Canadian Journal of Pure and Applied Sciences
Vol. 13, No. 2, pp. 4799-4805, June 2019
Online ISSN: 1920-3853; Print ISSN: 1715-9997
Available online at www.cjpas.net

HOST DENSITY OF THE APHID *BREVICORYNE BRASSICAE* LINNAEUS (HEMIPTERA: APHIDIDAE) ALTERS THE BIOTIC POTENTIAL OF THE APHID PARASITOID *DIAERETIELLA RAPAE* (HYMENOPTERA: BRACONIDAE: APHIDIINAE)

*Muhammad Jaffar Hussain[1], Muhammad Anjum Aqueel[1], Abu Bakar Muhammad Raza[1] and Errol Hassan[2]
[1]University College of Agriculture, University of Sargodha, 40100, Sargodha, Pakistan
[2]School of Agriculture and Food Sciences, The University of Queensland Gatton, Australia

ABSTRACT

Parasitoids are the most widely used group of natural enemies in biological control programs of insect pests especially for aphid species. Among the aphid parasitoids, *Diaeretiella rapae* is one of the most important to parasitize the aphid species *Brevicoryne brassicae.* The present study was done under laboratory condition (25±2 ºC temperature and 65-70% R.H.) to assess the biotic potential of *D. rapae* on *B. brassicae*. We used host densities of 10, 20, 40, 80 and 120 aphids per cage. For each host density only two couples of male and female of *D. rapae* were released. Results showed that the highest parasitism rate (40.95%) was observed at the lowest host density (10 aphids), while minimum parasitism (23.41%) was observed at the highest host density (120 aphids). Parasitism rates of 36.08%, 33.63% and 31.76% were observed in host densities of 20, 40 and 80 aphids, respectively. The percent emergence of adult *D. rapae* from each host density of 10, 20, 40, 80 and 120 aphids was 81.17%, 69.44%, 63.34%, 48.42% and 44.76% respectively. The coefficients of determination (R^2) values for percent parasitism and adult emergence were 91.95% and 90.24%, respectively. Our f0069ndings revealed that an increase in host density decreased the parasitic potential as well as the percent emergence of the aphid parasitoid.

Keywords: *Diaeretiella rapae*, host density, percent parasitism, adult emergence.

INTRODUCTION

Canola (*Brassica napus*) belongs to the family Cruciferae and is newly established as an oilseed crop in Pakistan. It is promoted as a health food due to its nutritional value i.e, little erucic acid <2% and <30% micro mg, low acid glucosinolates and lack of cholesterol (Beversdorf and Hume, 1990). In Pakistan the normal yield of canola is very low compared to other *Brassicae* growing countries for many reasons. Among them pest attack is prominent as canola is attacked by thirty (30) different types of pests (Hati *et al*., 2001; Rahnema and Bakhshandeh, 2006). Among the pests of canola, aphids are a serious threats to canola crops (Talpur *et al*., 1991; Syed *et al*., 1999; Saljoqi *et al*., 2001).

Parasitoids are used as a biological control of aphids. One species of parasitoid used to control *Brevicoryne brassicae.* The name *Brevicoryne* refers to the small pipes called cornicles at the posterior end of abdomen. Their waxy coating (present on the surface of the body) and small cornicles distinguish them from other aphid species (Carter and Sorenson, 2013; Opfer and Mcgrath, 2013). Aphid attack on *Brassicae* seedlings can cause wilting of cotyledon and flower, yellowing of leaves and cessation of flowering and podding (Berlandier, 2004). Generally aphids cause 30-35% yield losses of canola crops (Butin and Raymer, 1994; Rana, 2005), but this damage can reached up to 70% (Khattak *et al.*, 2002). *Diaeretiella rapae* is the most important parasitoid of *B. brassicae* (Jankowska and Wiech, 2003; Saleh, 2008; Saleh *et al*., 2009; Pramanik *et al*., 2012). It has the potential to control *B. brassicae* but, among the factors which affect the efficacy of this parasitoid, host density is an important one (Sinha and Singh, 1979). The percentage of parasitism increases with an increase in number of parasitoids. However, the functional response and rate of parasitism by *D. rapae* at different densities of *Diuraphis noxia* are different. The increase in host densities leads to a decrease in proportion of host parasitized by the parasitoid (Zahra *et al*., 2011; Ralec *et al*., 2011). Nutritional and physiological components of the host directly disturb development, death rate, longevity and fecundity of bio control agents such as parasitoids (Roitberg *et al*., 2001). The present study was done to

*Corresponding author e-mail: jaffar2285@gmail.com

evaluate the efficacy of *D. rapae*on different densities of its host *B. brassicae* under laboratory conditions.

