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Editors : Prof. Rajendra Singh
Dr. S.V.S. Raju

The Aphidological Society, India,
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Gorakhpur-273 009, U.P., INDIA

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Journal of Aphidology is the official publication of **The Aphidological Society, India.** It presents original research (full-length papers and short communications) and reviews in the fields of aphid research and covers following areas: evolution, biosystematics, cytogenetics, bioecology, population dynamics and forecasting of aphids and their predators and parasitoids; trophic interactions involving aphids; aphids as vector of plant viruses; aphid control - cultural, biological, genetical, and IPM.

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EFFECT OF SOWING DATES ON THE INFESTATION OF *LIPAPHIS ERYSIMI* (KALTENBACH) (HOMOPTERA : APHIDIDAE) AND YIELD OF TEN VARIETIES OF MUSTARD AND RAI CROPS

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Abstract : Impact of four sowing dates on *Lipaphis erysimi* (Kaltenbach) infestation and yields of ten varieties of mustard and rai crops for three consecutive seasons (2004-2005, 2005-2006 and 2006-2007) were studied in the field conditions. Ten varieties of mustard and rai under three species *Brassica rapa* subsp. *campestris* (L.) A.R. Clapham : Sari Sarisha-6, Sari Sarisha-9, Sari Sarisha-12, Tory-7 and Sonaly-75; *Brassica juncea* L. Czern. *:* Sari Sarisha-I 0, Sari Sarisha-I I, Rai-5 and *Brassica napus* L.*:* Sari Sarisha-7, Sari Sarisha-8) were selected and sown at four dates (first sowing date - 28^{th} October; second sowing date - 12^{th} November; third sowing date - 27^{th} November; fourth sowing date -12^{th} December for aforesaid three seasons). Aphid population were very low (0.10-2.90 aphid per plant) on first sown crops of all the varieties of mustard and rai. Yield of first sowing dates of three seasons were higher (1.55- 4.18 ton per hectare) for all the varieties of mustard and rai. However, aphid population on the successive late sowing crops gradually increased and reached to peaks at fourth sowing dates (4.39-21.37 aphids per plant). Yield of mustard and rai gradually decreased on successive late sowing crops and lowest yield recorded for fourth sowing crops (0.00-0.72 ton per hectare). It was observed that early sowing plants avoid aphid incidence, plant grown up before the peak time of aphid incidence and yield become higher than late sowing.

Key words : Sowing date, *Lipaphis erysimi,* mustard aphid.

INTRODUCTION

Date of sowing is an important tool of cultural control as well as integrated pest management system (Gu *et al.,* 2007). The damage caused to a crop by aphids is likely to be related to sowing date. Late sown crops suffer greater damage as higher aphid abundance occurs at sowing than on early sown crops. It is important to sow a crop as early as possible to minimize damage by the aphid (Singh and Dhaliwal, 2004). Early sowing plant avoid aphid incidence (Wangai *et al.,* 2000; Singh, 2006), plant grown up before the peak time of aphid incidence and yield become higher than later sowing (Ofuya, 1997). Yield and aphid population both depend on weather parameters, which have relationship with the date of sowing. So, date of sowing has significant impact on yield (Robertson *et al.,* 2004) as well as pest population (Biswas and Das, 2000). A number of workers (Jenkins and Leitch, 1986; Bhatnagar *et al.,* 1997; Brown *et al.,* 1999; Yadav *et al.,* 1999; Ghimiray *et al.,* 2004; Robertson *et al.,* 2004; Chattopadhyay *et al.,* 2005; Jat and Takar, 2005; Butkute *et al.,* 2006) conducted experiments on the impact of date of sowing as well as cultural control of mustard and rai crops in abroad. In Bangladesh, few works on this aspect have been carried out (Rahman *et al.*, 1988; Biswas, 1989; Islam *et al.,* 1991, 1994a, b; Mondal *et al.,* 1992, 1999; Poddar *et al.*, 1996; Shahidullah *et al.,* 1997; Biswas *et al.,* 2002; Raquibullah *et al.,* 2006). However, none of them worked in relation to all the present varieties of mustard and rai crops. Present investigation is therefore taken to study the influence of sowing dates on the abundance of *Lipaphis erysimi* (Kalt.) infesting the aforesaid varieties of mustard and rai crops. Yields of these varieties are also assessed in relation to the aphid infestation.

MATERIALS AND METHODS

Experimental design

For the assessment of impact of sowing dates on aphid infestation and yield on ten varieties of mustard and rai for four sowing dates of three consecutive seasons (2004-2005, 2005-2006 and 2006-2007), same experimental fields were used in the research field of Zoology Department, Rajshahi University campus. Altogether 40 blocks (each 1.35 m^2) each contained 3 replicated plots were used. Ten varieties of mustard and rai under three species *(Brassica repa* subsp. *campestris* - Bari Sarisha-6, Bari Sarisha-9, Bari Sarisha-12, Tory-7 and Sonaly-75; *Brassica juncea* - Bari Sarisha-10, Bari Sarisha-11, Rai-5 and *Brassica napus* - Bari Sarisha-7, Bari Sarisha-8) were selected and collected from Bangladesh Agric., Research Institute (BARI) and were sown at different dates (first sowing date-28th October; second sowing date-12th November; third sowing date-27th November; fourth sowing date-12th December for aforesaid three seasons) for three aforesaid seasons using equal amount of fertilizers and two times of irrigations and more or less uniform mulching.

Data of aphid population

Data of aphid populations (aphids per plant) on ten varieties of mustard and rai for four sowing dates of three seasons were taken as per week.

Yield assessment

When about 90 percent pods of mustard and rai plants were matured, the crops were then harvested. The harvested grains of mustard and rai were weighed to assess yields in terms of varieties and sowing dates.

Data analysis

Analyses of variance (ANOVA) were performed to find out difference, if any, among the yields of ten varieties of mustard and rai in respect of sowing dates. Comparison of means was done using Duncan's Multiple Range Test (DMRT). Correlation of coefficients ('r' values) were determined to examine the type of relationships between aphid population and yield or mustard and rai which reveals the impact or sowing dates on yield and aphid population for three cropping seasons.

RESULTS AND DISCUSSION

Mean populations of *L. erysimi* for four sowing dates of ten varieties of mustard and rai for three consecutive seasons are presented in Table 1. Yield in respect of four sowing dates of ten varieties of mustard and rai for three aforesaid seasons are tabulated (Table 2).

Yield vs aphid population

a. Season 2004-2005

Yields of first sowing dates were higher (Table 2) for all the varieties of mustard and rai where aphid population was very low (Table 1). The yields in other sowing dates gradually decreased in terms of late sowing (Table 2). Aphid populations of these sowing dates gradually increased during this period (Table 1).

Aphid population during this period especially first, second and third sowing dates increased gradually, however; during fourth sowing date, their number somewhat decreased (Table 1). Significant difference (P<0.01) exists among the yields of four sowing dates for ten varieties of mustard and rai.

Highest yield (4.03 t/h) was recorded on the variety, Tory-07 (first sowing date) and lowest (0.02 t/h) yield was found for Sonali-75 (fourth sowing date) for this season. The correlation of coefficients ('r' values) between aphid populations and yield of ten varieties of mustard and rai were significant except Bari Sarisha-7, Tory-7 and Sonali -75. First sowing crops in 2004-05 season, variety Tory-7 yielded highest (4.03 t/h) grains, followed by Bari Sarisha-11 (3.68 *t/h).* Second sowing, Sonaly-75 yielded highest (3.01 t/h) followed by Bari Sharisa-l 1 (2.41 t/ h). Bari Sarisha-l l yielded highest (2.5 t/h) at third sowing date followed by the variety, Rai-5 (1.5 t/h); and in fourth sowing, Bari Sarisha-11 yielded highest (0.69 t/h) amount of grains followed by Bari Sarisha-10 (0.32 t/h).

b. Season 2005-2006

First sowing date yielded higher amount of grains (Table 2) among all the varieties of mustard and rai in this season where aphid population was low among in all four sowing dates (Table 1): Yields on other sowing dates decreased gradually as in second, third and fourth sowing dates.

Aphid population during this period especially second and third sowing dated crops increased gradually, however; their number somewhat decreased on the crops of fourth sowing date (Table 1). Significant difference (P<0.01) exists among the yields of four sowing dates for ten varieties of mustard and rai crops. Highest (4.11 t/h) yield was recorded for the variety Tory-07 (first sowing date) and lowest (0.03 t/h) yield found on the variety Bari sarisha-9 (fourth sowing date). Significant (P<0.05) relationships found between the aphid population and the yields of ten varieties of mustard and rai, which suggest that sowing dates influenced the infestation of aphids as well as the amount of yields.

Highest yield occurred (Table 2) for the first sowing dated crop, followed by second, third and fourth sowing dates respectively (Table 1). In first sowing dated crop, highest (4.11 t/h) yield obtained for the variety Tory-7, followed by Bari Sarisha-11 (3.67 t/h) and Rai-5 (3.67 t/ h).

Bari Sarisha-11 yielded highest amount of grains (2.37t/h) followed by Rai-5 (2.08 t/ h) for the second sowing dated crops. Bari Sarisha-11 yielded highest (2.08 t/h) followed by Rai-5 (1.48 t/h) for the third sowing dated crops. Bari Sarisha-II also yielded highest amount or grains (0.72 t/h) followed by Bari Sarisha-10 (0.33 t/h) (Table 1) for the fourth sowing dated crops.

c. Season 2006-2007

During this season. first sowing dated crops produced highest yields (Table 2) for all the varieties of mustard and rai where aphid population was very low (Table 1). The yield of other sowing dates gradually decreased in terms of successive sowing dates, *i.e.* second, third and fourth (Table 2). Aphid population gradually increased on the ten varieties of mustard and rai crops sown on four different dates (Table 1). Significant difference (P<0.01) exists among the yields of four sowing dates for ten varieties of mustard and rai crop. Highest (4.18 t/h) yield was recorded for the variety, Tory-07 (first sowing date) and lowest (0.00 t/h) yield on Bari sarisha-8 (fourth sowing).

Significant (P<0.05) relationships found between the aphid population and the yields of ten varieties of mustard and rai for this season, which suggest that sowing dates influenced the infestation of aphids as well as the amount of yields.

Highest (4.18 t/h) yield recorded on the variety Tory-7 at first sowing dates, followed by Bari Sarisha-11 (3.84 t/h) (Table 2). Sonaly-75 yielded highest (3.08 t/h) followed by Bari Sharisa-11 (2.51 t/h) at second sowing date (Table 2). Bari Sarisha-11 yielded highest (2.24 t/h) at third sowing date followed by Ral-5 (1.66 t/h) (Table 2). Bari Sarisha-11 yielded highest (0.71 t/h) followed by Bari Sarisha-10 (0.35 t/h) at fourth sowing date (Table 2). From the result it is clear that early sowing mustard and rai produced higher yields for all ten varieties of mustard and rai crops. During this time aphid infestation was very low on the aforesaid crop varieties. Mustard and rai plants of first sowing date escaped the peak period of aphid infestation. Mustard and rai plants sown on second, third and fourth successive dates produced comparatively less amounts of grains. This is because of high aphid infestation during the time. Sowing date had significant influence on the activities of *L. erysimi*. Number of aphid increased mostly in cool, low temperature and cloudy weather (temperature-16 to 21°C, relative humidity- 65 to 70 % and dew point-12 to 16°C) which found mostly in mid winter (December to January). Early sowing mustard and rai plants grown up before the peak infestation of aphid, which occurred in mid winter.

Earlier reports reveal that aphid population goes its peak during January and is destroyed completely by mid to late February in Indian Sub-Continent (Bakhetia and Sidhu, 1983; Das, 2002; Singh and Sharma, 2002). The sustenance of such favourable conditions influences the longevity of the period of aphid infestation on the crop, which consequently affects yield. Thus the damage caused to a crop by mustard aphids is likely to be related to sowing date, *i.e.* late sowing results in higher aphid densities at flowering stage (Mc Vean *et al.*, 1999).

A number of workers got the similar results of higher yields from earlv sown crops and lower yields from the late sown crops of mustard and rai (Mendham *et al.,* 1990; Chakraborty *et al.*, 1991; Rajput *et al.*, 1991; Brar *et al.*, 1998; Saha and Kanchan, 1999; Srivastava, 1999; Vekaria and Patel *et al.*, 2000; Mishra *et al.*, 2001; Patel *et al.*, 2004; Singh and Dhaliwal, 2004; Patil *et al.*, 2005).

Islam *et al.* (1991) obtained maximum yield from early sowing (15 October to 5 November) mustard in Bangladesh when the aphid infestation were very low. They got small amount of grain from the late sown crop (4 December to 11 December) when the aphid populations were comparatively high. Raquibullah *et al.* (2006) also got highest yield from early sown mustard crop and lowest from late sown crop at Gazipur, Bangladesh for the two consecutive seasons, 1998-1999 and 1999-2000. Bhatnagar *et al.* (1997) got highest seed yield for early sown mustard crops and lowest for late sown crops in Rajasthan, India. Phadke and Prasad (1987) reported that early sown mustard yielded highest amount of grains (8.1 q/h for 1978-79 and 8.6 q/h for 1979-80) when lowest aphid infestation occurred. They also observed that late sown crops were injured by higher percentage of aphid infestation and produced less amount of grains (3.9 q/h for 1978-79 and 5.3 q/h for 1979-80) in New Delhi, India. Singh and Sachan (1999) reported that *Brassica carinata* sown

Table 1. Mean aphid population (per plant) of ten varieties or mustard and rai at four sowing dates for three seasons : 2004-2005, 2005-2006 and 2006-2007.

Mustard and rai varieties		Mean aphid population (per plant) (Mean±SE)			
		First sowing	Second sowing	Third sowing	Fourth sowing
2004-2005 season	Bari Sharisha-6	2.90±0.14	7.25±0.65	12.41±0.24	6.61±0.48
	Bari Sharisha-7	0.23±0.06	23.59±2.22	14.90±0.64	9.34±0.70
	Bari Sharisha-8	1.49±0.08	21.61±2.24	18.16±0.97	10.69±0.98
	Bari Sharisha-9	0.25±0.06	1.12±0.20	7.57±0.06	5.27±0.15
	Bari Sharisha-10	0.12±0.03	4.24±0.34	7.80±0.51	9.03±0.89
	Bari Sharisha-11	0.12±0.02	12.32± 1.51	8.45±0.36	10.30±0.68
	Bari Sharisha-12	0.10±0.01	4.32±0.45	6.98±0.12	4.39±0.22
	Rai-5	0.10±0.02	13.54±1.6	10.07±0.42	8.71±0.66
	Tory-7	2.47±0.86	2.43±0.1	13.97±0.67	6.66±0.05
	Sonali-75	0.68±0.26	4.57±0.25	7.74±0.18	5.52±0.36
	Mean	0.85±0.34	9.50±2.52	10.81±1.22	7.65±0.71
2005-2006 season	Bari Sharisha-6	1.93±0.29	11.19±0.25	14.69±0.41	9.52±0.16
	Bari Sharisha-7	1.20±0.11	19.56±0.57	13.58±0.48	14.40±0.24
	Bari Sharisha-8	2.10±0.23	15.42±0.35	14.45±0.47	15.54±0.25
	Bari Sharisha-9	0.79±0.11	1.98±0.08	8.24±0.08	4.41±0.27
	Bari Sharisha-10	0.26±0.06	1.57±0.08	6.34±0.43	5.66±0.03
	Bari Sharisha-11	0.33±0.05	1.22±0.I3	7.62±0.51	8.76±0.12
	Bari Sharisha-12	0.19±0.07	1.99±0.31	6.06±0.37	6.02±0.30
	Rai-5	0.27±0.05	7.18±1.11	6.88±0.30	11.02±0.65
	Tory-7	0.97±0.14	2.20±0.18	7.32±0.66	9.36±0.49
	Sonali-75	1.41±0.11	6.11±0.12	14.48±0.65	10.49±0.35
	Mean	0.95±0.22	6.84±2.06	9.97±1.20	9.52±1.14
2006-2007 season	Bari Sharisha-6	1.06±0.14	7.55±0.64	20.61±1.10	18.56±1.15
	Bari Sharisha-7	1.02±0.22	8.08±0.63	10.90±0.81	18.91±0.39
	Bari Sharisha-8	0.90±0.05	9.69±1.l8	10.50±0.64	19.10±0.66
	Bari Sharisha-9	0.44±0.03	1.57±0.17	5.39±0.19	10.11±0.44
	Bari Sharisha-10	0.30±0.05	1.17±0.09	4.84±0.45	5.96±0.37
	Bari Sharisha-11	0.24±0.07	0.87±0.14	5.46±0.51	5.66±0.36
	Bari Sharisha-12	0.39±0.15	1.37±0.13	6.23±O.32	9.89±0.41
	Rai-5	0.32±0.10	2.23±0.24	5.04±0.27	8A6±0.28
	Tory-7	0.42±0.03	1.36±0.05	17.37±O.84	8.11±0.20
	Sonali-75	0.99±0.07	6.53±0.41	23.11± 1.40	21.37±0.72
	Mean	0.61±0.11	4.04±1.10	10.95±2.21	12.61±1.94

Table 2. Mean yields (t/ha) of ten varieties or mustard and rai at four sowing dates for three seasons: 2004-2005, 2005-2006 and 2006-2007.

