefficient showed that *A. gossypii* population as monitored by yellow sticky trap was significantly correlated with the aphid population as monitored by leaf count method that used as standard method (p = 0.000; n = 62). Therefore, yellow sticky trap could be used as a suitable monitoring tool in *A. gossypii* IPM on *H. rosa-chinensis*.

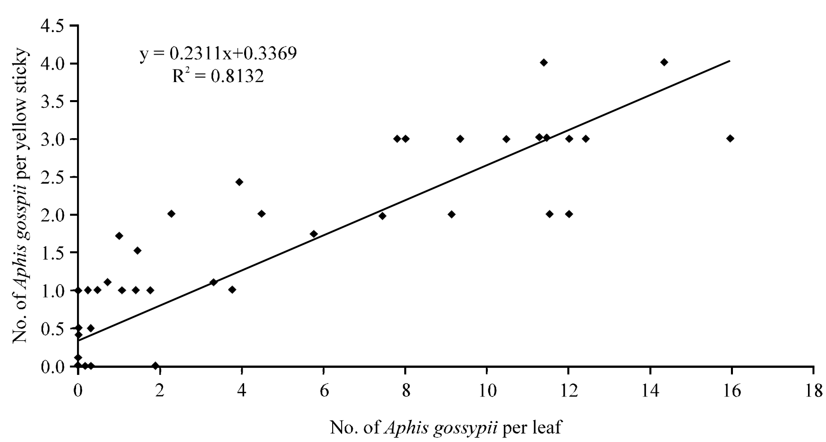

Fig. 3: Regression relationship between densities of *Aphis gossypii* as monitored by leaf count and yellow sticky trap methods

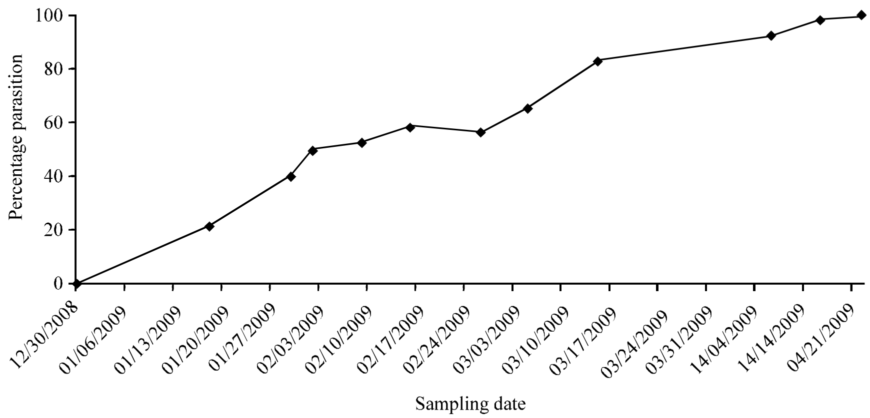

Fig. 4: Parasitism percentage of *Aphis gossypii* by Aphidiidae wasps during the first period of aphid activity

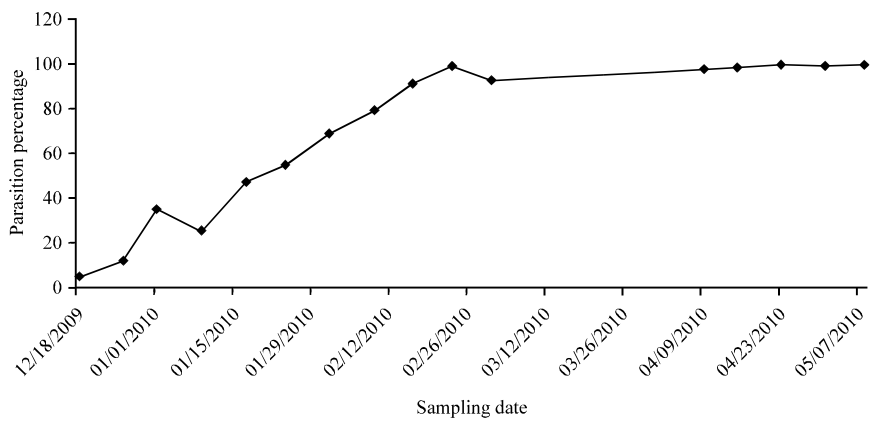

Fig. 5: Parasitism percentage of *Aphis gossypii* by Aphidiidae wasps during the second period of aphid activity

Parasitation of *Aphis gossypii* by Aphidiidae wasps: Parasitism percentage of *A. gossypii* by Aphidiidae wasps during the first and second periods of aphid activity were showed in Fig. 4 and 5, respectively. Mummified aphids due to activity of Aphidiidae wasps were observed from January and December in the first and second periods of aphid activity, respectively. Parasitism percentage of the aphid in beginning of these periods was low. Parasitism percentage of *A. gossypii* was gradually enhanced by the parasitoid wasps. Highest parasitism percentage (100%) was recorded in April and May in the first and second periods of aphid activity.