MATERIALS AND METHODS

To check the impact of *B. brassicae* density on the biotic potential of *D. rapae*, an experiment was carried out under laboratory conditions at 25±2 ºC and 65-70% R.H.

Experimental procedure

Seeds of canola "cv, Punjab sarsoon" were bought from a local market and sown in plastic pots under laboratory conditions. Aphids and parasitoids were selected from reared cultures. After three weeks of germination, different aphid densities (10, 20, 40, 80 and 120 aphids) were released on this cultivar (one pot for each density). A third instar of aphid was released on the canola plant.

The potted plants were put into plastic cages (35×25×25 cm). Two pairs of (♀=2 and ♂=2) of newly emerged aphid parasitoids were released for each aphid density. *D. rapae* was offered for a 24 hour stinging period for each aphid density (Behan *et al*., 2007). After one day of stinging period the parasitoids were removed from the cages with the help of an aspirator. The aphids were kept under laboratory conditions until the formation of mummies.

Study Parameters

Percent parasitism

After mummies formation, percent parasitism was recorded by using by the formula:

$$\text{Percent parasitism} = \frac{\text{No. of mummies}}{\text{Total number of aphids}} \times 100$$

Percent emergence

For percent emergence of adult parasitoid, each mummy was put into an Eppendorf tube. When mummies changed dark brown (near to emergence), a honey solution (9:1) soaked cotton ball was placed in the tube (Wang *et al*., 2010). Percent emergence was recorded by using the formula:

$$\text{Percent emergence} = \frac{\text{No. of adult emerged}}{\text{Total number of mummies}} \times 100$$

Adult longevity

To calculate adult longevity of *D. rapae* from each aphid density, emerged parasitoids were transferred into clean Eppendorf tubes. Parasitoids were fed with the 10 % honey solution. Daily observation was done to check their longevity until they died.

Statistical analysis

Data on percent parasitism, adult emergence and adult longevity of parasitoids were analyzed using a completely randomized design (CRD) to check the effect of different aphid densities. The means were separated using Tukey's HSD all pair-wise comparison test.

RESULTS

Analysis of variance for percent parasitism and percent emergence of adult *D. rapae* against different *B. brassicae* densities

The analysis of variance regarding percent parasitism and adult emergence is shown in Table 1. The results show that host density had a significant impact on percent parasitism and adult emergence of parasitoids.

Table 1. Analysis of variance for percent parasitism and percent emergence of adult *D. rapae* against different *B. brassicae* densities.

SOV	DF	SS	MS	F-value	P-value
% Parasitism					
Treatment	4	832.10	208.026	3.51	0.0251*
Error	20	1185.65	59.282		
Total	24	2017.75			
% Emergence					
Treatment	4	4523.03	1130.76	24.3	<0.001***
Error	20	931.45	46.57		
Total	24	5454.48			

* Significant (P < 0.05), *** Highly Significant (P < 0.001)

Percent parasitism of *Diaeretiella rapae* at different host densities, *Brevicoryne brassicae*

Percent parasitism of the parasitoid at different host densities is shown in Figure 1. The result showed that maximum percent parasitism (40.95% ± 1.84)was recorded at the lowest host density (10 aphids) and minimum parasitism(23.41% ± 2.24) was observed at the highest host density (120 aphids). Host densities of 20, 40 and 80 aphids resulted in 36.08% ± 1.88, 33.63% ± 1.55 and 31.76% ± 1.28 parasitism respectively. The percent parasitism of *D. rapae* decreased with the increase in *B. brassicae* density.