Mustard and rai varieties		Mean aphid population (per plant) (Mean±SE)			
		First sowing	Second sowing	Third sowing	Fourth sowing
2004-2005 season	Bari Sharisha-6	1.97±0.035eA	0.84±0.02efB	0.39±0.009deC	0.032±0.005bcD
	Bari Sharisha- 7	1.55±0.042fA	0.93±0.020eB	0.48±0.012deC	0.030±0.007cD
	Bari Sharisha-8	1.96±0.040eA	0.27±0.024gB	0.22±0.007deB	0.027±0.010cC
	Bari Sharisha-9	2.28±0.036dA	0.32±0.009gS	0.20±0.012eC	0.025±0.007cD
	Bari Sharisha-10	2.74±0.09ScA	1.29±0.069dB	0.83±0.109cC	0.322±0.037bD
	Bari Sharisha-11	3.68±0.066bA	2.41±0.288bB	2.50±0.262aB	0.693±0.163aC
	Bari Sharisha-12	2.00±0.035eA	0.56±0.027fgB	0.33±0.015deC	0.012±0.007cD
	Rai-5	3.64±0.074bA	1.81±0.123cB	1.50±0.115bB	0.312±0.123 bC
	Tory-7	4.03±0.087aA	I.35±0.026dB	0.54±0.020dC	0.030±0.007cD
	Sonali-75	1.90±0.044eB	3.01±0.044aA	0.34±0.009deC	0.020±0.009cD
	Mean	2.575±0.28	1.279±0.28	0.733±0.23	0.150±0.07
2005-2006 season	Bari Sharisha-6	1.97±0.04geA	0.96±0.072cdB	0.46±0.061eC	0.13±0.024cD
	Bari Sharisha- 7	1.55±0.051fA	0.95±0.017cdB	0.49±0.014eC	0.05±0.017cD
	Bari Sharisha-8	1.97±0.068eA	0.48±0.095eB	0.25±0.036fC	0.10±0.011cC
	Bari Sharisha-9	2.32±0.047dA	0.74±0.063deB	0.23±0.040fC	0.03±0.008cD
	Bari Sharisha-10	2.S7±0.130cA	1.25±0.056cB	1.08±0.072cB	0.33±0.029bC
	Bari Sharisha-11	3.67±0.056bA	2.37±0.256aB	2.08±0.050aB	0.72±0.150aC
	Bari Sharisha-12	1.99±0.054eA	0.79±0.149deB	0.37±0.032efC	0.05±0.024cD
	Rai-5	3.67±0.111bA	2.05±0.202abB	1.48±0.078bC	0.32±0.082bD
	Tory-7	4.11±0.065aA	1.39±0.020cB	0.66±0.044dC	0.06±0.034cD
	Sonali-75	1.97±0.035eA	1.80±0.189bA	0.39±0.029efB	0.04±0.033cC
	Mean	2.609±0.29	1.284±0.20	0.749±0.19	0.183±0.07
2006-2007 season	Bari Sharisha-6	2.12±0.032eA	1.74±0.092cdB	0.49±0.041deC	0.14±0.031cD
	Bari Sharisha- 7	1.73±0.049fA	1.03±0.017gB	0.54±0.015dC	0.03±0.009cD
	Bari Sharisha-8	2.03±0.039eA	0.99±0.116gB	0.25±0.020fC	0.00±0.003cD
	Bari Sharisha-9	2.46±0.043dA	1.17±0.029fgB	0.34±0.026efC	0.04±0.006cD
	Bari Sharisha-10	2.92±0.058cA	I.38±0.074etB	0.85±0.080cC	0.35±0.041bD
	Bari Sharisha-11	3.S4±0.038bA	2.51±0.236bB	2.24±0.073aB	0.71±0.124aC
	Bari Sharisha-12	2.11±0.036eA	0.70±0.021hB	0.45±0.018deC	0.10±0.018cD
	Rai-5	3.7S±0.079bA	1.93±0.092cB	1.66±0.096bC	0.27±0.023bD
	Tory-7	4.1S±0.084aA	1.51±0.028deB	0.72±0.035cC	0.02±0.006cD
	Sonali-75	1.95±0.064eB	3.08±0.045aA	0.40±0.038defC	0.04±0.012cD
	Mean	2.709±0.29	1.604±0.23	0.794±0.21	0.170±0.07

*Means followed by the same letter did not differ significantly at the $P < 0.05$ or 0.01 by DMRT. Small and capital letters indicate column and row, respectively.

on October 8 (normal sowing date) escaped from the attack of *L. erysimi* in the tarai region of India whereas the crop delayed in the sowing by 10 days than normal one is damaged economically by the aphid. They also added that yield and its component were differed significantly on different dates of sowing. Due to delay in sowing time the flower and pod initiation stage of the crop synchronize with the peak population of the aphid, above the economic threshold level which is influenced with date of sowing, soil type, crop season, crop growth stage and insecticides used (Singh and Sachan, 1997). Ghimiray *et al.* (2004) reported that early sown crop attracted lower number of aphids yet the grain yield was highest in crop sown during the first week of December in West Bengal, India. Patel *et al.* (2004) reported that early sowing mustard produced highest yield where low aphid infestation occurred in Raigarh, India. They also found that grain yield was decreased significantly in delayed sown crops when aphid population comparatively high, which support the present study. Chattopadhyay *et al.*, 2005) found that early sowing crops had low aphid infestation and recorded higher amount of grains in eight different agro-climatic zones in India; but, late sowing mustard infested by higher number of aphid gave less amount of mustard grains in all the zones. Jat and Takar (2005) got highest yield from the early sown crops and lowest yield from the late sown crops in Rajasthan, India.

Yousaf *et al.* (2002) found that early sowing canola (11 October) produced higher yield (21.11 q/ha) than late sown (31 October) canola (18.06 q/ha) crop in Bhawalpur, Pakistan. Hocking and Stapper (2001) determined the effects of sowing time on grain yield and yield components of the mustard crops at New South Wales, Australia. They compared with an April sowing; the grain yield of canola was reduced by 35% for a May sowing and by 67% for a July sowing. Robertson *et al.* (2004) noticed that the yield of Indian mustard declined with delayed sowing varied from -10% to +4% per week delay in sowing in Tamworth, Moree, Lawes and Dalby (Australia).

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LIST OF PREDATORY COCCINELLIDAE (COLEOPTERA) OF INDIA AND THEIR PREYS : A REVIEW AND BIBLIOGRAPHY

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Abstract : Coccinellid beetles (Coleoptera: Coccinellidae) are the most important group of polyphagous predatory insects. A list is given for 347 species of ladybird beetles (Coleoptera : Coccinellidae) that occur in India, based on literature searches. The list includes the species of preys of 151 coccinellid species while preys for rest 196 species of predatory ladybirds are yet to be discovered. Most of the preys comprise aphids and other plant bugs while few prey upon scales, mealybugs, whiteflies, mites etc. Maximum polyphagy was recorded for *Cheilomenes sexmaculata* (Fabr.) (64 prey species) followed by *Coccinella septempunctata* (Linn.) (56 prey species). References for all prey records are given for further studies.

Keywords : Coccinellidae, predators, aphids.

INTRODUCTION

The coccinellid beetles (Coleoptera : Coccinellidae), commonly known as ladybirds have attracted attention by different workers because of their common occurrence and for great economic importance (Obrycki and Kring 1998). About 6000 species under 360 genera are known from the world (Vandenberg, 2002). About 90 percent of the species are arthropod predators, the remainder being phytophagous or mycetophagous (Iperti, 1999; Vandenberg, 2002). In India, 347 species under 73 genera of predatory coccinellids are known (Poorani, 2004). Out of them about 43.5% (151 species) are predator on aphids, coccids, other soft-bodied homopterans, caterpillars, mites etc. and are beneficial serving as bioagent in their natural/biological control. Prey species for others are yet to be discovered.

From the available literature it has been observed that stray work on coccinellids in India started almost 252 years ago when Fabricius (1798) for the first time described *Coccinella suturalis* as a predaceous coccinellid beetle (valid name: *Brumoides suturalis* (Fabricius, 1798)). Mulsant (1850) in his world monograph on the Coccinellidae described 3 more species namely *Rodolia fumida*, *Rodolia ruficollis*, and *Coelophora westermanni* (valid name : *Coelophora circumusta* (Mulsant)). In 1853, Mulsant (1853a, b) added two more species *Scymnus (Pullus) pyrocheilus* and *Aspidimerus ariasi* (valid name: *Cryptogonus ariasi* (Mulsant)). Later, Motschulsky (1866) added another species *Scymnus brunnescens* (valid name: *Scymnus* (*Neopullus*) *fuscatus* Boheman).

Weise (1892, 1895) in his papers on the coccinellids of Chhota Nagpur and Bengal added 2 more predacious coccinellids *i.e.*, *Scymnus pauperculus* (valid name: *Stethorus pauperculus* (Weise)) and *Chilocorus braeti*. Thereafter, Kapur (1942-1973) added several predaceous coccinellids from India (see Poorani, 2004). Since then a number of new species are described by several workers and some widely distributed species are recorded from India. Agarwala and Ghosh (1988) compiled the information about the preys of predatory coccinellids for the first time from India followed by Agarwala and Yasuda (2000) and Omkar and Pervez (2000a). Since then, several new additions were made and in this compilation, attempt was made to list all the predatory coccinellids recorded so far from India alongwith their prey species.

Most of the preys of coccinellids belong to Hemiptera (Homoptera and Heteroptera). The family rank of all the prey is provided. The ordinal rank was given only if the prey species does not belong to the Order Hemiptera. For synonymy, Poorani (2004) for coccinellids and Remaudière and Remaudière (1997) for aphids were followed or otherwise references are given.

The arrangement of the species is alphabetical for convenience, and does not reflect phylogenetic relationships anyhow. For the species, the most recent combination is given followed by the author name and synonymy. To avoid any kind of confusion regarding the generic names, the generic names were not abbreviated.

The paper has been divided in to two parts: (a) the coccinellids with species of preys and (b) the predatory coccinellids whose preys are yet to be ascertained. Each prey record is followed by reference(s).

This list is mainly based on available literature rather than on extensive taxonomic studies.

A. List of coccinellid predators of arthropods along with arthropod preys

1. *Adalia bipunctata* (L.) (=*Coccinella bipunctata* Linnaeus)

   Aphididae: *Brachycaudus helichrysi* (Kalt.)[1], *Eriosoma lanigerum* (Hausmann)[2], *Pentalonia nigronervosa* Coq.[3]

2. *Adalia indica* Crotch

   Phylloxeridae: *Adelges* sp.[4]

3. *Adalia luteopicta* Mulsant

   Phylloxeridae: *Adelges* sp.[4]

4. *Adalia simmondsi* Kapur and Sudha Rao

   Phylloxeridae: *Adelges* sp.[4]

5. *Adalia tetraspilota* (Hope) (= *Coccinella tetraspilota* Hope, *Adalia hopii* Mulsant, *Adalia (Adalia) tetraspilota* (Hope))

   Aphididae: *Aphis pomi* De Geer[5], *Brevicoryne brassicae* (Linn.)[6], *Brachycaudus helichrysi* (Kalt.)[1], *Hyalopterus pruni* (Geoff.)[7], *Lipaphis erysimi* (Kalt.)[8], *Myzus persicae* (Sulzer)[9]

6. *Aiolocaria hexaspilota* (Hope) (= *Coccinella hexaspilota* Hope, *Aiolocaria mirabilis* (Motschulsky), *Aiolocaria sexspilota* (Hope), *Aeolocaria hexaspilota* (Hope), *Caria sexspilota* (Hope), *Leis mirabilis* Motsch.)

   Aphididae: *Rhopalosiphum padi* (Linn.)[8]

7. *Alloneda dodecaspilota* (Hope) (= *Coccinella 12-spilota* Hope, *Aiolocaria dodecaspilota* (Hope), *Alloneda dodecastigma* (Sicard), *Caria duodecimspilota* (Hope), *Palaeoneda dodecaspilota* (Hope))

   Aphididae: *Rhopalosiphum maidis* (Fitch)[10], *Taoia indica* (Ghosh and Raychaudhuri)[1,11,12], *Tuberculatus (Acanthocallis) indicus* Ghosh[13]

8. *Anegleis cardoni* (Weise) (= *Verania*

cardoni Weise, *Coelophora cardoni* (Weise), *Micraspis cardoni* (Weise))

Aphididae: *Acyrthosiphon pisum* (Harris)[14], *Aphis craccivora* Koch[15], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[15], *Brevicoryne brassicae* (Linn.)[14], *Lipaphis erysimi* (Kalt.)[8], *Macrosiphum euphorbiae* (Thomas)[16], *Toxoptera citricida* (Kirk.)[16], *Toxoptera aurantii* (Boyer d. Fonsc.)[16]; Aleyrodidae: *Dialeurodes citri* (Ashmead)[17]; Coccidae: *Chloropulvinaria psidii* (Mask.)[18,19], coccids[20]; Fulgoridae: *Pyrilla perpusilla* Walker[21]

9. *Axinoscymnus puttarudriah* Kapur and Munshi

Aleyrodidae: *Aleurodicus disperses* Russel[21]

10. *Bothrocalvia albolineata* (Gyllenhal) (= *Coccinella albolineata* Gyllenhal, *Calvia albolineata* (Gyllenhal))

Aphididae: Unidentified aphid[10]

11. *Bothrocalvia lewisii* Crotch

Aphididae: Unidentified aphid[10]

12. *Bothrocalvia pupillata* (Swartz) (= *Coccinella pupillata* Swartz, *Coelophora pupillata*: Mulsant, *Bothrocalvia decemsignata* Iablokoff-Khnzorian)

Aphididae: *Melanaphis sacchari* (Zehntner)[22]

13. *Brumoides suturalis* (Fab.) (=*Coccinella suturalis* Fabricius, *Brumus suturalis*: Mulsant)

Aleyrodidae : *Bemisia gossypiperda* Mishra and Lamba[24], *Bemisia tabaci* (Gennadius)[25], Aphididae: *Acyrtho-siphon pisum* (Harris)[8], *Aphis affinis* del Guercio[26], *Aphis craccivora* Koch[15,27], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[15,28], *Aphis nerii* Boyer De Fonsc.[29], *Aphis pomi* de Geer[30], *Asiphonella cynodonti* (Das)[31], *Brevicoryne brassicae* (L.)[32], *Brachycaudus helichrysae* (Kalt.)[32], *Eriosoma lanigerum* (Haus.)[2], *Hyadaphis coriandri* (Das)[8], *Hyalopterus atriplicis* (Linn.)[28], *Lipaphis erysimi* (Kalt.)[33,34], *Melanaphis sacchari* (Zehnt.)[31], *Myzus persicae* (Sulz.)[35], *Rhopalosiphum nymphaeae* (L.)[36], *Therioaphis trifolii* (Monell)[8], *Uroleucon compositae* (Theohold)[37], Fulgoridae: *Pyrilla perpusilla* Walker[38;] Pseudococcidae: *Ferrisa virgata* (Cockerell)[33], mealybug[31], *Phenacoccus insolitus* Green[39], *Planococcus pacificus* Cox[33,] *Pseudococcus* sp.[39]; Tetranychidae (Acari): *Tetranychus neocaledonicus* Koch[23].