Spatial distribution of the aphid and parasitoid wasps: The regression relationship between logarithm mean and logarithm variance of *A. gossypii* is presented in Fig. 6. The correlation coefficient value for Taylor's model was significantly different from 0. Therefore, this model accurately describes the mean-variance linear relation for the *A. gossypii* data set (p = 0.000, df = 10, t = 8.3). Slope value of the regression (b) was significantly different from 1 (p = 0.000, df = 10, t = 6.54) that indicated an aggregated distribution pattern for *A. gossypii* on *H. rosa-chinensis* leaves.

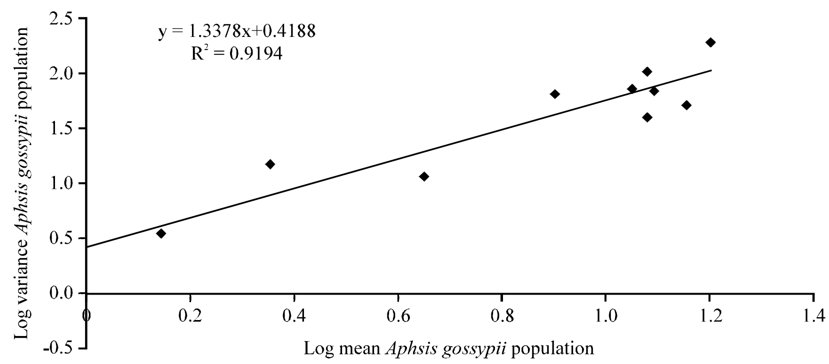

Fig. 6: Regression relationship between logarithm mean and logarithm variance of *A. gossypii*

DISCUSSION

Population of *A.* gossypii was sampled during moderate months of year (from beginning of November to mid of May) in Khuzestan province. In this period, weather temperature was 15-30°C in this province. The first populations of *A. gossypii* were sampled in November that weather temperature gradually decreases. The winged aphids were sampled by yellow sticky trap before establishment of wingless aphid. The winged aphids probably were migrating aphids that migrated from weeds or other aestivating places to *H. rosa-chinensis* canopy. Migration is prevalent phenomenon in life cycle of aphids (Williams and Dixon, 2007). This Yellow sticky trap could be used as a good tool for early detection of *A. gossypii* infestations. The result agrees with those observed by Ferrari and Nocoli (1994). They showed that *Hibiscus syriacus* infested by *A. gossypii* during winter and then its population migrated on cucurbitaceae crops. This result conflicts with those observed by Karim *et al.* (2001b) and Lee *et al.* (2002) on *Solanum melongena* L. and *Capsicum annum* L., respectively. Differences between climatic condition and host plant may be due to conflict of the results with our study. Kids (1985) showed that, host plant quality affect population dynamic of aphids.

Various traps were suggested to aphid population monitoring and infestation time forecasting such as air suction trap (Stary and Lukasova, 2000), water pan trap (Idris *et al.*, 2002; McDonald *et al.*, 2003), yellow pan trap (Singh *et al.*, 1996) and yellow sticky trap (Saljoqi and Van Emden, 2003; Horrocks *et al.*, 2010).

Weeds could be a main colonization source of *H. rosa-chinensis* infestation to *A. gossypii* in Khuzestan province. Hence, Effective weed control could be helpful to decrease the aphid population on *H. rosa-chinensis*. Also, weeds could be serve as plant viruses source such as Eggplant Mottled Dwarf Virus (EMDV) that aphid could transmit it to *H. rosa-chinensis* (Kartis *et al.*, 2007; Valizadeh *et al.*, 2011).

Parasitism percentage of Aphidiidae wasps on *Aphis gossypii* was high especially in end of the aphid activity period. Similar results were presented by Farrel and Stufkenes (1990). This result indicated that the aphid could be effectively suppressed by Aphidiidae wasps if the parasitoid conserved. Reducing the application of unnecessary insecticide especially during the parasitoid wasps activity peak (end of January to end of April) could be effective to the natural enemy conservation. Also, using more selective insecticide or more selective approaches for application of broader spectrum insecticide are other strategies that are applied to natural enemies' conservation (Naranjo *et al.*, 2003; Kumar *et al.*, 2012).

Spatial distribution of *A. gossypii* was aggregative on *H. rosa-chinensis*. Analysis of spatial distribution pattern is recognized as a necessary procedure for insect population studies and provides basic information to designing efficient and cost effective sampling plans for population estimation and pest management (Madadi *et al*., 2011). Aggregative distribution of *A. gossypii* was reported by some authors such as Zhang *et al*. (1998) and Afshari *et al*. (2009). So, this study found the seasonal population dynamic and spatial distribution of *A. gossypii* and parasitism of it by its main associated nature enemies.

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