Journal of Biological Control, 27(4): 247–252, 2013

Research Article

Dynamics of *Diaeretiella rapae* (M'Intosh) (Braconidae: Aphidiidae) and its hyper parasitoid on mustard aphid, *Lipaphis erysimi* Kalt infesting brown mustard, *Brassica campestris* Linn. in Kashmir, India

M. JAMAL AHMAD* and S. BILAL AHMED

Division of Entomology, SKUAST-K, Shalimar campus, Srinagar (J&K), India.
**Corresponding author E-mail* : ahmad_j@ rediffmail.com

ABSTRACT: The dynamics of *Diaeretiella rapae* L. and its hyper parasitoid on mustard aphid, *Lipaphis erysimi* Kalt. infesting brown mustard, *Brassica campestris* L. was studied. Average mustard plant infestation by *L. erysimi*, and its density were 13.07 and 16.0 per cent 121.3 and 161.75 per plant, respectively, during 2007 and 2008. A positive correlation was observed between aphid density and plant infestation. Rise in aphid density was positively and negatively correlated with maximum temperature and relative humidity, respectively. Maximum parasitism by *D. rapae* was 21.6 and 34.7 per cent during 2007 and 2008, respectively. The parasitism was totally aphid density dependent. Average hyper parasitism in *D. rapae* by *Pachyneuron aphidis* (Bouche) was 2.52 and 5.07 per cent during corresponding years, and showed insignificant impact on parasitism as well as aphid density.

KEY WORDS: *Brassica campestris*, *Diaeretiella rapae*, Kashmir, *Lipaphis erysimi*, *Pachyneuron aphidis*

(Article chronicle: Received: 31-08-2013; Revised: 23-12-2013; Accepted: 26-12-2013)

INTRODUCTION

Brown sarson, *Brassica campestris* Linn. is an important oil seed Rabi crop of Kashmir valley, grown over in an area of about 65000 acres with an annual production of approximately 49.5 thousand tonnes (Anonymous, 2007-08). In comparison to over 32 insect pest species on rapeseed-mustard crops in northern plains of India (Srivastava and Guleria, 2003), notable pests in Kashmir valley however, are mustard aphid, *Lipaphis erysimi* Kalt; mustard leaf miner, *Chromatomyia horticola* (Goureau)*;* cabbage butterfly, *Pieris brassicae* (Linnaeus); Diamond back moth, *Plutella xylostella* (Linnaeus); flea beetles, *Phyllotreta cruciferae* (Goeze); *P. striolata* Fabricius, *Psylliodes* spp., blue beetle, *Altica himensis* Shukla and painted bug, *Bagrada* sp. which cause severe damage to the crop. With the exception of occasional chemical applications in Anantnag district (1560 meter a.s.l. 33° N 71° E) of Kashmir, in Srinagar (1600 meter a.s.l. 34° N 74° E), mustard cultivation by and large, is pesticide free, which encourages healthy population of natural enemies. Natural association of the aphidiid parasitoid, *Diaeretiella rapae* (M'Intosh) with *Lipaphis erysimi* and cabbage aphid, *Brevicoryne brassicae* Linnaeus, is a common observation in the valley, but its actual role against mustard aphid is not known. The potential of *D. rapae* against aphids in various crops, including crucifers, has been indicated by several workers, and is described as one of the most important factors for natural control of mustard aphid (Mussury and Fernandes, 2002; Dogra *et al*., 2003; Dhiman, 2007). In view of the significance of this biological control agent, the present study was aimed to understand its dynamics in relation to mustard aphid as well as its hyper parasitoid, *Pachyneuron aphidis* (Bouche) (Chalcidoidea : Pteromalidae).