14. *Callicaria superba* (Mulsant) (= *Caria superba* Mulsant, *Callicaria superba japonica* Sicard, *Synonycha japonica* Kurisaki, *Pseudosynonycha japonica* (Kurisaki)

Aphididae: *Aphis gossypii* Glover[8]; Phylloxeridae: *Adelges* sp.[4]

15. *Calvia championorum* Booth

Aphididae: Aphid[40]

16. *Calvia punctata* (Mulsant) (= *Harmonia punctata* Mulsant, *Anisocalvia punctata* (Mulsant), *Propylea obversepunctata* Mulsant)

Aphididae: *Aphis craccivora* Koch[8], *Aphis gossypii* Glover[8], *Myzus persicae* (Sulzer)[8]

17. *Calvia quatuordecimguttata* (Linnaeus) (= *Coccinella 14-guttata* Linnaeus, *Anisocalvia quatuordecimguttata* (Linn.), *Coccinella 12-maculata* Gebler, *Oenopia dorsonotata* Mulsant)

Aphididae: Aphids; Psyllidae : psyllids?[41]

18. *Calvia sykesii* (Crotch) (= *Anisocalvia sykesii* Crotch)

Aphididae: unidentified aphid[10]

19. *Catana chapini* Kapur

Aleyrodidae: *Dialeurodes citri* (Ashmead)[42]

20. *Cheilomenes sexmaculata* (Fabr.) (=*Coccinella sexmaculata* Fabricius, *Coccinella 4-plagiata* Swartz, *Cheilomenes quadriplagiata* (Swartz), *Cheilomenes sexmaculata* var. *flavofasciata* Mulsant, *Orcus mollipes* Olliff, *Cheilomenes sexmaculata* var. *australis* Weise, *Menochilus sexmaculatus* Fabr., *Menochilus quadriplagiatus* (Swartz), *Chilomenes hiugaensis* Takizawa, *Cydonia triangulifera* var. *inops* Mulsant)

    Aleyrodidae: *Aleurolobus barodensis* (Maskell)[43], *Amrasca kerri* Pruthi[44], *Bemisia tabaci* (Gen.)[45], *Trialeurodes ricini* (Mishra)[45]; whiteflies[46]; Aphididae: *Acyrthosiphon pisum* (Harris)[47], *Aphis affinis* del Guercio[26], *Aphis craccivora* Koch[48,49], *Aphis fabae* Scop.[29,50], *Aphis gossypii* Glover[51], *Aphis longisetosa* Basu[1], *Aphis nerii* (B. de Fonsc.)[1,50], *Aphis pomi* De Geer[52], *Aphis spiraecola* Patch[53], *Aphis umbrella* Börner[54], *Brachycaudus helichrysi* (Kalt.)[32], *Brevicoryne brassicae* (L.)[6], *Capitophorus himalayensis* Ghosh *et al.*[1], *Cavariella simlaensis* Chowdhuri *et al.*[55], *Cerataphis brasiliensis* (Hampel)[8], *Ceratovacuna lanigera* Zehntner[8], *Cervaphis rappardi indica* A.N. Basu[56], *Cervaphis schouteniae* v. d. Goot[57], *Chaitophorus himalayensis* (Das)[53], *Coloradoa rufomaculata* (Wilson)[45], *Greenideoida ceyloniae* van der Goot[58], *Greenidea psidii* (van der Goot)[1], *Hyadaphis coriandri* (Das)[1], *Hyalopterus pruni* Geoffroy)[59], *Hysteroneura setariae* (Thomas)[1], *Liosomaphis atra* Hille Ris Lambers[1], *Lipaphis erysimi* (Kalt.)[60,61], *Macrosiphoniella sanborni* (Gillette)[62], *Macrosiphum rosae* (L.)[63], *Melanaphis sacchari* (Zehntner)[1], *Myzus persicae* (Sulz.)[64], *Myzus varians* Davidson[59], *Pemphigus ? napaeus* (Buckton)[1], *Pentalonia nigronervosa* Coq.[3], *Rhopalosiphum maidis* (Fitch.)[37,65], *Rhopalosiphum nymphaeae* (Linn.)[59], *Rhopalosiphum padi* (Linn.)[15], *Schizaphis graminum* (Rondani)[8], *Shivaphis celti* Das[53], *Sinomegoura citricola* (van der Goot)[66], *Sitobion avenae* (Fab.)[52], *Sitobion graminis* Takahashi[1], *Sitobion rosaeiformis* (Das)[63], *Therioaphis trifolii* (Monell)[8], *Tinocallis kahawaluokalani* (Kirk.)[57], *Toxoptera aurantii* (Boyer de Fonsc.)[67], *Toxoptera citricida* (Kirkaldy)[8], *Toxoptera odinae* (van der Goot)[1], *Tuberculatus nervatus* Chakrabarti & Raychaudhuri[68], *Uroleucan carthami* (Hille Ris Lambers)[1], *Uroleucon compositae* (Theobald)[15]; Cicadellidae: *Empoasca kerri* Pruthi[44], *Hishimonus phycitis* (Distant)[69]; Fulgoridae: eggs of *Pyrilla perpusilla* Walker[45]; Pseudococcidae: *Ferrisia virgata* (Cockrell)[1], *Pseudococcus saccharicola* Takahashi[70], mealybugs[31]; Psyllidae: *Heteropsylla cubana* Crawford[71]; Tetranychidae, Acari: mites[23]

21. *Chilocorus bipustulatus* (Linn.) (= *Coccinella bipustulata* Linn.)

    Aphididae: Aphids; Coccidae : coccids?[72]

22. *Chilocorus braeti* Weise

    Aphididae: unidentified aphid[40]

23. *Chilocorus cacti* (Linnaeus) (=*Coccinella cacti* Linnaeus)

    Aphididae: Aphid[73]; Diaspididae : *Melanaspis glomerata* (Gr.) Diaspididae[74-77]

24. *Chilocorus circumdatus* (Gyllenhal) (=*Coccinella circumdatus* Gyllenhal, *Chilocorus nigromarginatus* Motsch.)

    Coccidae: *Coccus viridis* (Green)[78]; Diaspididae: *Aonidiella aurantii* (Maskell)[79], *Chrysomphalus ficus* Ashmead[80], *Quadraspidiotus* *perniciosus* (Comstock)[81]

25. *Chilocorus coelosmilis* Kapur

Pseudococcidae: Pseudococcids[82]

26. *Chilocorus hauseri* Weise

Aphididae: Unidentified aphid[10]

27. *Chilocorus infernalis* Mulsant (=*Chilocorus bijugus* Mulsant)

Aleyrodidae: Citrus whitefly[18]; Aphididae: *Aphis pomi* De Geer[5], *Brachycaudus helichrysi* (Kalt.)[8], *Eriosoma lanigerum* (Haus.)[83]; Coccidae : *Metaceronema japonica* (Maskell)[73]; Diaspididae: *Pseudaulacaspis* sp.[84], *Quadraspidiotus perniciosus* (Comstock)[58]

28. *Chilocorus nigrita* (Fabr.) (=*Coccinella nigrita* Fabr., *Chilocorus nigritus* Fabr.)

Aleyrodidae: *Aleurodicus dispersus* Russel[85], *Alerolobus barodensis* (Maskell)[86], Aphididae: *Aphis craccivora* Koch[87], *Aphis* gossypii Glover[46], *Aphis nerii* Boyer de Fonsc.[88], *Brevicoryne brassicae* (Linn.)[88], *Lipaphis erysimi* (Kalt.)[89], *Myzus persicae* (Sulzer)[88], *Toxoptera aurantii* (Boyer de Fronsc.)[45], *Toxoptera citricida* (Kirkaldy)[8]; Coccidae: *Lecanium viride* Green[39]; Diaspididae: *Aspidiotus destructor* Signoret[90], *Lindingaspis rossi* (Maskell)[34]; Psyllidae: *Diaphorina citri* Kuw.[45]

29. *Chilocorus politus* Mulsant

Aphididae: *Macrosiphum rosae* (Linn.)[55], *Nippolachnus piri* Matsumura[1], *Sitobion rosaeiformis* (Das)[55]; Diaspididae: *Melanaspis glomerata* (Green)[18]

30. *Chilocorus rubidus* (Hope) (=*Coccinella tristis* Fald., *Chilocorus tristis* (Hope), *Chilocorus rubidus* ab. *Tristis* (Hope)

Aphididae: *Aphis pomi* De Geer[5], *Macrosiphum rosae* (Linn.)[8], *Sitobion rosaeiformis* (Das)[8]

31. *Chilocorus suryaphuli* Sathe and Bhosle

Aphididae: *Uroleucon campositae* (Theobald)[37]

32. *Coccinella septempunctata* L. (=*Coccinella 7-punctata* Linnaeus, *Coccinella divaricata* Olivier, *Coccinella confusa* Wiedemann, *Coccinella bruckii* Mulsant, *Coccinella septempunctata brucki* (Mulsant)

Aphididae: *Acyrthosiphon pisum* (Harris)[1], *Aphis craccivora* Koch[89,91,92], *Aphis fabae* Theobald[1], *Aphis gossypii* Glover[93], *Aphis longisetosa* Basu[1], *Aphis nerii* B. de Fonsc.[1,18], *Aphis pomi* de Geer[5], *Aphis spiraecola* Patch[1,18], *Aulacarthum magnoliae* (Essig and Kuwana)[1], *Brachycaudus helichrysi* (Kalt.)[94,95], *Brevicoryne brassicae* (L.)[1,96], *Capitophorus* sp.[1], *Cavariella aegopodii* (Scopoli)[1], *Cervaphis rappardi indica* Basu[8], *Chaetosiphon gracilicorne* David *et al.*[28], *Cinara tujafilina* (del Guercio)[66], *Dysaphis emicis* (Mimeur)[1], *Eriosoma lanigerum* (Haus.)[1], *Greenidea psidii* van der Goot[32], *Hyadaphis coriandri* (Das)[1], *Hysteronura setariae* (Thomas)[1], *Lachnus tropicalis* (van der Goot)[1], *Liosomaphis atra* Hille Ris Lambers[1], *Lipaphis erysimi* (Kalt.)[1], *Sitobion avenae* (Fab.)[1], *Macrosiphum centranthi* Theo.[97], *Macrosiphum euphorbiae* (Th.)[98], *Macrosiphum rosae* (L.)[86], *Matsumuraja capitophoroides* Hille Ris Lamb.[1], *Melanaspis glomerata* (Green)[89], *Pemphigus napaeus* Buckton[1], *Myzus dycei* Craver[1], *Myzus mumecola* (Muts.)[1], *Myzus ornatus* Laing[1], *Myzus persicae* (Sulz.)[99,100], *Neoacyrthosiphon holsti* (Takahashi)[1], *Nippolachnus* sp.[1], *Pentalonia nigronervosa* Coq.[1,3], *Prociphilus micheliae* Hille Ris Lambers[66], *Rhopalosiphum maidis*

(Fitch.)[101], *Rhopalosiphum nymphaeae* (L.)[1], *Sitobion miscanthi* (Takahashi)[1], *Sitobion rosaeiformis* (Das)[1], *Subovatomyzus leucosceptri* Basu[1], *Taoia indica* (Ghosh and Raychaudhuri)[1], *Therioaphis ononidis* (Kalt.)[1], *Therioaphis trifolii* (Monell)[1], *Toxoptera aurantii* (Boyer de Fonsc.)[13,102], *Toxoptera citricida* (Kirkaldy)[66], *Toxoptera odinae* (van der Goot)[13,102], *Uroleucon carthami* (H.R.L.)[1]; Delphacidae : *Peregrinus maidis* (Ashmead)[37]; Papilionidae, Lepidoptera: *Papilio demoleus* (L.)[16]; Pseudococcidae: *Planococcus pacificus* Cox.[34]; Fulgoridae: *Pyrilla perpusilla* Walker[103]; Tetranychidae, Acari: mites[1,58,104]

33. *Coccinella transversalis* Fabricious (=*Coccinella repanda* Thunberg)

    Aphididae: *Acyrthosiphon pisum* (Harris)[105], *Aphis affinis* del Guercio[26], *Aphis craccivora* Koch[37], *Aphis gossypii* Glover[106], *Aphis fabae* Scopoli[107], *Aphis nerii* Boyer de Fonsc.[108], *Aphis spiraecola* Patch[109], *Brachycaudus helichrysi* (Kalt.)[109], *Brevicoryne brassicae* (Linn.)[15], *Cervaphis quercus* (Takahashi)[109], *Cervaphis rappardi indica* Basu[109], *Lipaphis erysimi* (Kalt.)[110], *Macrosiphoniella yomogifoliae* (Shinji)[109], *Melanaphis donacis* (Passerini)[109], *Macrosiphum rosae* (Linn.)[8], *Myzus persicae* (Sulzer)[15], *Pentalonia* sp.[111], *Pentalonia nigronervosa* Coquerel[8], *Rhopalosiphum maidis* (Fitch.)[109], *Sitobion rosaeiformis* (Das)[109], *Taoia indica* (Ghosh and Raychaudhuri)[109], *Therioaphis trifolii* (Monell)[8], *Toxoptera aurantii* (Boyer de Fonsc.)[109], *Uroleucon sonchi* (Linn.)[109]

34. *Coccinella transversoguttata* Fald.

    Aphididae : *Rhopalosiphum maidis* (Fitch)[111]

35. *Coccinella undecimpunctata* Linn. (=*Coccinella* (*Dobzhanskia*) *undecimpunctata* Linn.)

    Aphididae: *Aphis craccivora* Koch[8], *Aphis gossypii* Glover[1,9], *Aphis nerii* Boyer de Fonsc.[8], *Aphis punicae* Passerini[8], *Brevicoryne brassicae* (Linn.)[8], *Hyalopterus pruni* (Geoffroy)[8], *Lipaphis erysimi* (Kalt.)[1,9], *Macrosiphoniella sanborni* (Gillette)[8], *Myzus persicae* (Sulzer)[8], *Rhopalosiphum maidis* (Fitch)[8], *Sitobion graminis* Takahashi[1], *Sitobion miscanthi* (Takahashi)[1]

36. *Coelophora biplagiata* (Swantz) (= *Coccinella biplagiata* Swartz, *Lemnia biplagiata* (Swartz), *Coccinella oblongata* Thunberg, *Coelophora nepalensis* Crotch)

    Aphididae: *Acyrthosiphon pisum* (Harris)[8], *Aphis achyranthi* Theob.[8], *Aphis craccivora* Koch[112], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[112], *Ceratovacuna lanigera* Zehntner[8], *Macrosiphum rosae* (Linn.)[8], *Schizaphis graminum* (Rondani)[8], *Toxoptera aurantii* (Boyer de Fonsc.)[113]

37. *Coelophora bissellata* Mulsant (= *Spilocaria bissellata* (Mulsant), *Lemnia* (*Spilocaria*) *bissellata* (Mulsant), *Lemnia bissellata* (Mulsant), *Caria gracilicornis* Weise)

    Aphididae: *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[112], *Aphis craccivora* Koch[114], *Cervaphis rappardi indica* Basu[13,115], *Dactynotus compositae* Theobald[37], *Rhopalosiphum maidis* (Fitch)[8], *Toxoptera aurantii* (Boyer de Fonsc.)[109], *Toxoptera odinae* (van der Goot)[8]

38. *Coelophora inaequalis* (Fab.) (= *Coccinella inaequalis* Fabricius, *Coccinella circularis* Thunberg, *Coelophora ripponi* Crotch, *Coelophora kochi* Weise, *Coelophora veranioides*

Blackburn, *Coelophora mastersi* Blackburn, *Lemnia desolata* Mulsant)

Aphididae: *Macrosiphum* sp.[18], *Toxoptera aurantii* (Boyer de Fonsc.)[113]

39. *Coelophora octosignata* Mulsant

Aleyrodidae: *Aleurolobus barodensis* (Maskell)[141]; hopper[43]

40. *Coelophora saucia* (Mulsant) (= *Lemnia saucia* Mulsant, *Coelophora swinhoeii* Crotch, *Lemnia melanota* Mulsant)

Aphididae: *Aphis craccivora* Koch[115a], *Cervaphis rappardi indica* Basu[13,115]

41. *Cryptognatha flavescens* Motsch

Aleyrodidae: *Dialeurodes citri* Ril. & How.[17]; hoppers[104]

42. *Cryptognatha nodiceps* Mshl.