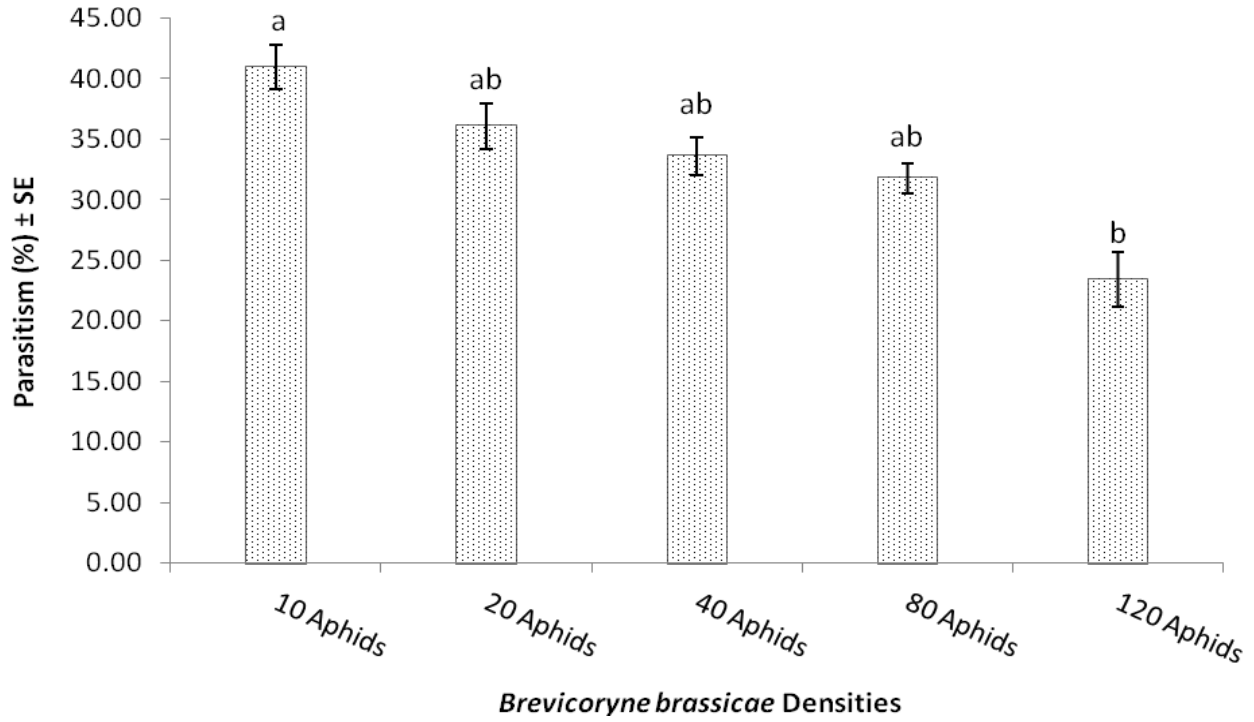

Fig. 1. Percent parasitism of *D. rapae* at different host densities (*B. brassicae*) (Mean ± SE). Means followed by the same letter are not significantly different (Tuckey HSD, P≤0.05).