Pachyneuron aphidis is a hyper parasitoid of a number of primary aphidiid parasitoids associated with different aphid species, and also other insect pests. Noyes (2006) has listed more than 120 species as hosts for *P. aphidis* in various insect taxa. Some commonly attacked aphidiid parasitoids are *Aphidius* spp., *Diaeretiella rapae*, *Ephedrus* spp., *Pauesia* spp., *Praon* spp., and *Lysaphidus* spp. *Pachyneuron aphidis* acts as an ecto parasitoid of the larvae/ pre pupae of the *D. rapae* developing inside the body of aphids. Its preferred host stage however, is the 1-24 hr. old pre pupae of the primary parasitoid. Life cycle is completed approximately in 15-16 days. Like all other hyper parasitoids *P. aphidis* also suppresses the

natural population of *D. rapae,* hence acting as counter productive in natural or applied biological control.

MATERIALS AND METHODS

The present study was conducted in Shalimar campus of the Sher-e-Kashmir University of Agricultural Sciences and Technology- Kashmir, during 2007 and 2008. Data was collected from pesticide free fields of brown sarson, *Brassica campestris* var. KOS-1, from an area of around one acre under the Division of Agronomy. Seeds were sown in third week of October of 2006 and 2007. Observations were recorded from March 2nd week until the maturity of crop i.e. second to third week of May during 2007 and 2008.

Weekly observations were made recording per cent plant infestation, aphid density per plant, per cent aphid parasitism by *D. rapae* and hyper parasitism by *P. aphidis*. The terminal shoots of about 10 centimeter with aphid density more than 10 were considered for recording plant infestation as well as aphid density. For per cent plant infestation, approximately 500 plants were thoroughly observed for the presence of aphids and percentage of infested plants determined. The observations were based on three replications. The number of aphids present on 10 cm terminal shoots of the randomly selected five infested plants, were counted at each observation and averaged. In order to study the dynamics of *D. rapae* and its hyper parasitoid *P. aphidis*, five terminal shoots with sufficient aphid density were selected randomly and brought to the laboratory for further studies. Number of aphids on each terminal shoot was considered as one replication, and they were counted with the help of hand lens and individual sample was kept in separate insect rearing cages (45x45x45 cm) at the bio control laboratory, at 27±1°C, 60±5 per cent R.H. and 12:12 photoperiodicity. Observations were made daily for the emergence of *D. rapae* and *P. aphidis*. Emerged parasitoids and hyper parasitoids were collected by means of alcohol wet brush, identified under stereoscopic binocular and counted. An up-to-date data regarding numerical density of aphids per plant, number of emerged parasitoids and hyper parasitoids week wise both during 2007 and 2008 was duly maintained. Per cent parasitism was determined by dividing number of *D. rapae* in each sample from total number of healthy and mummified aphids. Similarly, hyper parasitism was recorded by dividing number of *P. aphidis* emerged per sample from total number of mummified aphids. Each parameter was averaged week wise for both the years. Weather data of 2007 and 2008 was obtained from the Division of Agronomy, SKUAST, Kashmir for the purpose of correlation with observed parameters.

RESULTS AND DISCUSSION

The present study recorded unidentical period of appearances of *L. erysimi* on *Brassica campestris*, *D. rapae* and *P. aphidis* during Rabi 2007 and 2008 (Table 1), although date of sowing of mustard seeds was similar during both the years. Each of the above mentioned parameters during 2007 appeared a week later as compared to 2008. A gradual rise in per cent plant infestation by *D. rapae* from March 3rd and 4th week to May 2nd week was observed during both the years. Average plant infestation during March 2nd week to May 2nd week was 13.07 and 16.8 (N = 1500) during 2007 and 2008 respectively. Difference in plant infestation was found statistically significant period wise both during 2007 ($F = 73.38^{**}$; d.f. = 8(16); p = 0.000) and 2008 ($F = 15.8^{**}$; d.f. = 8(16); p = 0.000) when compared through ANOVA. The difference in plant infestation was found significant replication wise ($F = 4.73^{*}$; d.f. = 2(16); p = 0.024) only during 2007.