Diaspididae: *Aspidiotus destructor* Sign.[104], hoppers[37]

43. *Cryptogonus ariasi* (Mulsant) (= *Aspidimerus ariasi* Mulsant)

Aphididae: *Aphis gossypii* Glover[10,13]

44. *Cryptogonus bimaculatus* Kapur

Aphididae: *Hyalopterus pruni* (Geoff.)[59], *Toxoptera citricida* (Kirkaldy)[10]

45. *Cryptogonus complexus* Kapur

Aphididae: Aphids[10]

46. *Cryptogonus kapuri* Ghorpade

Aphididae: *Cerataphis brasiliensis* (Hampel)[8], *Cerataphis fransseni* (Hille Ris Lambers)[116], *Toxoptera odinae* (van der Goot)[116]

47. *Cryptogonus nitidus* Kapur

Aphididae: Unidentified aphid[10]

48. *Cryptogonus orbiculus* (Gyllenhal) (= *Aspidimerus fulvocinctus* Mulsant, *Coccinella antica* Walker, *Coccinella lunigera* Thunberg, *Coccinella orbicula* Gyllenhal, *Cryptogonus centroguttatus* Boheman, *Cryptogonus japonicus* Crotch, *Cryptogonus malasiae* Crotch, *Cryptogonus orbiculus* var. *apicalis* Weise, *Cryptogonus orbiculus* var. *japonicus* Weise, *Cryptogonus orbiculus* var. *lunatus* Kapur, *Cryptogonus orbiculus* var. *nigripennis* Weise, *Cryptogonus orbiculus* var. *sellatus* Weise, *Diomus futahoshii* ab. *koshunus* Ohta, *Diomus futahoshii* Ohta, *Platynaspis oculata* Mots., *Scymnus* (*Pullus*) *mitsuhashii* Takiz.)

Aphididae: *Aphis craccivora* Koch[8], *Pentalonia nigronervosa* Coquerel[8], *Toxoptera aurantii* (Boyer De Fonsc.)[109]

48. *Cryptogonus postmedialis* Kapur (=*Cryptogonus postmedialis* var. *sushila* Kapur)

Diaspididae: *Aspidiotus destructor* Sign.[18]

50. *Cryptogonus quadriguttatus* (Weise) (= *Aspidiphorus quadriguttatus* Weise, *Cryptogonus quadriguttatus* var. *confluens* Kapur, *Cryptogonus quadriguttatus* var. *nigriscens* Kapur)

Aphididae: *Aphis gossypii* Glover[59], *Hyalopterus pruni* (Geoff.)[59], *Macrosiphum rosae* (L.)[1], *Melanaphis sacchari* (Zehntner)[1], *Rhopalosiphum maidis* (Fitch.)[1,9], *Sitobion rosaeiformis* (Das)[1,9], *Toxoptera aurantii* (Boyer de Fonsc.)[1,9], *Toxoptera odinae* (van der Goot)[1]; Tetranychidae, Acari: tea mites[10]

51. *Cryptogonus trioblitus* (Gorham) (=*Aspidimerus trioblitus* Gorham)

Aphididae: Aphid[18]

52. *Cryptolaemus montrouzieri* Mulsant

Aleyrodidae: *Aleurodicus dispersus* Russell[37]; Aphididae: *Aphis craccivora* Koch[8], *Aphis gossypii* Glover[8], *Lipaphis erysimi* (Kalt.)[105]; Coccidae: *Chloropulvinaria polygonata* (Cockll.)[117], *Chloropul-*

vinaria psidii (Mask.)[46,118,119], *Pulvinaria psidi* Maskell[39], *Pulvinaria maxima* Green[39]; Pseudococcidae: *Coccidohystria insolita* (Green)[120], *Eriococcus araucaria* Maskell[39], *Ferrisia virgata* (Cock.)[120]; *Maconellicoccus hirsutus* (Green.)[121,122], *Planococcus citri* (Risso.)[123], *Planococcus lilacinus* (Cock.)[123], *Pseudococcus* sp.[39]

53. *Curinus coeruleus* (Mulsant) (=*Orcus (Curinus) coeruleus* Mulsant)

 Aphididae: *Ceratovacuna lanigera* Zehntner[8]; Psyllidae: *Heteropsylla cubana* (Crawford)[124a]

54. *Exochomus nigripennis* (Erichson) (=*Chilocorus nigripennis* Erichson, *Exochomus nigromaculatus* var. *nigripennis* (Erichson), *E. flavipes* ab. *nigripennis* (Erichson)

 Aphididae: Aphid[29]

55. *Halyzia sanscrita* Mulsant

 Aphididae: *Cinara tujafilina* (del Guercio)[8]

56. *Harmonia dimidiata* (Fabr.) (= *Coccinella dimidiata* Fabricius, *Coccinella dimidia* Hope, *Leis dimidiata* (Fabricius), *Coccinella quindecim-maculata* Hope, *Coccinella quindecim-spilota* Hope,*Coccinella bicolor* Hope)

 Aphididae: *Acyrthosiphon pisum* (Harris)[1], *Aphis achyranthi* Theob.[8], *Aphis craccivora* Koch[114], *Aphis gossypii* Glover[112], *Aphis pomi* de Geer[5], *Aphis spiraecola* Patch[8], *Brevicoryne brassicae* (Linn.)[6], *Cervaphis rappardi indica* Basu[102,115], *Myzus persicae* (Sulz.)[123], *Rhopalosiphum maidis* (Fitch)[8], *Schizaphis graminum* (Rondani)[8]; Phylloxeridae: *Adelges* sp.[4]; Tetranychidae, Acari: mite[123a],

57. *Harmonia eucharis* (Mulsant) (= *Ballia brahmae* Mulsant, *Ballia christophori* Mulsant, *Ballia dianae* Mulsant, *Ballia dianae* var. *saundersii* Crotch, *Ballia eucharis* Mulsant, *Ballia gustavi* Mulsant, *Ballia mayeti* var. *perplexa* Crotch, *Ballia montivaga* Mulsant, *Ballia testacea* Mulsant, *Harmonia korschefskyi* Mader, *Neda bayaderae* Mulsant, *Pelina mayeti* Mulsant, *Pelina zephyrinae* Mulsant)

 Aphididae: *Aphis craccivora* Koch[124], *Aphis pomi* de Geer[5], *Aphis spiraecola* Patch[8], *Brachycaudus helichrysi* (Kalt.)[32], *Brevicoryne brassicae* (Linn.)[8], *Cervaphis rappardi indica* Basu[115], *Eriosoma lanigerum* (Housm.)[2], *Hyalopterus pruni* (Geoffroy)[125], *Myzus persicae* (Sulzer)[9], *Myzus varians* Davidson[59], *Macrosiphoniella pseudoartemisiae* Shinji[59], *Phorodon cannabis* (Passerini)[125], *Rhopalosiphum nymphaeae* (L.)[8]; Phylloxeridae: *Adelges* sp.[126]

58. *Harmonia expallida* (Weise) (= *Coccinella* (*Harmonia*) *quadripunctata* var. *expallida* Weise, *Harmonia 4-punctata* var. *expalliata* (Weise) Sicard, *Harmonia breiti* Mader)

 Phylloxeridae: *Adelges* sp.[18]

59. *Harmonia octomaculata* (Fab.) (= *Coccinella octomaculata* Fabricius, *Coccinella arcuata* Fabricius, *Harmonia arcuata* var. *octomaculata*: Mulsant, *Harmonia arcuata*: Mulsant, *Harmonia octomaculata*, *Harmonia octomaculata* var. *arcuata*: Mader, *Coccinella arcuata* var. *octomaculata*, *Ptychanatis octomaculata*)

 Aphididae: *Acyrthosiphon pisum* (Harris)[127], *Aphis craccivora* Koch[29,37], *Aphis gossypii* Glover[8], *Ceratovacuna lanigera* Zehntner[8], *Myzus persicae* (Sulzer)[8], *Geoica lucifuga* (Zehntner)[49], *Myzus persicae* (Sulz.)[17,27,128], *Rhopalosiphum maidis* (Fitch)[8]; hoppers[129-131]

60. *Harmonia sedecimnotata* (Fab.)

(= *Coccinella sedecimnotata* Fabricius, *Daulis 16-notata*: Mulsant, *Callineda sedecimnotata* (Mulsant))

Aphididae: *Aphis craccivora* Koch[8], *Myzus persicae* (Sulzer)[8], *Mollitrichosiphum montanum* (van der Goot)[132]

61. *Hippodamia tredecimpunctata* (Linn.) (= *Coccinella tredecimpunctata* Linn.)

Aphididae: *Brevicoryne brassicae* (Linn.)[6]

62. *Hippodamia variegata* (Goeze) (= *Coccinella variegata* Goeze, *Adonia variegata* (Goeze), *Hippodamia (Adonia) variegata* (Goeze))

Aphididae: *Aphis craccivora* Koch[133,134], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[1], *Aphis pomi* de Geer[5], *Aphis spiraecola* Patch[1,29], *Aphis umbrella* (Borner)[1], *Brachycaudus helichrysi* (Kalt.)[6], *Brachyunguis harmalae* Das[1,28], *Brevicoryne brassicae* (Linn.)[6], *Eriosoma lanigerum* (Hausmann)[135], *Hayhursitia atriplicis* (Linn.)[1,28], *Hyalopterus pruni* (Geoff.)[7], *Hyperomyzus carduellinus* (Theobald)[1], *Liosomaphis himalayensis* Basu[1], *Lipaphis erysimi* (Kalt.)[1,9], *Macrosiphum rosae* (Linn.)[1,9], *Myzus ornatus* Laing[1], *Myzus persicae* (Sulz.)[1,28], *Sitobion avenae* (Fabr.)[52], *Sitobion graminis* Takahashi[1], *Sitobion miscanthi* (Tak.)[1,28,32], *Uroleucon sonchi* (Linn.)[1]

63. *Hippodamia variegata doubledayi (*Mulsant) (=*Adonia doubledeayi* Mulsant, *Adonia variegata doubledeayi* (Mulsant))

Aphididae: *Aphis gossypii* Glover[1,32], *Sitobion miscanthi* (Takah.)[32]

64. *Horniolus dispar* Weise

Aphididae: *Brachycaudus helichrysi* (Kalt.)[135]

65. *Horniolus guimeti* (Mulsant) (= *Scymnus (Pullus) latemaculatus* Motschulsky, *Scymnus guimeti* Mulsant)

Aphididae: *Aphis spiraecola* Patch[1], *Aphis gossypii* Glover[29], *Aphis nerii* Boyer de Fonsc.[129], *Brachyunguis harmalae* Das[28]

66. *Horniolus nigripes* Miyatake

Aphididae: *Dactynotus compositae* Theobold[37]

67. *Hyperaspis maindroni* Sicard (= *Hyperaspis maindroni* ab. *brumoides* Sicard, *Hyperaspis maindroni* ab. *includens* Sicard)

Aphididae: *Aphis fabae* Scopoli[84], *Aphis gossypii* Glover[84], *Aphis spiraecola* Patch[104]; Pseudococcidae: *Antonina graminis* (Mask)[19], *Maconellicoccus hirsutus* (Green)[19], *Plannococcus lilacinus* (Cock.)[136]

68. *Hyperaspis marginaloides* Canepari

Aphididae: *Aphis spiraecola* Patch[29], *Aphis fabae* Scopoli[29], *Aphis gossypii* Glover[29]

69. *Illeis bistigmosa* (Mulsant) (= *Psyllobora bistigmosa* Mulsant, *Thea bistigmosa* (Mulsant), *Illeis bielawskii* Ghorpade, *Psyllobora simplex* Mulsant)

Aphididae: Unidentified aphid[1]

70. *Illeis cincta* (Fab.) (= *Coccinella cincta* Fabricius, *Psyllobora cincta* (Fabricius), *Thea cincta* (Fabricius))

Aphididae: *Aphis gossypii* Glover[64], *Aphis craccivora* Koch[138], *Aphis nerii* Boyer de Fonsc.[133], *Myzus persicae* (Sulz.)[37,139,140], *Pentalonia nigronervosa* Coq.[138], *Rhopalosiphum maidis* (Fitch)[37], *Toxoptera odinae* (van der Goot)[138]; Tetranychidae, Acari: *Tetranychus* sp.[137].

71. *Illeis sathei* Sathe and Bhosle

Aphididae: *Aphis craccivora* Koch[37]

72. *Jauravia assamensis* Kapur

Aphididae: Unidentified aphid[10]

73. *Jauravia hanifi* Afroze & Shujauddin

Aleyrodidae: *Aleurocanthus rugosa* Singh[142], *Dialeurodes eugeniae* Maskell[142]

74. *Jauravia opaca* (Weise) (= *Clanis opaca* Weise, *Coccinella pusilla* Thunberg)

Aphididae: *Toxoptera aurantii* (Boyer de Fonsc.)[109] : Tetranychidae, Acari : *Tetranychus urticae* Koch[109].

75. *Jauravia pallidula* Mols. (= *Clanis pallidula* (Motschulsky))

Diaspididae: *Parlatoria orientalis* Rao[143]; Pseudococcidae: *Pseudococcus gilbertensis* Beardsley[143]

76. *Jauravia pubescens* (Fab.) (=*Clanis pubescens* (Fabricius), *Coccinella pubescens* Fabricius)

Aphididae: *Toxoptera aurantii* (Boyer de Fonsc.)[109]; Oecophoridae, Lepidoptera: *Opisina arenosella* Walker[144]; Tortricidae, Lepidoptera: *Cydia leucostoma* Meyrick[145]

77. *Jauravia quadrinotata* Kapur

Aphididae : unidentified aphid[10]

78. *Jauravia simplex* (Walker) (=*Clanis simplex* (Walker), *Coccinella simplex* Walker, *Scymnus simplex* (Walker))

Aphididae: *Toxoptera aurantii* (B. de Fonsc.)[109]; Tetranychidae, Acari: *Tetranychus* sp.[109]

79. *Jauravia soror* (Weise) (= *Clanis soror* Weise, *Jauravia pubescens* Gorham (not Fabricius))

Aphididae: *Toxoptera aurantii* (Boyer de Fonsc.)[18], Margarodidae: *Icerya purchasi* Maskell[18]

80. *Megalocaria dilatata* (Fabr.) (= *Coccinella dilatata* Fabricius, *Caria dilatata* (Mulsant), *Anisolemnia dilatata* (Mulsant))

Aphididae: *Aphis nasturtii* Kalt.[1], *Aphis spiraecola* Patch[8], *Astegopteryx minuta* van der Goot[1], *Astegopteryx bambusae* (Buckton)[1], *Ceratovacuna lanigera* Zehntner[39], *Ceratovacuna silvestrii* (Taka.)[1], *Cervaphis schouteniae* van der Goot[1], *Greenideoida ceyloniae* van der Goot[1], *Pentalonia nigronervosa* Coquerel[8], *Pseudoregma bambusicola* (Takahashi)[39,63], *Pentalonia nigronervosa* Coq.[1], *Pyrolachnus piri* (Buckton)[29], *Toxoptera aurantii* (Boyer de Fonsc.)[1]

81. *Micraspis allardi* (Mulsant) (= *Lemnia allardi* Mulsant, *Verania allardi* (Mulsant), *Verania malaccensis* Crotch, *Verania allardi* var. *malaccensis* (Mulsant))

Aphididae: *Aphis craccivora* Koch[146], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[146,147], *Brevicoryne brassicae* (Linn.)[146], *Lipaphis erysimi* (Kalt.)[146], *Myzus persicae* (Sulzer)[8]; Fulgoridae: *Pyrilla perpusilla* Walker[21,38,148]

82. *Micraspis discolor* (Fab.) (= *Coccinella discolor* Fabricius, *Verania discolor*, *Coccinella simplex* Thunberg)