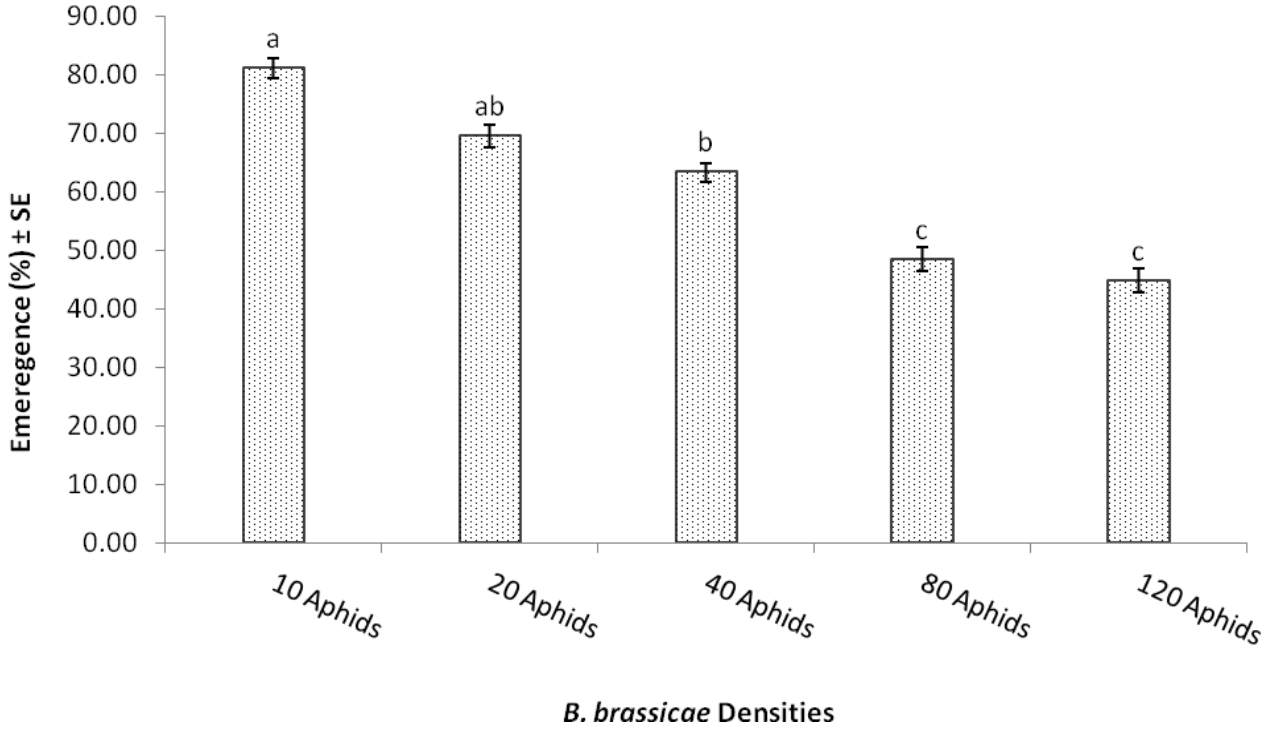

Fig. 2. Percent emergence of adult *D. rapae*at different host densities (*B. brassicae*) (Mean ± SE). Means followed by the same letter are not significantly different (Tuckey HSD, P≤0.05).

Percent emergence of adult *Diaeretiella rapae* from different host densities (*Brevicoryne brassicae*)

Percent emergence of adult *D. rapae* at different host densities is shown in Figure 2. The results show that the maximum (81.17% ± 1.67) adult percent emergence was recorded at the lowest host density (10 aphids) and the minimum(44.76% ± 2.05) adult emergence was observed at the highest host density (120 aphids). Host densities of 20, 40 and 80 aphids resulted in 69.44% ± 1.90, 63.34% ± 1.57 and 48.42% ± 2.08 emergence, respectively. The percent adult emergence of *D. rapae* decreased with an increase in *B. brassicae* density.

Relationship of different *B. brassicae* densities with percent parasitism and adult emergence of *D. rapae*

The relationships between host density and percent parasitism and adult emergence of parasitoid are shown in Figure 3. The results show that percent parasitism was closely related to *B. brassicae* density (R^2=0.9195) but this relation was negative because when host density increased the parasitism rate of *D. rapae* decreased. The rate of adult emergence of parasitoids from mummies of *B. brassicae* also showed a close relationship to host density but this was also negative because increased host density led to decreased adult emergence of the parasitoid.