Average density of mustard aphids per plant during the entire cropping season was 121.3 and 161.75 during 2007 and 2008 respectively with peak density up to 277.4 and 279.6 during April 4th and 3rd weeks of corresponding years, followed by a noticeable decline thereafter. Statistically significant difference in *B. brassicae* population of per plant was found period wise both during 2007 ($F = 30.87^{*}$; d.f. 8(32); p = 0.000) and 2008 ($F = 11.76^{**}$; d.f. 8(32); p = 0.000). Replication wise, the aphid population varied significantly only during 2007 ($F = 3.33^{*}$; d.f. 4(32); p = 0.000). Aphid parasitism by *D. rapae* recorded a gradual upswing from 2.9 to 21.6 and 1.41 to 34.7 and per cent during 2007 and 2008 respectively. Average aphid parasitism by *D. rapae* was found more during 2008 as compared to 2007 (Table 2). Difference in the aphid parasitism was found statistically significant period wise, both during 2007 ($F = 15.74^{**}$; d.f. = 8(32); p = 0.000) and 2008 ($F = 43.63^{**}$; d.f. = 8(32); p = 0.000), but non significant replication wise.

Hyper parasitism of *D. rapae* by *P. aphidis* exhibited a gradual increase from 4.4 to 7.5 and 3.4 to 16.4 per cent during 2007 and 2008 respectively (Table 1). Average hyper parasitism in *D. rapae* was found nearly twice during 2008 as compared to 2007 (Table 2). Difference in hyper parasitism was found significant period wise, both during 2007 ($F = 13.45^{**}$; d.f. = 8(32); p = 0.000) and 2008 ($F = 12.74^{**}$; d.f. = 8(32); p = 0.000), but replication wise only during previous year ($F = 3.66^{*}$; d.f. = 4(32); p = 0.014). Overall inter action between parasitism and hyper parasitism was found positively correlated whereas, the latter showed no impact on aphid density (Table 4). Results

Table 1. Population densities of *Lipaphis erysimi, Dieretiella rapae* and *Pachyneuron aphidis* on brown mustard in Srinagar during 2007 and 2008

Period of observation	Year 2007				Year 2008			
	plant infestation %	Av. Aphids/ plant	Aphid parasitism%	Hyper parasitism%	plant infestation%	Av. Aphids/ plant´	Aphid parasitism %	Hyper parasitism %
March 2nd week	0.0 (4.05)[a]	0.0 (1.0)[a]	0.0 (4.05)[a]	0.0 (4.05)[a]	0.0 (4.05)[a]	0.0 (1.0)[a]	0.0 (4.05)[a]	0.0 (4.05)[a]
March 3rd week	0.0 (4.05)[a]	0.0 (1.0)[a]	0.0 (4.05)[a]	0.0 (4.05)[a]	2.0 (7.6)[a]	45.4 (6.6)[b]	0.0 (4.05)[a]	0.0 (4.05)[a]
March 4th week	8.3 (16.8)[b]	32.4 (5.7)[b]	0.0 (4.05)[a]	0.0 (4.05)[a]	4.3 (12.6)[ab]	94.2 (9.5)[b]	1.41 (6.5)[a]	0.0 (4.05)[a]
April 1st week	13.3 (21.8)[c]	47.8 (6.72)[b]	2.9 (10.2)[b]	0.0 (4.05)[a]	12.0 (20.6)[b]	135.2 (11.5)[bc]	2.6 (10.0)[ab]	0.0 (4.05)[a]
April 2nd week	14.6 (22.8)[c]	150.8 (12.01)[c]	4.9 (10.8)[b]	0.0 (4.05)[a]	20.7 (26.9)[b]	165.2 (12.8)[bc]	9.2 (18.5)[b]	3.4 (10.6)[b]
April 3rd week	16.0 (23.9)[cd]	249.6 (15.4)[d]	7.0 (15.6)[c]	4.4 (10.4)[b]	24.7 (29.8)[bc]	279.6 (16.3)[c]	12.9 (20.4)[b]	4.6 (16.3)[c]
April 4th week	18.6 (25.95)[cd]	277.4 (16.2)[d]	12.8 (21.3)[d]	4.91 (11.1)[b]	26.6 (31.3)[bc]	232.0 (14.4)[bc]	22.3 (28.3)[c]	6.2 (16.03)[c]
May 1st week	22.0 (28.3)[cd]	200.0 (14.2)[cd]	15.04 (23.03)[d]	5.8 (13.4)[b]	28.7 (32.2)[bc]	210.4 (14.2)[bc]	25.2 (31.2)[c]	8.4 (17.2)[c]
May 2nd week	24.6 (30.1)[cd]	133.6 (11.3)[c]	21.6 (22.07)[d]	7.5 (22.5)[c]	32.0 (34.5)[bc]	154.2 (12.2)[bc]	34.7 (36.9)[d]	16.4 (24.06)[d]
C.D. (0.05)	2.8	2.52	4.8	4.2	7.09	3.28	4.47	5.05