Aleyrodidae: *Aleurolobus barodensis* (Maskell)[147]; Aphididae: *Aphis craccivora* Koch[149,150], *Aphis gossypii* Glover[1,15,149], *Aphis spiraecola* Patch[35], *Brevicoryne brassicae* (Linn.)[15], *Lipaphis erysimi* (Kalt.)[15,35], *Myzus persicae* (Sulzer)[150a]; *Rhopalosiphum nymphaeae* (Linn.)[36], *Pentalonia nigronervosa* Coq.[138], *Toxoptera odinae* (van der Goot)[138]; Fulgoridae: *Pyrilla perpusilla* Walker[17]; Oecophoridae, Lepidoptera : *Opisina arenosella* Walker[144]

83. *Micraspis univittata* (Hope) (= *Coccinella univittata* Hope, *Alesia univittata* (Hope), *Tytthaspis univittata* (Hope))

Aphididae: *Rhopalosiphum rufiabdominalis* (Sasaki)[8]

84. *Micraspis vincta* (Gorham) (=*Verania vincta* Gorham, *Verania inops* f. *vincta* (Gorham))

Aleyrodidae: *Bemisia tabaci* (Gennadius)[151]; Aphididae: *Aphis gossypii* Glover[152], *Brevicoryne brassicae* (Linn.)[152], *Hyalopterus pruni* (Geoffroy)[59], *Lipaphis erysimi* (Kalt.)[152], *Myzus persicae* (Sulz.)[153], *Toxoptera aurantii* (Boyer de Fonsc.)[154]

85. *Nephus quadrimaculatus* (Herbst) (=*Sphaeridium quadrimaculatus* Herbst)

Pseudococcidae: *Pseudococcus* sp.[39]

86. *Nephus regularis* (Sicard) (=*Scymnus (Nephus) regularis* Sicard)

Aphididae: *Aphis gossypii* Glover[18,146], *Brevicoryne brassicae* (Linn.)[146], *Lipaphis erysimi* (Kalt.)[146], *Rhopalosiphum maidis* (Fitch.)[146]; Coccidae: *Chloropulvinaria polygonata* (Ckll.)[117]; Pseudococcidae: *Centrococcus insolitus* Green[34], *Chorizococcus* sp.[18], *Ferrisa virgata* (Cockerell)[34], *Maconellicoccus hirsutus* (Green.)[34], *Planococcus pacificus* Cox[34], *Pseudococcus* sp.[18]

87. *Nephus tagiapatus* (Kamiya) (= *Nephus roonwali* Kapur, *Scymnus (Nephus) tagiapatus* Kamiya)

Aphididae : unidentified aphid[10]

88. *Oenopia adelgiovora* Poorani

Phylloxeridae: *Adelges* sp.[155,156]

89. *Oenopia billieti* (Mulsant) (=*Adalia indica* Crotch, *Coccinella (Synharmonia) billieti* (Mulsant), *Coccinella (Synharmonia) billieti* var. *pruthii* Kapur, *Coccinella (Synharmonia) billieti* var. *testacea* Kapur, *Coccinella* [sic] *transgressa* Mulsant, *Coccinella billieti* (Mulsant), *Harmonia billieti* Mulsant, *Oenopia gonggarensis* Jing, *Oenopia picithoroxa* Jing), *Oenopia pomiensis* Jing, *Propylea kehamae* Crotch, *Protocaria billieti* (Mulsant), *Synharmonia billieti* (Mulsant))

Aphididae: *Brachycaudus helichrysi* (Kalt.)[94], Delphacidae: *Nilaparvata lugens* Stal.[157]

90. *Oenopia conglobata* (Linn.) (= *Coccinella conglobata* Linn., *Harmonia conglobata* (Linn.), *Oenopia conglobata* (Linn.), *Propylea conglobata* (Linn.), *Synharmonia conglobata* (Linn.))

Aphididae: *Hyalopterus pruni* (Geoffroy)[8], *Macrosiphum rosae* (Linn.)[8], *Toxoptera aurantii* (Boyer de Fonsc.)[8]; Phylloxeridae: *Adelges* sp.[18]

91. *Oenopia kirbyi* Mulsant (=*Gyrocaria kirbyi* (Mulsant))

Aphididae: *Aphis fabae* Scopoli[18], *Aphis fabae solanella* Theobold[1], *Aphis gossypii* Glover[1], *Aphis paraverbasci* Chakrabarti[1], *Aphis spiraecola* Patch[1], *Brevicoryne brassicae* (Linn.)[6], *Capitophorus formosartemisiae* (Takahashi)[1], *Cervaphis rappardi indica* Basu[10], *Coloradoa rufomaculata* (Wilson)[1], *Eriosoma lanigerum* (Hausmann)[158], *Eulachnus thunbergi* (Wilson)[13], *Hayhurstia atriplicis* (Linn.)[8], *Hyalopterus pruni* (Geoffroy)[6], *Macrosiphum rosae* (Linn.)[6], *Myzus persicae* (Sulz.)[53], *Rhopalosiphum maidis* (Fitch)[1], *Sitobion rosaeiformis* (Das)[6], *Taoia indica* (Ghosh and Raychaudhuri)[13]

92. *Oenopia manipurensis* Devi, Singh & Singh

Aphididae: *Cervaphis rappardi indica* Basu[115]

93. *Oenopia mimica* Weise (= *Gyrocaria mimica* (Weise))

Phylloxeridae: *Adelges* sp.[18]

94. *Oenopia quadripunctata* Kapur

Aphididae: *Aphis fabae* Scopoli[12],

Aphis fabae solanella Theobald[1], *Aphis gossypii* Glover[8], *Cervaphis rappardi indica* Basu[115], *Hyalopterus pruni* (Geoffroy)[12], *Toxoptera aurantii* (B. de Fonsc.)[102]

95. *Oenopia sauzeti* Mulsant (= *Gyrocaria sauzeti* (Mulsant))

Alerodidae : *Neomaskellia andropogonis* Corbett[1], Aphididae: *Aphis fabae* Scopoli[12], *Aphis gossypii* Glover[1], *Aphis kurosawai* Takahashi[1], *Aphis longisetosa* Basu[1], *Aphis pomi* de Geer[5,52], *Aphis spiraecola* Patch[1], *Brachycaudus helichrysi* (Kalt.)[1], *Brevicoryne brassicae* (Linn.)[1], *Capitophorus formosartemisiae* (Takahashi)[1], *Capitophorus hippophaes javanicus* Hille Lis Lambers[1], *Cavariella aegopodii* (Scopoli)[1], *Coloradoa artemisiae* (del Guercio)[99], *Clethrobius dryobius* Chakrabarti & Raychaudhuri[53], *Eriosoma lanigerum* (Haus.)[5], *Liosomaphis atra* H.R.L.[1], *Macrosiphoniella pseudoartemisiae* Shinji[159], *Macrosiphum rosae* (Linn.)[55], *Macrosiphoniella sanborni* (Gillette)[55], *Melanaphis donacis* (Passer.)[1], *Myzus persicae* (Sulz.)[53], *Myzus obtusirostris* David, Narayan & Rajasingh[1], *Paraphorodon cannabis* (Passerini)[1], *Rhopalosiphum padi* (Fabr.)[159], *Sipha maydis* Passerini[1], *Sitobion avenae* (Fabr.)[159], *Sitobion rosaeiformis* (Das)[6], *Toxoptera aurantii* (Boyer de Fonsc.)[8]; Psyllidae : *Arytaina sp.*[1]

96. *Oenopia sexareata* (Mulsant) (= *Coelophora sexareata* Mulsant, *Coelophora sexareata* var. *lacerata* Sicard, *Gyrocaria sexareata* (Mulsant))

Aphididae: *Aphis gossypii* Glover[18], *Brachycaudus helichrysi* (Kalt.)[1], *Brevicoryne brassicae* (Linn.)[1], *Macrosiphum rosae* (Linn.)[6], *Mollitrichosiphum montanum* (van der Goot)[13,55,102], *Myzus persicae* (Sulz.)[1,9], *Neotoxoptera geranii* (Chowdhuri, Basu, Chakrabarti & Raychaudhuri)[1], *Pemphigus napaeus* Buckton[1], *Rhopalosiphum maidis* (Fitch.)[1], *Shinjia orientalis* (Mordvilko)[1], *Sitobion miscanthi* (Takahashi)[1], *Sitobion rosaeiformis* (Das)[1,9], *Taoia indica* (Ghosh & Raychaudhuri)[1,55;] Phylloxeridae: *Adelges* sp.[18]

97. *Oenopia signatella* (Mulsant) (=*Coccinella signatella* (Mulsant), *Harmonia signatella* Mulsant, *Synharmonia signatella* (Mulsant), *Coccinella (Synharmonia) signatella* (Mulsant))

Phylloxeridae: *Adelges* sp.[18]

98. *Palaeoneda auriculata* (Mulsant) (= *Coccinella miniata* Hope, Mulsant, *Palaeoneda miniata* ab. *auriculata* (Mulsant), *Neda auriculata* (Mulsant), *Neda miniata* (Hope), *Palaeoneda miniata* (Hope))

Phylloxeridae: *Adelges* sp.[18]

99. *Pharoscymnus flexibilis* (Mulsant) (=*Pharus flexibilis* (Mulsant), *Scymnus (Diomus) flexibilis* Mulsant)

Coccidae: *Chloropulvinaria polygonata* (Cockerell)[117]; Diaspididae: *Hemiberlesia lataniae* Signoret)[160], *Quadraspidiotus perniciosus* (Comstock)[17], *Parlatoria blanchardii* Targ.[160]; Pseudococcidae: *Rastrococcus iceryoides* (Green)[146]; *Pheonicoccus marlatti* (Cockerell)[160]

100. *Pharoscymnus flexibilis kashmirensis* Kapur

Aphididae: *Aphis craccivora* Koch[133], Diaspididae: *Quadraspidiotus perniciosus* (Comstock)[161]

101. *Pharoscymnus horni* (Weise) (=*Pharus horni* Weise)

Diaspididae: *Hemiberlesia lataniae* Signoret)[160], *Melanaspis glomerata* (Green)[34,76], *Parlatoria blanchardii* Targ.[160]; Pseudococcidae: *Rastro-*

coccus iceryoides (Green)[152], *Pheonicoccus marlatti* (Cockerell)[160]

102. *Platynaspis indicus* Devi, Singh & Singh

Aphididae: *Aphis spiraecola* Patch[32]

103. *Phrynocaria perrotteti* (Mulsant) (= *Anegleis* (*Pseudanegleis) perrotteti* (Mulsant), *Coelophora perrotteti* Mulsant)

Aleyrodidae: *Aleurolobus barodensis* (Maskell)[43]; Jassidae: hopper[17]

104. *Phrynocaria unicolor* (Fabricius) (= *Coccinella unicolor* Fabricius), *Lemnia (Microlemnia) unicolor* (Fabricius))

Aphididae: *Taoia indica* Ghosh and Raychaudhuri)[13,102]

105. *Platynaspidius bimaculata* (Pang and Mao) (=*Platynaspis bimaculata* Pang & Mao, *Platynaspis kapuri* Chakraborty & Biswas)

Aphididae: *Aphis spiraecola* Patch[8]

106. *Platynaspidius saundersi* (Crotch) (=*Platynaspis saundersi* Crotch)

Aphididae: *Aphis gossypii* Glover[8], *Aphis spiraecola* Patch[32]

107. *Priscibrumus uropygialis* (Mulsant) (= *Exochomus uropygialis* Mulsant, *Brumus uropygialis* (Mulsant), *Exochomus (Exochomus) uropygialis* (Mulsant))

Aphididae: *Aphis gossypii* Glover[8], *Brachycaudus helichrysi* (Kalt.)[104], *Myzus persicae* (Sulzer)[18]; Phylloxeridae: *Adelges* sp.[18]

108. *Propylea dissecta* (Mulsant) (= *Harmonia feliciae* Mulsant, *Lemnia (Vola) dissecta* Mulsant, *Lemnia dissecta* (Mulsant), *Lemnia mystacea* Mulsant, *Propylaea fallax* Yablokov-Khnzoryan, *Propylea japonica* ab. *dissecta* (Mulsant))

Aphididae: *Eriosoma lanigerum* (Hausmann)[2], *Rhopalosiphum maidis* (Fitch)[8]

109. *Propylea japonica* (Thunb.) (= *Coccinella japonica* Thunberg, *Coccinella tetraspilota* Hope, *Propylea quatuordecimpunctata japonica* Thunberg))

Aphididae: *Acyrthosiphon pisum* (Harris)[8], *Aphis craccivora* Koch[146], *Aphis gossypii* Glover[146], *Aphis nerii* Boyer d. Fonsc.[146], *Brevicoryne brassicae* (Linn.)[146], *Hyadaphis coriandri* (Das)[146], *Lipaphis erysimi* (Kalt.)[146], *Myzus persicae* (Sulzer)[8], *Rhopalosiphum padi* (Linn.)[8]

110. *Propylea luteopustulata* (Mulsant) (= *Anatis thibetina* Mulsant, *Caria thoracica* Weise, *Coelophora birmanica* Gorham, *Coelophora insularis* Sicard, *Coelophora korschefskyi* Mader, *Coelophora luteopustulata* (Mulsant), *Coelophora mariae* Mulsant, *Coelophora octopunctata* Iablokoff-Khnzorian, *Coelophora pedicata* Mulsant, *Coelophora victoriae* Mulsant, *Coelophora weisei* Miwa, *Oenopia (Pania) luteopustulata* Mulsant, *Oenopia hauseri* Mader, *Oenopia luteopustulata* var. *subpedicata* Kapur, *Oenopia luteopustulata* Korschefsky, *Oenopia pracuae* Weise, *Pania insularis* (Sicard), *Pania luteopustulata* (Mulsant), *Pania thoracica* (Weise), *Pania victoriae* (Mulsant))

Aphididae: *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[8], *Brachycaudus helichrysi* (Kalt.)[10], *Hyalopterus pruni* (Geoffroy)[59], *Lipaphis erysimi* (Kalt.)[8], *Macrosiphoniella sanborni* (Gill.)[8], *Macrosiphum rosae* (Linn.)[55], *Myzus persicae* (Sulzer)[8], *Rhopalosiphum maidis* (Fitch)[8], *Sitobion rosaeiformis* (Das)[55]

111. *Propylea quatuordecimpunctata* (Linn.) (= *Coccinella 14-punctata* Linnaeus)

Aphididae: *Acyrthosiphon pisum* (Harris)[2], *Aphis craccivora* Koch[152], *Aphis gossypii* Glover[152], *Lipaphis* *erysimi* (Kalt.)[152], *Myzus persicae* (Sulz.)[152]; *Schizaphis graminum* (Rondani)[2]; Oecophoridae, Lepidoptera: *Opisina arenosella* Walker[144]

112. *Pseudaspidimerus flaviceps* (Walker) (= *Aspidimerus horni* Weise, *Coccinella flaviceps* Walker, *Pseudaspidimerus flaviceps* var. *limbatus* Kapur, *Scymnus flaviceps* (Walker))

Aphididae: *Aphis craccivora* Koch[8], *Aphis spiraecola* Patch[8]

113. *Pseudaspidimerus trinotatus* Thunb. (= *Coccinella trinotata* Thunberg, *Platynaspis circumflexa* Motschulsky, *Pseudaspidimerus circumflexa* var. *testaceus* Weise, *Pseudaspidimerus circumflexa* (Motschulsky))

Aphididae: *Aphis craccivora* Koch[151,162,163], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[29], *Aphis nerii* Boyer de Fonsc.[1], *Aphis spiraecola* Patch[28,43], *Hysteroneura setariae* (Thomas)[1], *Lipaphis erysimi* (Kalt.)[8], *Melanaphis sacchari* (Zehntner)[162], *Pentalonia nigronervosa* Coq.[138], *Toxoptera aurantii* (Boyer de Fonsc.)[109], *Toxoptera odinae* (van der Goot)[138]; Diapspididae: *Aspidiotus destructor* Signoret[18,90]

114. *Pseudoscymnus dwipakalpa* Ghorpade

Diaspididae: *Aspidiotus destructor* Signoret[164]

115. *Pseudoscymnus pallidicollis* (Mulsant) (= *Scymnus pallidicollis* Mulsant, *Scymnus* (*Pullus*) *pallidicollis* Mulsant)

Pseudococcidae: *Planococcus citri* (Risso.)[18]

116. *Psyllobora bisoctonotata* (Mulsant) (= *Thea bisoctonotata* (Mulsant), *Vibidia bisoctonotata* Mulsant)