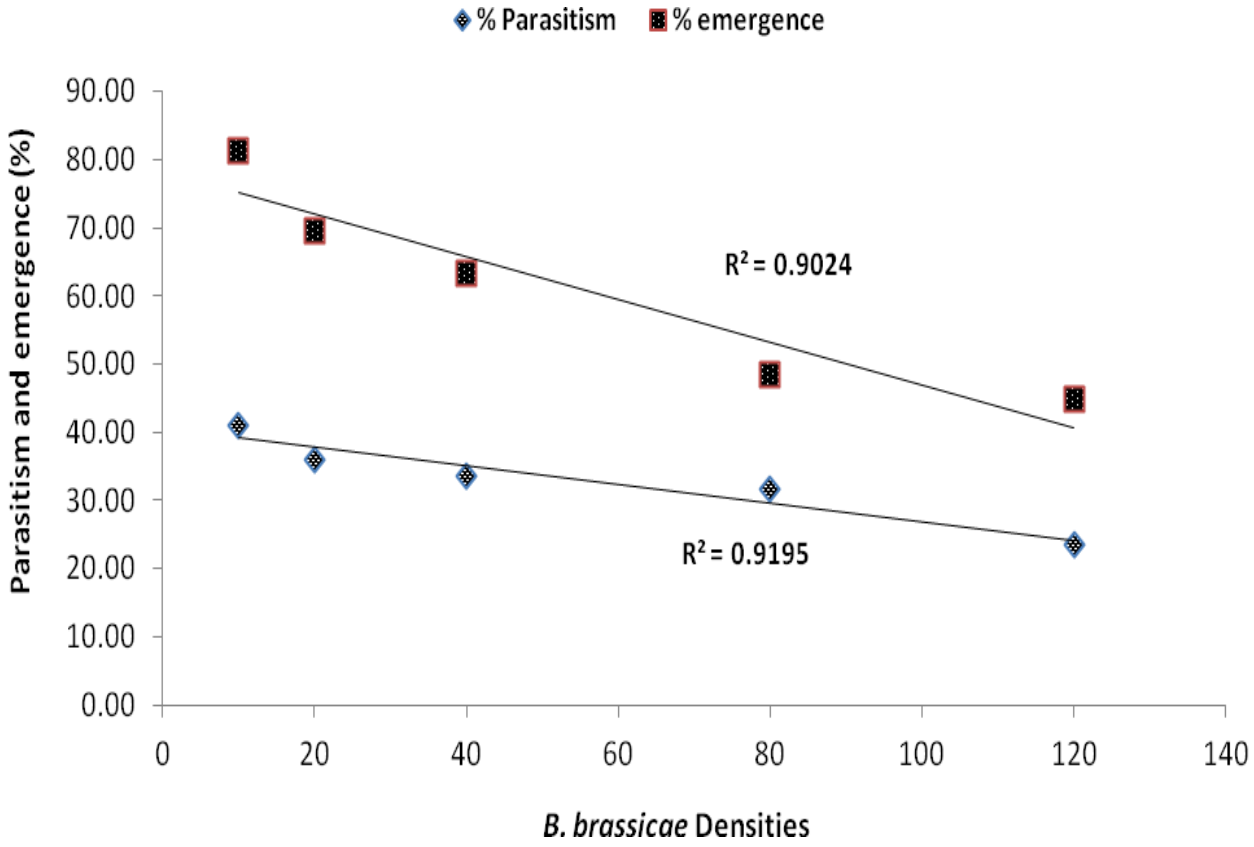

Fig. 3. Relationship of different *B. brassicae* densities with percent parasitism and adult emergence of *D. rapae*.

Adult longevity of *Diaeretiella rapae* at different densities of *Brevicoryne brassicae*

The adult longevity of *D. rapae* at different host densities of *B. brassicae* is shown in Figure 4. The results show that when aphid density increased the total longevity of adult parasitoids decreased. The maximum adult longevity (8.6±0.25 days)of *D. rapae* was noticed in lowest host density (10 aphids) and minimum adult longevity (6±0.32 days) of the parasitoid was observed in the highest density (120 aphids). Host densities of 20, 40 and 80 aphids resulted in adult longevity of 8±0.32, 7.6±0.4 and 6.8±0.2 days, respectively.