Figures in columns are mean of three replications. Values in parentheses are $\sqrt{n+1}$

• Figures in remaining columns represent mean of five replications. Values in parentheses are arc sin transformation of $\sqrt{n+0.5}$; Different alphabetic superscripts indicate data as statistically significant

A Average

Table 2. Two years' mean and Two- way ANOVA of percent plant infestation, average number of aphids, percent aphid parasitism and percent hyper parasitism

Year	Plant infestation (%)	Av. Aphids/ plant	Aphid parasitism (%)	Hyper parasitism (%)
2007	13.07± 8.7	121.3± 123.2	7.15 ± 8.15	2.52±4.03
2008	16.8±13.5	161.754 ± 167.8	12.3± 13.3	5.07± 6.7

Two way ANOVA with main effects

	F	d.f.	p	F	d.f.	P	F	d.f.	p	F	d.f.	P
Year	4.3*	1.36	0.000	8.3*	1.72	0.005	28.7*	1.72	0.000	7,05**	1,72	0.010
Period	35.5**	8.36	0.000	33.9**	8.72	0.000	52.8**	8.72	0.000	22.9**	8.72	0.000
Year*	1.12	8.36	0.376	1.91NS	8.72	0.072	3.25*	8.72	0.003	0.94NS	8.72	0.4982
Period	NS											

Where ± = Standard Deviation; * and ** significant at 0.05 and 0.01; d.f. = degree of freedom; p = probability

Table 3. Effect of weather parameters on the population density of aphids during 2007 and 2008

Weather parameters	Year 2007 (d.f.=8)	Year 2008 (d.f.=8)
$Temp._{max}$	0.85**	0.44 NS
$Temp._{min}$	0.72*	0.55 NS
$RH_{max.}$	–0.77**	–0.13 NS
$RH_{min.}$	–0.64*	0.28 NS

Where * and ** indicate significance at 0.05 and 0.01; d.f. = degree of freedom

of two way ANOVA on per cent plant infestation, aphid density, per cent aphid parasitism and per cent hyper parasitism have been presented in Table 2. Regression equations for aphid parasitism vs. hyper parasitism as well as for hyper parasitism vs. aphid density has also been established and presented in Table 4.