Aphididae: *Brevicoryne brassicae* (Linn.)[146], *Hyadaphis coriandri* (Das)[146], *Lipaphis erysimi* (Kalt.)[146]

117. *Rodolia amabilis* Kapur

Margarodidae: *Icerya aegyptiaca* (Douglas)[18], *Icerya purchasi* Maskell[18]

118. *Rodolia breviuscula* Weise

Margarodidae: *Icerya purchasi* Maskell[21], *Icerya seychellarum* Westwood[39]; Pseudococcidae: *Rastrococcus iceryoides* (Green)[146]

119. *Rodolia cardinalis* (Mulsant) (=*Vedalia cardinalis* Mulsant, *Novius cardinalis* (Mulsant), *Eurodolia cardinalis* (Mulsant), *Rodolia* (*Macronovius*) *cardinalis* (Mulsant), *Macronovius cardinalis* (Mulsant)

Aphididae: *Eriosoma lanigerum* (Hausmann)[18]

120. *Rodolia fumida* Mulsant

Margarodidae: *Icerya pilosa* Green[143,165], *Icerya* sp.[18]

121. *Rodolia netara* Kapur

Margarodidae: *Icerya purchasi* Maskell[21]

122. *Rodolia ruficollis* Mulsant

Aphididae: *Brevicoryne brassicae* (L.)[146], *Lipaphis erysimi* (Kalt.)[146]

123. *Scymnus* (*Neopullus*) *fuscatus* Boheman (= *Pullus brunnescens* ab. *fuscatus* Weise, *Scymnus* (*Pullus*) *fuscatus* Boheman, *Scymnus (Scymnus) fuscatus* Boheman, *Scymnus brunnescens* Motschulsky, *Scymnus picescens* Gorham)

Aphididae: *Greenidea psidii* van der Goot[10], *Rhopalosiphum nymphaeae* (Linn.)[29,129]

124. *Scymnus (Pullus) castaneus* Sicard

Aphididae: *Aphis craccivora* Koch[8], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[16], *Aphis nerii* Boyer de Fonsc.[129,166], *Aphis punicae* Passerini[167], *Dactynotus compositae* Theobald[37], *Melanaphis sacchari* (Zehntneri)[8], *Rhopalosiphum maidis* (Fitch.)[129,166], *Schoutedenia emblica* (Patel & Kulkarni)[8]

125. *Scymnus* (*Pullus*) *coccivora* Ayyar (= *Pullus coccidivora* Chelliah, *Scymnus (Pullus) elegans* Sicard, *Scymnus (Pullus) elegans* var.

clathratus Sicard)

Aphididae: *Aphis punicae* Passerini[8], Coccidae: *Pulvinaria* sp.[39]; Pseudococcidae: *Maconellicoccus hirsutus* (Green.)[168], *Pseudococcus* sp.[39], *Rastrococcus iceryoides* (Green)[147]

126. *Scymnus (Pullus) giganteus* Kamiya

Aphididae: *Aphis gossypii* Glover[13], *Taoia indica* Ghosh and Raychaudhuri)[13]

127. *Scymnus (Pullus) gracills* Motschulsky

Aphididae: *Aphis pomi* de Geer[5,7], *Hyalopterus pruni* (Geoff.)[5,7], *Myzus persicae* (Sulz.)[88]

128. *Scymnus (Pullus) hilaris* Motschulsky

Aphididae: *Aphis gossypii* Glover[13,59] , *Greenidea psidii* van der Goot[13,59]

129. *Scymnus (Pullus) impexus* (Mulsant) (=*Pullus impexus* Mulsant)

Aphididae: Unidentified aphids[169]

130. *Scymnus (Pullus) latemaculatus* Motschulsky (=*Nephus quadrillum* Iablokoff-Khnzorian, *Pullus taiwanus* Ohta, *Scymnus transversoplagiatus* Motschulsky, *Scymnus (Pullus) taiwanus* Ohta)

Aphididae: *Aphis craccivora* Koch[134], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover8, *Aphis nerii* Boyer de Fonsc.8, *Aphis punicae* Passerini167, *Aphis spiraecola* Patch[8], *Myzus persicae* (Sulzer)[8], *Pentalonia nigronervosa* Coquerel[8], *Rhopalosiphum maidis* (Fitch)[8]

131. *Scymnus (Pullus) nymphaeus* (Kapur & Munshi) (=*Pullus nymphaeus* Kapur & Munshi)

Aphididae: *Rhopalosiphum nymphaeae* (Linn.)[170]

132. *Scymnus (Pullus) posticalis* Sicard (= *Scymnus (Nephus) inops* Smirnoff, *Scymnus (Scymnus) ishidai, Scymnus (Pullus) sodalis* (Weise),*Pullus sodalis* Weise)

Aphididae : *Brachycaudus helichrysi* (Kalt.)[8]

133. *Scymnus (Pullus) pyrocheilus* Mulsant (=*Scymnus pyrocheilus* Mulsant, *Pulus pyrochilus* – miss spelled[150a])

Aphididae: *Aphis craccivora* Koch[35], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[53], *Aphis spiraecola* Patch[53], *Capitophorus formosartemisiae* (Takahashi)[35,53], *Lipaphis erysimi* (Kalt.)[62], *Macrosiphoniella sanborni* (Gillette)[62], *Myzus persicae* (Sulzer)[9,147], *Pentalonia nigronervosa* Coquerel[8], *Sitobion rosaeiformis* (Das)[53,62], *Toxoptera aurantii* (Boyer de Fonsc.)[109]

134. *Scymnus (Pullus) quadrillum* Motsch.

Aphididae: *Aphis craccivora* Koch[171], *Aphis gossypii* Glover[29], *Aphis nerii* Boyer de Fonsc.[28], *Aphis rumicis* Linn.[133], *Myzus persicae* (Sulz.)[28], *Rhopalosiphum maidis* (Fitch.)[1,28]

135. *Scymnus (Pullus) sapporensis* (Ohta) (= *Pullus sapporensis* Ohta)

Aphididae: Unidentified aphid[10]

136. *Scymnus (Pullus) victoris* Crotch (= *Pullus victoris* var. *obsignatus* Weise, *Scymnus limbatus* Motschulsky)

Aphididae: *Aphis nerii* Boyer de Fonsc.[129]

137. *Scymnus (Pullus) xerampelinus* Mulsant

Aleyrodidae: *Bemisia tabaci* (Genn.)[31], *Phenacoccus insolitus* Green[39]; Aphididae: *Aphis craccivora* Koch[39], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[29], *Aphis nerii* Boyer de Fonsc.[1,39], *Brevicoryne brassicae* (Linn.)[1], *Lipaphis erysimi* (Kalt.)[1], *Sitobion graminis* Takahashi[1], *Toxoptera aurantii* (Boyer de Fonsc.)[8]

138. *Scymnus (Pullus) zonatus* Sicard (=*Pullus zonatus* Sicard)

Pseudococcidae: *Pseudoregma bambusicola* (Takahashi)[1]

139. *Scymnus (Scymnus) apiciflavus* (Motschulsky) (= *Diomus apiciflavus* Motschulsky, *Scymnus (Scymnus) andamanensis* Kapur)

Aphididae: Unidentified aphid[18]

140. *Scymnus (Scymnus) nubilus* Mulsant (= *Scymnus curtisii* Mulsant, *Scymnus lateralis* Sicard, *Scymnus stabilis* Motschulsky, *Scymnus suturalis* Motschulsky)

Aleyrodidae: *Aleurolobus barodensis* (Maskell)[172]; Aphididae: *Aphis craccivora* Koch[34,39], *Aphis fabae* Scopoli[8], *Aphis gossypii* Glover[39], *Aphis nerii* Boyer de Fonsc.[166], *Pentalonia nigronervosa* Coq.[138], *Rhopalosiphum nymphaeae* (L.)[8], *Therioaphis trifolii* (Monell)[8], *Toxoptera odinae* (van der Goot)[138], *Uroleucon compositae* (Theobald)[88]; Phylloxeridae: *Adelges* sp.[4]; Pseudococcidae: *Maconellicoccus hirsutus* (Green.)[173]

141. *Serangium montazerii* Fürsch

Citrus scale insects[152]

142. *Serangium parcesetosum* Sicard (= *Catana parcesetosa* (Sicard)

Aleyrodidae: *Aleurodicus disperses* Russel[21], *Bemisia tabaci* (Genn.)[17,174]; Aphididae: *Aphis craccivora* Koch[175], *Aphis gossypii* Glover[175]

143. *Stethorus gilvifrons* (Mulsant) (=*Scymnus gilvifrons* Mulsant)

Aphididae: *Toxoptera aurantii* (B. De Fonsc.)[176]; Tetranychidae, Acari: *Oligonychus coffeae* (Niet.)[18]

144. *Stethorus keralicus* Kapur

Tenuipalpidae, Acari: *Raoiella indica* Hirst[177]

145. *Stethorus pauperculus* (Weise) (=*Scymnus* (*Stethorus*) *pauperculus* Weise)

Tetranychidae, Acari: *Paratetranychus indicus* Hirst[39], *Tetranychus cinnabarinus* (Boisd.)[21,177]; Tenuipalpidae: *Raoiella indica* Hirst[178]

146. *Sticholotis binotata* (Gorham) (=*Clanis binotata* Gorham, *Jauravia binotata* (Gorham))

Aphididae : *Brachycaudus helichrysi* (Kalt.)[29], *Hyalopterus pruni* (Geoffroy)[29]

147. *Sticholotis ruficeps* Weise (= *Sticholotis madagassa* Weise)[179]

Diaspididae: *Aonidiella aurantii* (Maskell)[180], *Aonidomytilus albus* (Cookerell)[180], *Aspidiotus destructor* Signoret[180], *Aulacaspis tubercularis* Newstead[180], *Chrysomphalus aonidum* (L.)[180], *Hemiberlesia lataniae* (Signoret)[180], *Lepidosaphes cornutus* Green[180], *Melanaspis glomerata* (Green)[181,182], *Quadraspidiotus perniciosus* (Comstock)[180]

148. *Sticholotis marginalis* Kapur

Aphididae: *Eriosoma lanigerum* (Haus.)[161]; Diaspididae: *Quadraspidiotus perniciosus* (Comstock)[161]

149. *Stictobura pallideguttata* (Mulsant) (=*Calvia? pallideguttata* Mulsant)

Diaspididae: Scale insects, mealy bugs[18]

150. *Synona melanaria* (Mulsant) (= *Synia melanaria* Mulsant)

Aphididae: *Brevicoryne brassicae* (Linn.)[18]; Pentatomidae: *Coptosoma ostensum* Distant[183]

151. *Synonycha grandis* (Thunb.) (= *Coccinella grandis* Thunberg)

Aphididae: *Aphis gossypii* Glover[37], *Astegopteryx bambusae* (Buckton)[1], *Ceratovacuna) lanigera* Zehntner[39], *Ceratovacuna silvestrii* (Takah.)[1], *Pseudoregma alexanderi* (Tak.)[1], *Pseudoregma bambusicola* (Tak.)[1,39]

List of coccinellid predators without prey record

1. *Aspidimerus spencei* Mulsant
2. *Brumoides lineatus* (Weise) (=*Brumus lineatus* Weise, *Brumus lineatus* var. *ruficollis* Weise)
3. *Bulaea lichatschovi* (Hummel) (=*Coccinella lichatschovii* Hummel, *Bulaea bocandei* Mulsant, *Bulaea flavidula* Mulsant)
4. *Buprestodera inornata* Miyatake
5. *Buprestodera mimetica* Sicard
6. *Calvia albida* Bielawski
7. *Calvia andrewesi* (Weise) (= *Anisocalvia andrewesi* Weise)
8. *Calvia breiti* Mader
9. *Calvia flaveola* Booth
10. *Calvia monosha* Bielawski
11. *Calvia quindecimguttata* (Fabricius) (=*Coccinella quindecimguttata* Fabricius, *Calvia bis-7-guttata*: Mulsant, *Anisocalvia quindecimguttata*: Sasaji, *Eocaria quindecimguttata* (Fabr.), *Calvia (Anisocalvia) quindecimguttata* (Fabr.))
12. *Calvia shiva* Kapur
13. *Calvia vulnerata* (Hope) (=*Coccinella vulnerata* Hope, *Coccinella uniramosa* Hope, *Calvia flaccida* Mulsant, *Anisocalvia vishnu* Crotch, *Anisocalvia krishna* Crotch, *Anisocalvia buddha* Crotch)
14. *Chilocorus subindicus* Booth
15. *Chilocorus matsumurai* Miyatake
16. *Chilocorus melanophthalmus* Mulsant
17. *Chilocorus melas* Weise (=*Chilocorus gressitti* Miyatake)
18. *Clitostethus fumatus* (Sicard) (= *Scymnus (Clitostethus) fumatus* Sicard)
19. *Coccinella lama* Kapur
20. *Coccinella luteopicta* (Mulsant) (= *Adalia luteopicta* Mulsant, *Lioadalia luteopicta* (Mulsant))
21. *Coccinella magnopunctata* Rybakow (= *Coccinella undecimpunctata magnopunctata* Rybakow)
22. *Coccinella marussi* Kapur
23. *Coccinella nigrovittata* Kapur (= *Micraspis trilineata* Weise), *Tytthaspis trilineata* (Weise))
24. *Coccinella saucerottei* Muls. (=*Coccinella tibetina* Kapur)
25. *Coccinella undecimpunctata aegyptiaca* Reiche
26. *Coccinella undecimpunctata aegyptiaca* Reiche
27. *Coelophora 9-maculata* (Mulsant)[184]
28. *Coelophora bowringii* Crotch
29. *Coelophora circumusta* (Muls.) (= *Artemis circumusta* Mulsant, *Lemnia (Artemis) circumusta* (Muls.), *Coelophora westermanni* Mulsant)
30. *Coelophora decemgutta* Weise
31. *Coelophora duvaucelii* (Muls.) (= *Caria duvauceli* Mulsant, *Cyphocaria duvaucelii* (Mulsant), *Lemnia (Artemis) duvaucelii* (Mulsant), *Alloneda novemmaculata* Cao & Pu)
32. *Coelophora nitidicollis* Kapur
33. *Coelophora ramosa* (Oliv.)[185]
34. *Cryptogonus bilineatus* Kapur
35. *Cryptogonus himalayensis* Kapur
36. *Cryptogonus hingstoni* Kapur
37. *Cryptogonus lepidus* (Weise) (= *Aspidimerus lepidus* Weise)
38. *Cryptogonus loebli* Canepari
39. *Cycloneda* sp.
40. *Eoadalia juliae* (Muls.) (= *Harmonia juliae* Mulsant, *Coccinella juliae* (Mulsant)