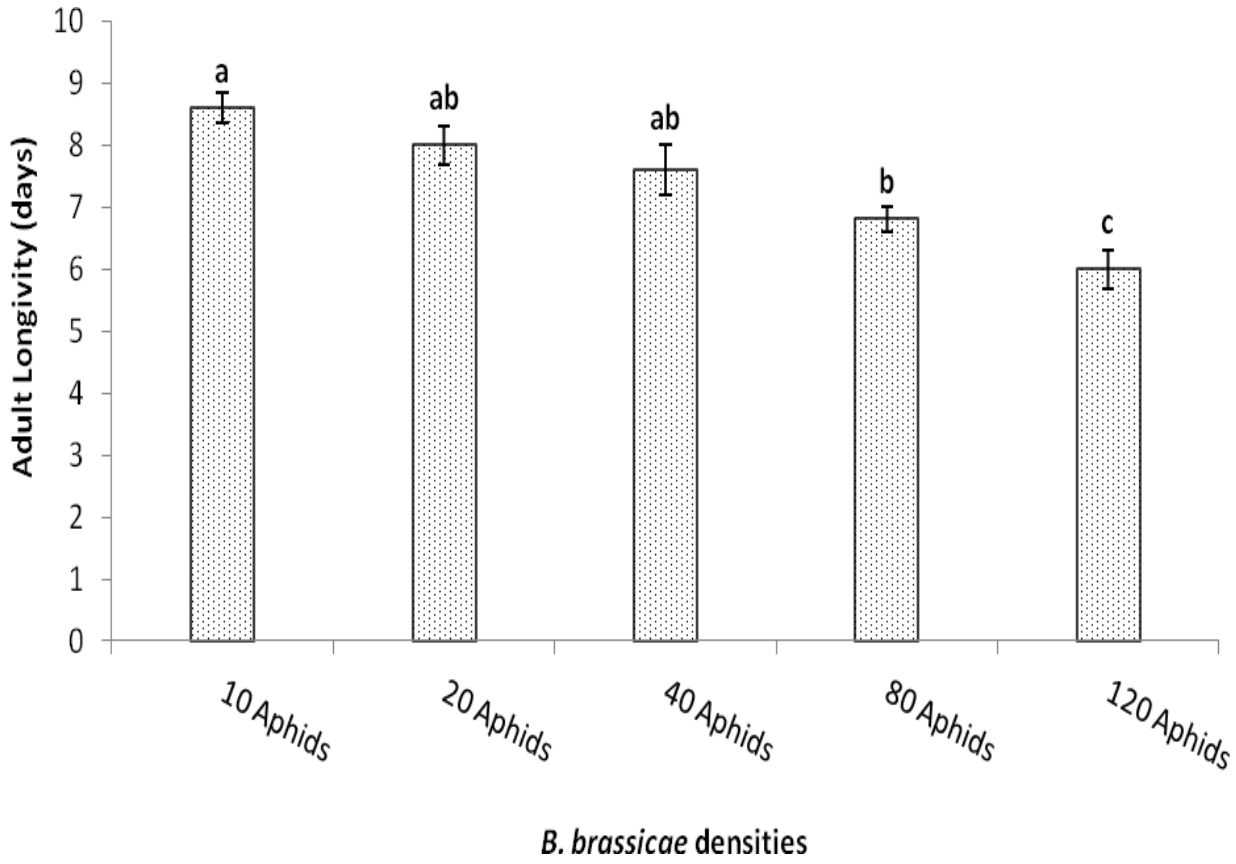

Fig. 4. Longevity of *Diaeretiella rapae* at different densitiesof *Brevicoryne brassicae* (Mean ± SE). Means followed by same letter are not significantly different (Tuckey HSD, P≤0.05).

DISCUSSION

To reduce *B. brassicae* population, *D. rapae* is the most important natural enemy of this aphid specie all over the world. *D. rape* is important among all the natural enemies of cabbage aphid due to its high population densities and high rates of parasitism (Stary *et al.,* 2000). As seen from present results, the percent parasitism of *D. rapae* decreased with an increase in *B. brassicae* density because the egg laying capacity of *D. rapae* decreased with an increase in *B. brassicae* density. This might be due to searching time and number of patch visits by parasitoids. The percent parasitism decreases with increased host density (Stadler and Volkl, 1991; Van Steenis and El-Khawass, 1995). These results are similar to those of Henter (1995), who concluded that parasitism rate decreased due to hyper parasitism. According to Foster *et al*. (2007) and Gillespie *et al*. (2009) parasitoids use different aspects for host selection, thus leading to different host consequences in host suppression and host acceptance by the parasitoid (*A. colemani*). Likewise, percent parasitism and emergence of adult parasitoids are also depending upon the aphid life history (Gillespie *et al*., 2009). Present results are similar to those of Messelink *et al*. (2012) who observed that at the lowest density of the host, the parasitoid (*A. colemani*) showed maximum parasitism and gave better control.

Our results are also in accord with Pedro *et al*. (2016) who observed that parasitism rate depend on host density. The fertility ratio of parasitoid decreased with increase in host density and mortality increased with increase in parasitoid densities. Our results show that percent adult emergence of *D. rapae* decreases with increase in host density. These findings are similar to the findings of Chau and Mackauer (2001) who observed that parasitoids prefer lower host densities. *D. rapae* is the most important biological control if it is available at the right place and the right host parasitoid ratio (Rehman and Powell, 2010).

Findings of study show that percent parasitism has a negative relation with *B. brassicae* density. When *B. brassicae* density increased, the parasitism rate of *D. rapae* decreased. In the case of adult emergence of *D. rapae* from mummies of different *B. brassicae* our results showed that as aphid density increased the adult

emergence of the parasitoid decreased. Adult longevity of *D. rapae* decreased with increase in aphid density. Our observation are also similar to Yu (1999) who reported that when egg density is higher on the hosts then the death rate of immature progeny is increased with respect to time.

Present findings are similar to those of Ull-yett (1945) who reported that *B. hebetor* normalizes distribution of eggs among hosts by reducing the number of eggs laid on a host as host density increases (Doutt, 1959; Hagstrum and Smittle, 1977). Khaskasa *et al*. (2016) observed that the 3rd instar of *B. brassicae* is the most favorable host for parasitism of *D. rapae*. The percent parasitism was higher on 3rd instar of *B. brassicae*. Different factors can be affect the efficacy of parasitoids like number of instars (Colinet *et al*., 2005) and egg laying capacity of the host (Stary, 1970).

CONCLUSION

It was concluded that the percentage parasitism of *D. rape* decreased as the density of host increased and at lower density the percent parasitism increased. The reduction of percentage parasitism was due to decrease in egg laying capacity. The egg laying capacity of the parasitoid decreased when host density increased. In the case of adult emergence of *D. rapae*, the emergence rate was highest at the lowest host density. Strongly negative correlations exist between percentage parasitism and adult emergence with host density.

REFERENCES

Behan, SO., Ulusoy, MR. and Bayhan, E. 2007. Is the parasitization rate of *D. rapae* influenced when *B. brassicae* feeds on Brassica plants? Phytoparasitica. 35(2):146-149.