The Kashmir valley being a temperate region, the effect of winter prolongs till late March to April, which influences profoundly the first appearance of insect pests, and also their natural enemies. Late arrival of natural enemies and their slow build up resulted in the unchecked rise of the population of *B. brassicae*, until the appearance of sufficient population of natural enemies. The un identical period of appearances of *B. brassicae*, *D. rapae* and *P. aphidis* could be attributed to significant differences in temperature during 2007 (max. 13.07°C; min. 1.81°C) and 2008 (max. 19.1°C; min. 3.6°C) particularly during the month of March (Student's t test = 4.95*; d.f. = 38). Such unidentical seasonal appearances of aphids have also been reported from other parts of the country (Akhtar *et al*., 2010; Ansari *et al*., 2007). Weekly rise in per cent infested plants by *B. brassicae*, both during 2007 and 2008 was due to gradual increase in temperature, which favored nearly 6.0 to 8.0 fold increase in average density of *B. brassicae* per plant, during April 3rd and April 4th weeks of the 2007 and 2008 respectively. Aphid density however, was negatively correlated with relative humidity (Table 3). Similar observations have also been made by a number of workers (Ansari *et al*., 2007; Gami *et al.,* 2002; Zahra *et al*., 2012 and Wains *et al*., 2010) who have also recorded positive correlation of temperature and population density of wheat aphid, *Diuraphis noxia* (Mordvilko) from temperate areas of Iran and Pakistan. Although, a few workers have observed insignificant effects of temperature on aphid density (Lal and Bhajan, 2003; Dogra *et al*., 2003) such reports are mainly from the tropical parts of India, where decline or collapse in the population density of mustard aphids is mainly due to maturity of crop, before the extremes of summer temperature. In the present case, gradual rise in aphid population yielded a positive correlation between aphid density and per cent plant infestation, both during 2007 (r = 0.76**; d.f. = 7) and 2008 (r = 0.85**; d.f. = 7). Since the average aphid density per plant was approximately 25.0 per cent more during 2008, a significant difference both for plant infestation and aphid density year wise was also obtained (Table 2). Our findings on variable aphid densities during successive two years gains support from similar observations made by Singh and Malik (1998) and Kular *et al.* (2012).

Average parasitism (7.15 and 12.3 per cent) by *D. rapae*, with their peak activity of 21.6 and 34.7 per cent during 2007 and 2008 respectively, was however found considerably low in Kashmir, as compared to 75.46 and 68.96 per cent in Delhi (Akhtar *et al*., 2010) and 51.07 per cent in Himachal Pradesh (Dogra *et al*., 2003). Substantially low level of aphid parasitism in the present case is ascribed to sparse and low level of plant infestation (13.0 and 16.0 per cent) with less population densities (121.0 and 161.0) of mustard aphids. Low level of aphid parasitism by *D. rapae* has also been reported from other temperate parts of the world, such as 19.5 per cent from Iran (Amini *et al*., 2012), 37.0 per cent from Rawalpindi, Pakistan (Kakakhel, 2006) and 22.0 per cent from France (Desneux *et al*., 2006). In our studies, over 12.0 per cent parasitism by *D. rapae* was found too little to overcome the aphid population till the April 4th and 3rd weeks of 2007 and 2008, respectively, nevertheless a subsequent decline in aphid population because of rising parasitism up to maximum of 21.6 and 34.7 per cent definitely alludes the contribution of *D. rapae*, in the suppression of mustard aphid population. Although present investigation could not establish a negative correlation between aphid parasitism and aphid density (r = 0.42; d.f = 88) which was mainly due to marginally slow rise of parasitism in comparison to aphid population, during first five weeks, the parasitism was nevertheless purely aphid density dependent as confirmed by the regression equation (Table 4). Similar findings on the correlation between aphid density and *D. rapae* have been documented by Mussury and Fernandes (2002) and Amini *et al*. (2012).

Present level of hyper parasitism with an average of 2.52 and 5.07 per cent during 2007 and 2008 respectively, was found insufficient enough to exert any influence over *D. rapae* except growing along correlatively as also

Table 4. Coefficient of correlation and regression equation between observed parameters

Parameters	Coefficient of correlation (r=)	d.f. (n-2)	Coefficient of Determination (R^2)	Regression equation (Y= a+bx)
Aphid density and % parasitism	0.42*	88	0.17	Y_1= 88.18+5.485x_1
% Parasitism and hyper parasitism	0.64**	88	0.40	Y_2= 4.882+1.273x_2
Aphid density and hyper parasitism	0.36**	88	0.13	Y_3= 90.9+9.31x_3