41. *Exochomus pubescens* Küster (=*Exochomus* (*Parexochomus*) *pubescens* Küster)
42. *Exochomus quadripustulata* (Linn.) (=*Coccinella quadripustulata* Linn.)
43. *Ghanius schawalleri* Canepari
44. *Halyzia feae* Gorham (=*Verania feae* (Gorham))
45. *Halyzia straminea* (Hope) (= *Coccinella straminea* Hope)
46. *Halyzia tschitscherini* Semenow
47. *Harmonia dunlopi* (Crotch) (=*Leis dunlopi* Crotch)
48. *Hippodamia glacialis* (F.)
49. *Hippodamia heydeni* (Weise) (= *Semiadalia heydeni* Weise, *Hippodamia (Asemiadalia) heydeni* (Weise), *Semiadalia andrewesi* Sicard)
50. *Illeis confusa* Timb.
51. *Illeis indica* Timb.
52. *Illeis kapuri* Anand *et al.*
53. *Illeis koebelei* Timb.
54. *Jauravia dorsalis* (Weise) (=*Clanis dorsalis* Weise)
55. *Jauravia indica* Kapur
56. *Jauravia kanarensis* Kapur
57. *Jauravia limbata* Mols. (=*Clanis limbata* (Motschulsky), *Paraclitostethus ovatus* ab. *kokuronis* Ohta, *Paraclitostethus ovatus* Ohta, *Sticholotis limbata* (Motschulsky))
58. *Jauravia pilosula* (Weise) (=*Clanis pilosula* Weise)
59. *Macroilleis hauseri* (Mader) (= *Halyzia hauseri* Mader)
60. *Megalocaria pearsoni* Crotch (=*Anisolemnia pearsoni* (Crotch)
61. *Micraspis guerini* (Muls.) (= *Alesia guerini* Mulsant)
62. *Micraspis yasumatsui* Sasaji
63. *Microsaerangium laterale* (Mots.) (= *Oeneis laterale* Motschulsky, *Oeneis lateralis* (Motschulsky), *Crytogratha laterale* (Motschulsky), *Serangium laterale* (Motschulsky))
64. *Microserangium brunneonigrum* Poorani
65. *Nephus bistillatus* (Mulstant) (=*Scymnus* (*Nephus*) *bistillatus* Mulsant
66. *Nephus lentiformis* (Booth) (= *Aponephus lentiformis* Booth)
67. *Nephus patruus* Weise (=*Scymnus (Nephus) patruus* (Weise)
68. *Nephus severini* (Weise) (= *Scymnus (Nephus) severini* Weise)
69. *Oenopia diabolica* Canepari
70. *Oenopia smetanai* Canecpari
71. *Oenopia walteri* (Sicard) (= *Coelophora walteri* Sicard)
72. *Oridia pubescens* Gorham
73. *Ortalia chlorops* Gorham
74. *Ortalia discoidea* Weise
75. *Ortalia horni* Weise (= *Ortalia yunnanensis* Pang & Mao)
76. *Ortalia maeklini* Mulsant
77. *Ortalia pectoralis* Weise
78. *Ortalia pusulla* Weise
79. *Ortalia quadripunctata* Gorham
80. *Parajauravia testivestis* (Mulsant) (= *Pentilia testivestis* Motschulsky)
81. *Paraplotina flavomaculata* Miyatake
82. *Phaenochilus flaviceps* Miyatake
83. *Phaenochilus indicus* Miyatake
84. *Phaenochilus lituratus* (Gorham) (=*Exochomus lituratus* Gorham, *Priscibrumus lituratus* (Kapur)
85. *Phaenochilus trijunctus* (Kapur) (=*Exochomus trijunctus* Kapur, *Priscibrumus trijunctus* (Kapur)

86. *Phaenochilus trubetzkoi* (Barovsky) (=*Exochomus trubetzkoi* Barovsky, *Priscibrumus trubetzkoi* (Barovsky)

87. *Phaenochilus uropygialis* (Mulsant) (=*Exochomus uropygialis* Mulsant, *Brumus uropygialis* (Mulsant), *Exochomus (Exochomus) uropygialis* (Mulsant), *Priscibrumus uropygialis* (Mulsant))

88. *Phrynocaria congener* (Billberg) (= *Coccinella congener* Billberg, *Coelophora congener* (Billberg), *Lemnia congener* (Billberg))

89. *Phrynocaria funebris* (Crotch.) (= *Coelophora funebris* Crotch)

90. *Phrynocaria vidua* Muls. (= *Coelophora vidua* Mulsant, *Lemnia (Microlemnia) vidua* (Mulsant))

91. *Phymatosternus lewisi* (Crotch) (=*Platynaspis lewisii* Lewis, *Platynaspis lewisi* Crotch, *Platynaspis lewisi* var. *obscura* Sicard)

92. *Platynaspis flavoguttata* (Gorham) (= *Scymnus flavoguttata* Gorham, *Pharus flavoguttata* (Gorham)

93. *Platynaspis trimaculata* Weise

94. *Priscibrumus disjunctus* Canepari

95. *Priscibrumus lituratus* (Gorham)

96. *Priscibrumus trijunctus* (Kapur) (=*Exochomus trijunctus* Kapur)

97. *Priscibrumus trubetzkoi* (Barovsky) (=*Exochomus trubetzkoi* Barovsky)

98. *Promecopharus andrewesi* Sicard (=*Promecopharus andrewesi* var. *ancoralis* Sicard)

99. *Protoplotina nigrosuturalis* Poorani[186]

100. *Protothea quadripunctata* (Muls.) (= *Thea quadripunctata* Mulsant, *Protothea indica* Weise)[187]

101. *Pseudaspidimerus infuscatus* Poorani

102. *Pseudaspidimerus lambai* Kapur

103. *Pseudaspidimerus mauliki* Kapur

104. *Pseudaspidimerus uttami* Kapur

105. *Pseudoscymnus funerarius* Canepari

106. *Pseudoscymnus luteus* (Sicard) (=*Scymnus (Nephus) luteus* Sicard)

107. *Pseudoscymnus murreensis* Ahmad

108. *Pseudoscymnus simmondsi* Chapin & Ahmad

109. *Rodolia andamanica* Weise

110. *Rodolia fulvescens* Hoang

111. *Rodolia minima* Kapur

112. *Rodolia nigrofrontalis* Kapur

113. *Rodolia octoguttata* Weise

114. *Rodolia sexnotata* (Muls.) (=*Epilachna sexnotata* Mulsant, *Vedalia guerinii* Crotch, *Rodolia guerinii* (Crotch), *Rodolia immsi* Weise, *Rodolia 6-maculata* Korschefsky)

115. *Scotoscymnus popei* (Vazirani) (= *Sukunahikona popei* Vazirani)

116. *Scymnus (Neopullus) hoffmanni* Weise

117. *Scymnus (Neopullus) loebli* Canepari

118. *Scymnus* (*Pullus*) *assamensis* Canepari

119. *Scymnus* (*Pullus*) *bengalicus* Canepari

120. *Scymnus* (*Pullus*) *besucheti* Canepari

121. *Scymnus* (*Pullus*) *bourdilloni* (Kapur) (= *Pullus bourdilloni* Kapur)

122. *Scymnus (Pullus) ceylonicus* Motschulsky (=*Scymnus nitidulus* Motschulsky, *Scymnus uniformis* Motschulsky)

123. *Scymnus* (*Pullus*) *facetus* Canepari

124. *Scymnus (Pullus) godavariensis* Miyatake

125. *Scymnus (Pullus) harejoides* (Sicard) (= *Pullus harejoides* Sicard)

126. *Scymnus (Pullus) hingstoni* (Kapur) (=*Pullus hingstoni* Kapur)

127. *Scymnus (Pullus) kawamurai* (Ohta) (= *Pullus kawamurai* Ohta, *Scymnus* (*Pullus*) *kamiyai* Araki)
128. *Scymnus (Pullus) meghalayae* Canepari
129. *Scymnus (Pullus) nepalensis* Bielaw.
130. *Scymnus (Pullus) o-nigrum* Muls.
131. *Scymnus (Pullus) saciformis* Mots.
132. *Scymnus (Pullus) sodalis* (Weise) (=*Pullus sodalis* Weise)
133. *Scymnus (Pullus) testacecollis* (Kapur) (= *Pullus testacecollis* Kapur)
134. *Scymnus (Pullus) uninotata* (Gorham) (= *Clanis? uninotata* Gorham)
135. *Scymnus (Pullus) victoris unimaculata* Korsch.
136. *Scymnus (Scymnus) andrewesi* Sicard
137. *Scymnus (Scymnus) indicus* Weise
138. *Scymnus (Scymnus) lepidulus* Mots.
139. *Scymnus* (*Scymnus*) *levaillanti* (Mulsant) (= *Nephus levaillanti* Mulsant)
140. *Scymnus (Scymnus) tristigmaticus* Gorham
141. *Scymnus (Scymnus) venalis* Mulsant
142. *Scymnus seriatus* Weise
143. *Serangium serratum* Poorani
144. *Simmondsius pakistanensis* Ahmad & Ghani
145. *Stethorus guangxiensis* Pang & Mao
146. *Stethorus indira* Kapur
147. *Stethorus parcepunctatus* Kapur
148. *Stethorus rani* Kapur
149. *Sticholotis amator* Kapur
150. *Sticholotis besucheti* Canepari
151. *Sticholotis bilineata* Weise
152. *Sticholotis cribellata* Sicard
153. *Sticholotis decempunctata* Sicard
154. *Sticholotis decora* Weise
155. *Sticholotis discoidea* (Gorham) (= *Orcus discoideus* Gorham)
156. *Sticholotis duodecimpunctatus* Weise
157. *Sticholotis exsanguis* Sicard
158. *Sticholotis ferruginea* (Gorham) (= *Orcus? ferrugineus* Gorham)
159. *Sticholotis honesta* Weise
160. *Sticholotis marginalis* Kapur
161. *Sticholotis minuta* (Thunb.) (=*Coccinella minuta* Thunberg)
162. *Sticholotis nilgiriensis* Weise
163. *Sticholotis obscurella* Weise
164. *Sticholotis obscurocincta* Sicard
165. *Sticholotis quadrisignata* Weise
166. *Sticholotis rugicollis* Korschefsky (=*Sticholotis quadrisignata rugicollis* Korschefsky)[188]
167. *Sticholotis sanguinolenta* (Mots.) (=*Chilocorus sanguinolentus* Mots.)
168. *Sticholotis sanguinosa* (Mots.) (=*Chilocorus sanguinosus* Mots.)
169. *Sticholotis sexpunctata* Sicard
170. *Sticholotis substriata* Crotch
171. *Sticholotis transversa* (Motschulsky) (= *Chilocorus transversus* Motsch.)
172. *Sticholotis tredecimmaculata* Weise
173. *Stictobura gibbula* (Weise) (=*Sticholotis (Apterolotis) gibbula* Weise)
174. *Stictobura melanaria* (Weise) (=*Sticholotis melanaria* Weise)
175. *Stictobura rubroguttata* Sicard
176. *Stictobura semipolita* Sicard
177. *Sumnius cardoni* Weise
178. *Sumnius haematica* (Gorham) (= *Aulis haematica* Gorham)

179. *Sumnius notivestis* (Muls.) (=*Aulis notivestis* Mulsant)

180. *Sumnius vestita* (Mulsant) (=*Aulis vestita* Mulsant, *Sumnius renardi* Weise)

181. *Synona martini* (Iablokoff-khnzorian) (= *Lemnia* (*Synia*) *martini* Iablokoff-Khnzorian)

182. *Synona rougeti* (Mulsant) (= *Leis rougeti* Mulsant, *Synia melanaria* ab. *rougeti* Mulsant)

183. *Synonychimorpha immaculata* Poorani[189]

184. *Synonychimorpha chittagongi* (Vazirani) (=*Sticholotis chittagongi* Vazirani, *Sticholotis rufolimbata* Canepari)

185. *Synonychimorpha immaculata* Poorani

186. *Telsimia bangalorensis* Kapur

187. *Telsimia bicolor* Kapur

188. *Telsimia ceylonica* (Weise) (=*Platy-naspis ceylonica* Weise)

189. *Telsimia darjeelingensis* Kapur

190. *Telsimia flavomaculata* Poorani

191. *Telsimia humidiphila* Kapur

192. *Telsimia martis* (Muls.) (=*Scymnus martis* Mulsant, *Scymnus (Nephus) martis* (Mulsant)

193. *Telsimia postocula* Kapur

194. *Tetrabrachys gandhara* Kapur

195. *Tetrabrachys robusta* Kapur

196. *Vibidia korschefskii* (Mader) (= *Halyzia korschefskii* Mader)

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SEASONAL HISTORY OF *SITOBION MISCANTHI* (TAKAHASHI) (HOMOPTERA : APHIDIDAE) IN TERAI OF EASTERN UTTAR PRADESH

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Abstract : Seasonal history of wheat aphid *Sitobion miscanthi* (Takahashi) (Homoptera : Aphididae) was studied in terai of eastern Uttar Pradesh during two consecutive years, 2007 and 2008. The wheat aphid first appears during the last week of January and established well till the second or third week of April during both the years. Both the years the peak population reached during second week of March (2007: 70.0 aphids/ earhead, 2008: 81.5 aphids/earhead). No correlation exist between minimum and maximum temperature and relative humidity and the density of aphids. Following predators of *S. miscanthi* were recorded : spider (not identified), coccinellids (*Cheilomenes sexmaculata* (Fabr.), *Coccinella septempunctata* Linn., and *C. transversalis* Fabr.) (Coleoptera : Coccinellidae) both grubs and adults; and hover flies (*Episyrphus balteatus* (de Geer), *Ischiodon scutellaris* (Fabr.)) (Diptera : Syrphidae) and green lacewing (*Chrysoperla carnea carnea* (Stephens) (Neuroptera : Chrysopidae). Among the natural enemies, coccinellids were dominant group. Only one parasitoid, *Aphidius uzbekistanicus* (Luzh.) (Hymenoptera : Braconidae, Aphidiinae) was observed parasitising *S. miscanthi.*

Key words : Wheat aphid, *Sitobion miscanthi*, seasonal history, predators.

INTRODUCTION

Knowledge of the seasonal history of an insect is very important because its population biology is a result of the interaction between individuals of the species and their habitat (Southwood, 1978). It allows a better understanding of the relationship between an insect and its environment, and provides basic information for interpreting spatial dynamics, designing efficient sampling programmes for population estimation and pest management, and the development of population models (Croft and Hoyt, 1983).

Wheat is the dominant grain of world commerce and is the staple food of millions of people. Only rice challenges wheat for the title of most important food grain in the world. The world wheat market is enormous. The production of wheat is so widespread that it is being harvested somewhere in the world in any given month. Currently, India is second largest producer of wheat in the world after China with about 12% share in total world wheat production. In northeastern Uttar Pradesh, the major constraint of wheat production is the attack of aphids during the earhead stage. *Sitobion miscanthi* (Takahashi) is one of the major pest of wheat and barley in this area. However, very little is known about the seasonal history of *S. miscanthi* in terai of eastern Uttar Pradesh. As such, the objective of the present study was to observe the seasonal history of *S. miscanthi* and to correlate it with biotic and abiotic factors.

MATERIAL AND METHODS

The study was undertaken during January to April of 2007 and 2008 at the wheat (*Triticum aestivum* L.) fields near Kusumhi, about 10 kilometre east from Gorakhpur city. Observations on the weekly build up of aphids were recorded.

The crop was raised by the farmers themselves and was observed that all the recommended package of practice are followed.

Aphid population was determined by adopting the method of Church and Strickland (1954) with some modification, *i.e.*, weekly samples from 10 randomly selected plants were taken using random row, plant and earhead to determine aphid density per earhead. When the population of aphid was low, the count was made directly on earhead in situ. However, when the aphid density was high, samples earhead were put in polythene bags separately. The aphid were anaesthetised by using benzene and removed on to a white paper with the help of brush and mean aphid population per earhead was worked out.

RESULTS AND DISCUSSION

During 2007, the incidence of *S. miscanthi* was first recorded during last week of January (5.9 aphids/earhead : apterae – 0, alatae – 0.5, nymphs – 5.4) (Fig. 1) at a mean maximum temperature of 25.8 °C, minimum temperature 11.5 °C, maximum relative humidity 83.3 per cent and minimum relative humidity 55.1 per cent. Thereafter, the population of wheat aphid builds up and reached a peak during second week of March, 2007 (70.0 aphids/ earhead : apterae – 5.0, alatae – 4.8, nymphs – 60.2) at corresponding mean maximum temperature of 27.2 °C, minimum temperature 14.4 °C, maximum relative humidity 78.3 per cent and minimum relative humidity 44.6 per cent. Thereafter, the minimum and maximum relative humidity decreased up to first week of April, 2007 (Fig. 1A) and the crop began to mature. These situations are unfavourable for aphid growth and hence its population decreased so that it remains only less than half of the peak population on April 3, 2007 (30.5 aphids/earhead : apterae – 3.9, alatae – 5.4, nymphs – 21.2) mean maximum temperature of 37.94 °C, minimum temperature 20.1°C, maximum relative humidity 61.7 per cent and minimum relative humidity 19.7 per cent (Fig. 1A). The high temperature and low humidity in the month of April and the maturation of the crop leads to end of the population after third week of the april after which the crop is harvested.

Following predators of *S. miscanthi* were recorded : spider (not identified), coccinellids (*Cheilomenes sexmaculata* (Fabr.), *Coccinella septempunctata* Linn., and *C. transversalis* Fabr.) (Coleoptera : Coccinellidae) both grubs and adults; and hover flies [*Episyrphus balteatus* (de Geer), *Ischiodon scutellaris* (Fabr.)] (Diptera : Syrphidae) and green lacewing (*Chrysoperla carnea carnea* (Stephens) (Neuroptera : Chrysopidae). Among the natural enemies, coccinellids were dominant group. Their population was very poor up to third week of February, when less than 1.0 predator of any species was observed. They attain a mean value of 2.0-6.0 per earhead only after third week of March to third week of April. (Fig. 1). Because of their predatory activity and low humidity, the aphid population remained low during this period.