Berlandier, F. 2004. Aphid Management in Canola Crops. Farmnote No. 45. Department of Agriculture, South Perth, Western Australia, Australia.

Beversdorf, W. and Hume, DJ. 1990. Registration of 'Winfield' rapeseed. Crop Science. 30:1356.

Butin, GD. and Raymer, PL. 1994. Pest status of aphids and other insects in winter canola in Georgia, J. Econ. Ent. 87(4):1097-1104.

Carter, CC. and Sorensen, KA. 2013. Insect and related pests of vegetables. Cabbage and turnip aphid. Center for Integrated Cabbage aphid *Brevicoryne brassicae* Linnaeus (Insecta: Hemiptera: Aphididae) Pest Management. North Carolina State University, Raleigh, NC., USA.

Chau, A. and Mackauer, M. 2001. Preference of the aphid parasitoid *Monoctonus paulensis* (Hymenoptera: Braconidae, Aphidiinae) for different aphid species: Female choice and offspring survival. Biol. Control. 20(1):30-38.

Colinet, H., Salin, C., Boivina, G. and Hance, T. 2005. Host age and fitness-related traits in a koinobiont aphid parasitoid. Ecol. Entomol. 30:473-479.

Doutt, RL. 1959. The biology of parasitic Hymenoptera. Annu. Rev. Ent. 4:161-182.

Foster, SP., Tomiczek, M., Thompson, R., Denholm, I., Poppy, G., Kraaijeveld, AR. and. Powell, W. 2007. Behavioural side-effects of insecticide resistance in aphids increase their vulnerability to parasitoid attack. Anim. Behav. 74:621-632.

Gillespie, DR., Quiring, DJM., Foottit, RG., Foster, SP. and Acheampong, S. 2009. Implications of phenotypic variation of *Myzus persicae* (Hemiptera: Aphididae) for biological control on greenhouse pepper plants. J. Appl. Entomol. 133:505-511.

Hagstrum, DW. and Smittle, BJ. 1977. Host-finding ability of *Bracon hebetor* and its influence upon adult parasite survival and fecundity. Environ. Ent. 6:437-439.

Hati, KM., Mandal, KG., Mihsra, AK., Ghosh, PK. and Acharya, CL. 2001. Evapo-transpiration, water-use efficiency, moisture use and yield of Indian mustard (*Brassica juncea*) under varying levels of irrigation and nutrient management in Vertisol. Indian J. Agric. Sci. 74(6): 339-342.

Henter, HJ. 1995. The potential for coevolution in a host–parasitoidsystem. II. Genetic variation within a population of wasps in the ability to parasitize an aphid host. Evolution. 49:439-445.

Jankowska, B. and Wiech, K. 2003. Occurrence of *Diaretiella rapae* (M'Intosh) (*Aphididae*) in cabbage aphid (*Brevicoryne brassicae* L.) colonies on different crucifere crops. Sodininkyste ir darzininkyste. 22(3):155-164.

Khaskasa, SWR., Mohamed, SA., Lagat, ZO., Khamis, FM. and Tanga, CM. 2016. Host stage preference and performance of the aphid parasitoid *Diaeretiella rapae* (Hymenoptera: Braconidae) on *Brevicoryne brassicae* and *Lipaphis pseudobrassicae* (Hemiptera: Aphididae). Int. J. Tropical Insect Science. 36(1):10-21.

Khattak, SU., Muhammad, H., Khan, AU., Aslam, Z. and Abid, F. 2002. Pesticidal control of rapeseed aphid, *Brevicoryne brassicae* (L.). Pakistan J. Zool. 34:225-228.

Messelink, GJ. Bloemhard, CMJ., Sabelis, MW. and Janssen, A. 2012. Biological control of aphids in the presence of thrips and their enemies. Bio. Control. 58:45-55.

Opfer, P. and Mcgrath, D. 2013. Oregon vegetables, cabbage aphid and green peach aphid. Department of Horticulture. Oregon State University, Corvallis, OR, USA.

Pedro, LD., Beitia, FJ., Ferrara, F. and Thormos, J. 2016. Effect of host density and location on the percentage parasitism, fertility and induced mortality of *Aganaspis daci* (Hymenoptera: Figitidae), a parasitoid of *Ceratitis capitata* (Diptera: Tephritidae).

Pramanik, A., Dey, D. and Kumar, A. 2012. Rediscription of *Diaeretiella rapae* (M' Intosh) (Hymenoptera: Braconidae: Aphidiinae) with emphasis on morphometrics. J. Res. Entomol. 36(1):77-82.