Where Y_1 and Y_3= aphid density; Y_2 = % parasitism; x_1 = % parasitism, x_2 and x_3= % hyper parasitism; Where * and ** indicate significance at 0.05 and 0.01; d.f.= degree of freedom

indicated by their interaction (Table 4). Since aphidiid parasitism was least affected by the hyper parasitoid, an overall impact of hyper parasitism on aphid density was also non significant (Table 4). Varying levels of hyper parasitism by *P. aphidis* is known from different parts of the world. Pandey *et al*. (1985) observed 30-40% mortality in *D. rapae* in Uttar Pradesh, whereas Katarina *et al*. (2012) and Amini *et al*. (2012) reported 13.4 per cent and 15- 20 per cent hyper parasitism by *P. aphidis* in *D. rapae* in Slovania and Iran, respectively.

Diverse opinions are available regarding field exploitation of *D. rapae* for the biological control of aphids. Bernal and Gonzalez (1993) have mentioned its potential applications in classical and augmentative biological control of Russian wheat aphid *Diuraphis noxia* (Mordvilko) in USA. Many workers however, {e.g. Oatman and Platner (1973) and Chua (1977)} described *D. rapae* as weak biological control agent for aphids because of several factors including asynchrony between host and parasitoid populations and predation by coccinellids and syrphids. Bradburne and Mithen (2000) recommended *D. rapae* as good candidate for releases in cruciferous IPM programs because of their characteristic behavior to be attracted by volatiles released by such plants. Amini *et al*. (2012) suggested planting of attractant crops near *Brassica* spp. to attract and enhance the activity of *D. rapae*.

ACKNOWLEDGEMENTS

Present work was done under RCM approved project. The same is duly acknowledged to the Director Research, SKUAST-Kashmir. Thanks are also due to the Head, Division of Entomology, SKUAST-Kashmir, for providing necessary facilities and also Dr. Zubair Ahmad, Department of Zoology, A.M.U., Aligarh, U.P., India for the identification of aphidiid parasitoid.

REFERENCES

Akhtar MS, Dey D, Usmani MK, Choudhury RA. 2010. Seasonal abundance of *Diaeretiella rapae* (M'Intosh) (Braconidae : Aphidiinae) parasitizing *Lipaphis erysimi* (Kaltenbach) (Hemiptera : Aphidae) in *Brassica juncea* var. Pusa bold. *Mun Ent Zool*. **5(**2): 692–696.

Amini B, Madadi H, Nicolas D, Hosseni AL. 2012. Impact of irrigation systems on seasonal occurrence of *Brevicoryne brassicae* and its parasitism by *Diaeretiella rapae* on canola. *J Ent Res Soc*. **14**(2): 15–26.

Ansari MS, Hussain B, Qazi NA. 2007. Influence of abiotic environment on the population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) on *Brassica* germplasm. *J Biol Sci.* **7**: 993–996.

Anonymous. 2007–08. Digest of statistics, directorate of economics and statistics. Government of Jammu & Kashmir, 691 pp.

Bernal J, Gonzalez D. 1993. Temperature requirements of four parasites of the Russian wheat aphid, *Diuraphis noxia*. *Ent Exp et Applic.* **69**: 173–182.

Bradburne RP, Mithen R. 2000. Glucosinolate genetics and the attraction of the aphid parasitoid, *Diaeretiella rapae* to *Brassica*. *Proc R Soc.* **267**(1438): 89–95.

Chua TH. 1977. Population studies of *Brevicoryne brassicae* (L.), its parasites and hyperparasites in England. *Res Pop Ecol.* **19**: 125–139.

Desneux N, Rabasse, JM, Ballanger Y, Kaiser L. 2006, Parasitism of canola aphids in France in autumn. *J Pest Sci.* **79**: 95–102.

Dhiman SC. 2007. Population dynamics of *Diaeretiella rapae* (M'Intosh): a parasitoid of mustard aphid, *Lipaphis erysimi* (Kalt.). *J App Zool Res.* **18**: 117–120.

Dogra I, Devi N, Desh R. 2003. Parasitization of mustard aphid, *Lipaphis erysimi* Kalt. by *Diaeretiella rapae* M'Intosh in the mid-hill zone of Himachal Pradesh (India). *J Ent Res.* **27**: 145–149.

Gami LM, Bapodra JG, Rathod RR. 2002. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kaltenbach) in relation to weather parameters. *Ind J Pl Prot.* **30**: 202–04.

Kakakhel SA. 2006. Tri-trophic level interaction among host plant (Rapeseed-Mustard), turnip aphid (*Lipaphis arysimi* Kalt) parasitoid (*Diaeretiella rapae* McIntosh) and its augmentation on *Brassica napus*. PhD thesis, University of Arid Agriculture, Rawalpindi, Pakistan.

Katarina KOS, Petrovic O, Vladimir Z, Petrovic A, Stanislav T, •eljko T. 2012. Review of interactions between host plants, aphids, primary parasitoids and hyper parasitoids in vegetable and cereal ecosystems in Slovenia, *J Ent Res Soc.* **14**(3): 67–78.

Kular SJ, Brar SA, Kumar S. 2012. Population development of turnip aphid, *Lipaphis erysimi* (Kaltenbach, 1843) (Hemiptera: Aphididae) and the associated predator *Coccinella septempunctata* Linnaeus, 1758 as affected by changes in sowing dates of oilseed *Brassica*. *Entomotropica* **27**(1): 19–25.

Lal MN, Bhajan Ram. 2003 Population dynamics of mustard aphid, pp. 71–72. In: Proceedings of the *National Symposium on Frontier Areas of Entomological Research*. November 5–7, 2003, IARI, New Delhi, India.

Mussury RM, Fernandes WD. 2002. Occurrence of *Diaeretiella rapae* (M' Intosh, 1855) (Hymenoptera: Aphidiidae) parasitising *Lypaphis erysimi* (Kaltenbach, 1843) and *Brevicoryne brassicae* (L., 1758) (Homoptera: Aphididae) in *Brassica napus* in Mato Grosso do Sul. *Braz Arch Biol Technol.* **45**: 41–46.

Noyes JS. 2006. Universal Chalcidoidea Database – World Wide Web electronic publication, available at: http://www.nhm.ac.uk/entomology/chalcidoids/index.html .

Oatman ER, Platner GR. 1973. Parasitization of natural enemies attacking the cabbage aphid on cabbage in Southern California. *Environ Ent.* **2**: 365–367.

Pandey KP, Kumar A, Shanker S, Tripathi CPM. 1985. First record of *Pachyneuron aphidis* (Bouche) (Pteromalidae: Hymenoptera), a hyperparasitoid of *Diaeretiella rapae* (M'Intosh) (Aphidiidae: Hymenoptera) from India. *Curr Sci.* **54**, pp. 710.

Singh SV, Malik YP. 1998. Population dynamics and economic threshold of *Lipaphis erysimi* on mustard. *Ind J Ent.* **60**(1): 43–49.

Srivastava A, Guleria S. 2003. Evaluation of botanicals for mustard aphid, *Lipaphis erysimi* (Kalt.) control in *Brassica. Him J Agric Res.* **29**(1&2): 116–118.

Wains MS, Ali MA, Hussain M, Anwar J, Zulfikaal M, Sabir W. 2010. Aphid dynamics in relation to meteorological factors and various management practices in bread wheat. *J Pl Prot Res.* **50**: 385–392.

Zahra T, Asghar AT, Ehsan R. 2012. Temperature dependent functional response of *Diaeretiella rapae* (Hymenoptera: Braconidae), a parasitoid of *Diuraphis noxia* (Hemiptera: Aphididae). *J Ent Res Soc.* **14**(1): 31–40.