Rahnema, AA. and Bakhshandeh, AM. 2006. Determination of optimum irrigation level and compatible canola varieties in the Mediterranean environment. Asian J. Pl. Sci. 5(3):543-546.

Ralec, A., Ribule, A., Barragan, A. and Outerman, Y. 2011. Host range limitation caused by incomplete host regulation in an aphid parasitoid. J. Insect Physio. 57(3):363-371.

Rana, JS. 2005. Performance of *Lipaphis erysimi* (Homoptera: Aphididae) on different *Brassica* speciesin a tropical environment. J. Pestic. Sci. 78:155-160.

Rehman, A. and Powell, W. 2010. Host selection behavior of aphid parasitoids (Aphidiidae: Hymenoptera). J. Plant Breeding and Crop Science. 2(10):299-311.

Roitberg, BD., G. Boivin, G. and Vet, L. 2001. Fitness, parasitoids and biological control an opinion. Can. Entomol. 133:429-438.

Saleh, AAA. 2008. Ecological and biological studies of *Diaeretiella rapae* (M' Intosh) (Hymenoptera: Aphidiidae), the parasitoid of some aphid species in Egypt. Egyptian J. Biol. Pest Contr. 18(1):33-38.

Saleh, AAA., Desuky, WM., Hashem, HH. and Gatwarry, WG. 2009. Evaluating the role of *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Aphidiidae) parasitizing the cabbage aphid, *Brevicoryne brassicae* L. (Homoptera: Aphididae) at Sharkia Governorate, Egypt. Egyptian J. Biol. Pest Contr. 19(2):151-155.

Saljoqi, AUR., Moeez-ud-Din, S., Ahmed, S. and Karimullah. 2001. Effect of sowing dates and cultivar test of canola against aphid population. Sarhad J. Agric. 17:623-628.

Sinha, TB. and Singh, R. 1979. Studies on the bionomics of *Trioxys indicus* Subba Rao and Sharma (Hymenoptera: Aphidiidae) :A parasitoid of *Aphis craccivora* Koch (Hymenoptera: Aphidiidae) the area of discovery of parasitoid. Ze tschrift fur Angewandte Entomol. 89(2):173-178.

Stadler, B. and Volkl, W. 1991. Foraging patterns of two aphid parasitoids, *Lysiphlebus testaceipes* and *Aphidius colemani* on banana. Entomol. Exp. Appl. 58:221-229.

Stary, P. 1970. Biology of Aphid Parasites (Hymenoptera: Aphidiidae) with Respect to Integrated Control. Dr. W. Junk N.V., The Hague, The Netherlands.

Stary, P., Remaudiere, G., Gonzalez, D. and Shahrokhi, S. 2000. A review and host association of aphid parasitoids (Hym., Braconidae, Aphidiinae) of Iran. Parasitica. 56:15-41.

Syed, TS., Makorani, A. and Abro, GH. 1999. Resistance of different canola varieties against aphid, *Lipaphis erysimi* Kalt. Proc. Pak. Cong. Zool. 19:45-49.

Talpur, MA., Hussain, T., Nizamani, GH. and Baloch, HB. 1991. Relative resistance of some *Oliferous brassica* to mustard aphid, *Lipaphis erysemi* Kalt. Proc. Pak. Cong. ZooI. 11:125-129.

Ull-Yett, GC. 1945. Distribution of progeny by *Microbracon hebetor* Say. J. entomol., Soc. S. Afr. 8:123-131.

Van Steenis, MJ. and El-Khawass, KAMH. 1995. Behaviour of *Aphidius colemani* searching for *aphisgossypii*: Functional response and reaction to previously searched aphid colonies. Biocontrol Sci. Technol. 5:339-348.

Wang, X., Yang, Z., Gould, JR., Wu, H. and J. MA, 2010. Host-seeking behavior and parasitism by *Spathius agrili* Yang (Hymenoptera: Braconidae), a parasitoid of the emerald ash borer. Biological Control. 52:24-29.

Yu, SH., Ryoo, MI. and Na, JH. 1999. Life history of *Bracon hebetor* (Hymenoptera: Braconidae) on *Plodia interpunctella* (Lepidoptera: Pyralidae) on dried vegetable commodity. J. Asia-Pacific Ent. 2:149-152.

Zahra, T., Talebi, AA. and Rakhshani, E. 2011. The foraging behavior *Diaeretiella rapae* (Hymenoptera: Braconidae) on *Diuraphis noxia* (Hymenoptera: Aphidiidae). Arch. Biol. Sci. Belgrade. 63(1):225-2.

Received: April 1, 2019; Accepted: May 7, 2019