As far as parasitoids are concerned, only one parasitoid *Aphidius uzbekistanicus*

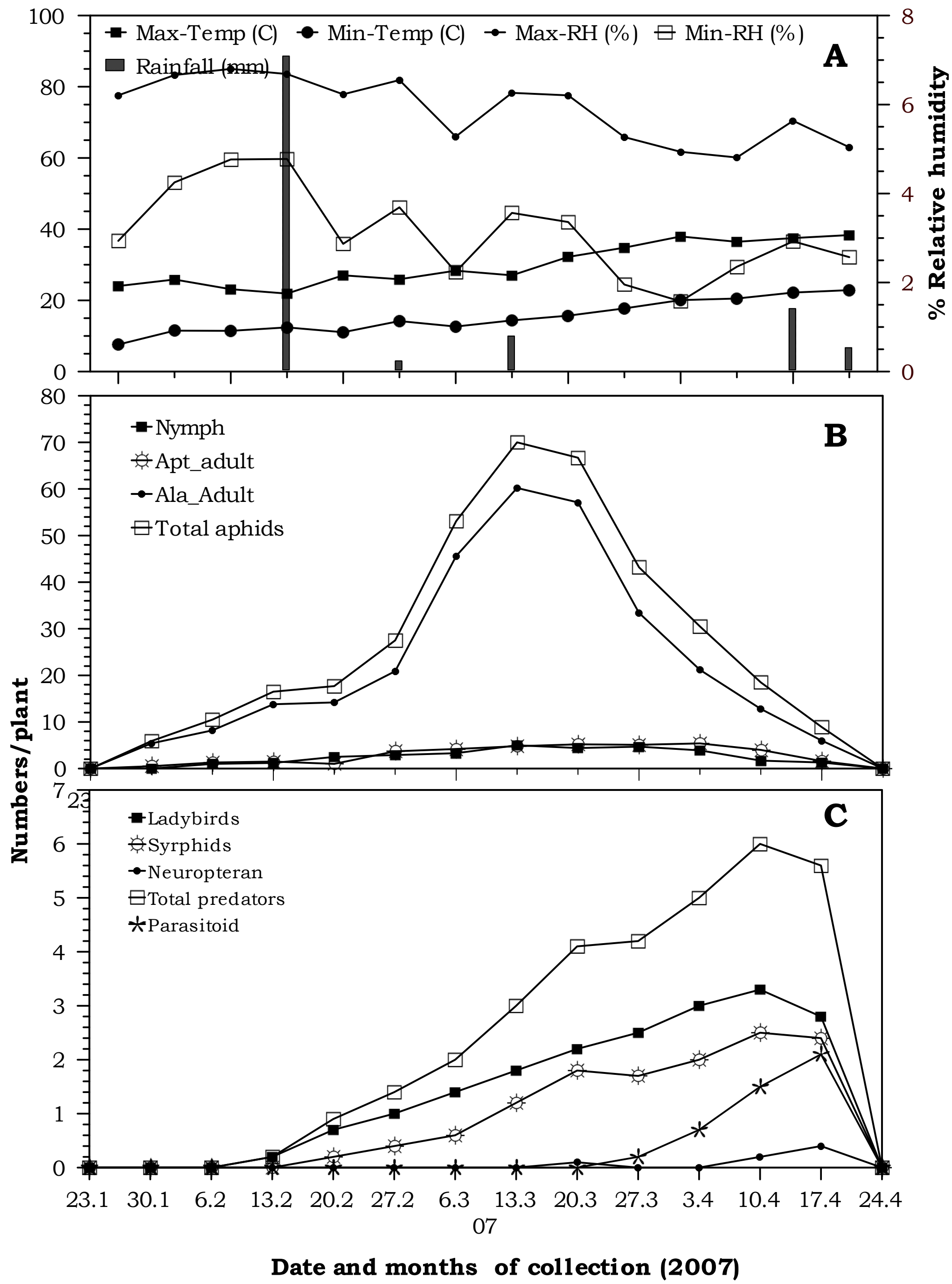

Fig. 1. Seasonal population build-up of *S. miscanthi* (B) and its natural enemies (C) on *T. aestivum* during 2007 at prevailing climatic conditions (A).

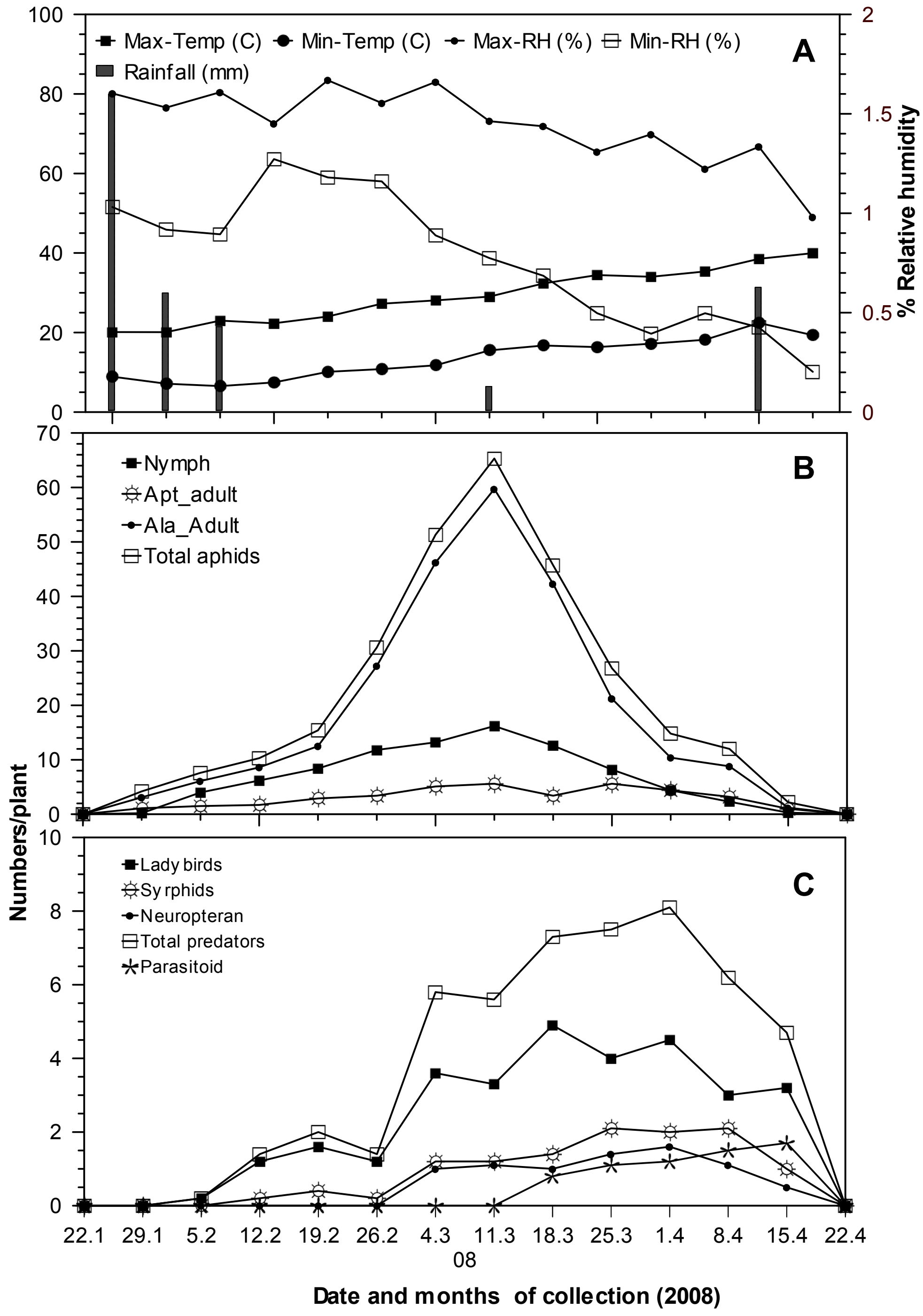

Fig. 2. Seasonal population build-up of *S. miscanthi* (B) and its natural enemies (C) on *T. aestivum* during 2008 at prevailing climatic conditions (A).

Luzhetzki (Hymenoptera : Braconidae : Aphidiinae) was observed only during April month with very low population. During the crop season, rainfall was not observed up to first week of February. During the second week the rainfall was only 7.1 mm. Because of this humidity increased and the aphid attained peak thereafter.

During 2008, the incidence of *S. miscanthi* was higher than that of the previous year. The aphid was first recorded on 29 January, 2008, like the previous year (4.4 aphids/earhead : apterae – 0.2, alatae – 1.1, nymphs – 3.1) (Fig. 2) at a mean maximum temperature of 20.1 °C, minimum temperature 7.1 °C, maximum relative humidity 76.6 per cent and minimum relative humidity 45.9 per cent. Thereafter, the population of the aphid builds up gradually and reached a peak during second week of March, 2008 (81.5 aphids/earhead : apterae – 16.2, alatae – 5.6, nymphs – 59.7) at corresponding mean maximum temperature of 29.0 °C, minimum temperature 15.5 °C, maximum relative humidity 73.1 per cent and minimum relative humidity 38.7 per cent. During this week 0.13 mm rainfall was recorded. Simultaneously, the crop began to end and the population of predators (species as mentioned before) increased. These two factors seem to cause a decrease in the aphid population and it remains only (19.2 aphids/earhead : apterae – 4.4, alatae – 4.4, nymphs – 10.4) on April 1, 2008 at mean maximum temperature of 34.0 °C, minimum temperature 17.2 °C, maximum relative humidity 69.9 per cent and minimum relative humidity 19.7 per cent (Fig. 2). The aphid population almost disappeared after second week of April as the crop was ready to harvest.

The predator arrived after the colonization of the aphid in the fields. Their population gradually builds up with the aphid population upto 8.1 predators/ earhead during first week of April (Fig. 2). Because of their predatory activity and low humidity, the aphid population decreased thereafter. During this year also, the extent of parasitism of the aphid was very poor and only few mummies having the parasitoid, *A. uzbekistanicus* were obaserved.

The rainfall was very poor during these months and less than 1.0 mm rainfall was observed during February to April, 2008. Because of this the maximum relative humidity remained around 70-80 % RH and minimum relative humidity remained around 20-50% RH.

The month of March during both the year was observed for higher growth of the *S. miscanthi* when maximum and minimum temperature ranged between 22-35 °C and 10-17 °C, respectively. Turak *et al.* (1998) have observed that *S. miscanthi* showed evidence of adaptation to warmer conditions.

No correlation between temperature and humidity and aphid population was observed during both the years as the build-up of the aphid population depends upon various other factors including crop health and natural enemies.

No field study was carried out in India regarding the seasonal changes of *S. miscanthi* on wheat. The response of the population growth with temperature/RH varied in aphids. However, for most of the aphid species, the temperature range 20-30 ºC was observed to be optimal when RH ranged between 70-90%. Debaraj *et al.* (1994) also reported in case of another aphid, the cabbage aphid (*Brevicoryne brassicae* (Linn.)) population and mean temperature being positively correlated.

Of all the forms, nymphal population was dominated followed by apterous and alate adults. Similar results were also reported in case of other aphid species by Ghosh and Mitra (1983) and Shantibala *et al.* (1995).

In the present study, it was observed that the aphid survived and build-up its population at a wide range of temperature

(11-37 °C) during 2007 and (10-35 °C) during 2008.

Present study revealed that the predators, besides sporadic incidence of hymenopteran parasitoid, *A. uzbekistanicus*, also appeared to influence the population of *S. miscanthi.* Though the *A. uzbekistanicus* was earlier recorded from the target area by Singh *et al.* (1999) and considered as a promising biocontrol agent against wheat aphids by Halbert *et al.* (1996) and Rakhshani *et al.* (2008) had no role in diminishing the population of *S. miscanthi* in this locality.

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COMPARATIVE SUSCEPTIBILITY OF BRINJAL VARIETIES AGAINST APHID, *APHIS GOSSYPII* (GLOVER) (HOMOPTERA : APHIDIDAE)

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Abstract : A field experiment was conducted during 2004 and 2005 in *kharif* crop to screen brinjal varieties against the aphid, *Aphis gossypii* Glover. On the basis of two year investigations the ascending order of brinjal varieties with regards to susceptibility to *A. gossypii* is as follow: Pusa purple long (PPL) > Pusa purple round (PPR) > KT-5 > Pusa purple cluster (PPC) > Pusa kranti (PK)> Pusa bhairav (PB).

Key words : Brinjal, varieties, aphid, *Aphis gossypii*.

INTRODUCTION

Brinjal, *Solanum melongena* L., is one of the three most important vegetables in South Asia (India, Bangladesh, Nepal and Srilanka), which accounts for almost 50% of the world's area under cultivation (Alam *et al.*, 2003). In the brinjal field, various arthropod species both pests and natural enemies prevail during seedling to harvesting stage. El-Shafie (2001) observed 28 species of insect pests under seven different insect orders from the brinjal ecosystem while Nayar *et al.* (1995) reported 53 species of insect pests of brinjal. Among the insect pests, aphid, *Aphis gossypii* (Glover) occur regularly during the cropping season and are considered as major pests (Joshi and Sharma, 1973, Latif *et al.,* 2009).

Due to development of insecticide resistance in aphids, the losses have been increased (Chellaiah, 1973). Plant resistance provides control of insect pests without any additional cost. It is also economical and environmentally safe (Khan and Sexena, 1998). By using resistant varieties the pest population can easily be controlled without insecticide application. Bindra and Mahal (1981) reported variations in resistance level in brinjal varieties against jassids. To cope with the problems, new varieties are introduced for possible resistance against pests. As the evaluation of new varieties for resistance against aphid is an important component of integrated management of aphid, the present studies were planned to screen newly developed brinjal cultivars under local agro-climatic conditions of Jaipur (Rajasthan).

MATERIALS AND METHOD

The crop was grown in a randomized block design (RBD) with six varieties *viz.*, Pusa purple long (PPL), Pusa purple round (PPR), Pusa purple cluster (PPC), Pusa kranti (PK), Pusa bhairav (PB) and KT-5, each replicated thrice. Each variety was grown in individual plot of size 3x3 m. The spacing between rows was kept at 60 cm. The crop was sown on 15th May during 2004 and on 16th May during 2005 and transplanted on 16th June during 2004 and on 17th June during 2005. For each variety, observations were taken for 7 consecutive fortnights. The crop was left for natural infestation. The estimation of aphid population was essentially on the numerical count methods as described by Heathcote (1972). The population was counted only on three leaves as per method suggested by Satpathy *et al.* (1968). For recording aphid population, marked leaf was grasped at the petiole by thumb and forefinger and twisted until entire underside of the leaf was clearly visible. With the help of a magnifying lenses the aphid population was counted, which was expressed on per plant basis. The observations were recorded till harvesting of the crop at fortnight interval. The replicated data collected had 42 treatments in all and were transformed into "(x + 0.5) transformation and subjected to analysis of variance in pooled randomized block design technique. The critical difference obtained was used to sort out varieties significantly differing from each other infestation. Accordingly, order of susceptibility for varieties was expressed in an ascending order.

RESULTS AND DISCUSSION

Observations on aphid population were started from 26th June 2004. The mean aphid population ranged from 7.79 to 11.40 per plant during the I fortnight (Table 1). Statistically there was no significant difference, however, PPR had the minimum while PPL had the maximum infestation. Observations were started from 28th June for the year 2005. The mean population ranged from 4.21 to 7.17 aphids per plant (Table 2). There was statistically no significant difference, however, minimum population was on PPC and maximum on PB. In the second fortnight (2004) the mean population ranged from 14.63 to 32.10 aphids per plant. The minimum infestation was on PPC at par with PK and PB while maximum on PPL. Similarly, during 2005 the mean population ranged from 12.39 to 28.12 aphids per plant. The minimum infestation was on PPC at par with PB and PK while maximum on PPL. Aphid populations stepped up in the third fortnight of 2004 and the mean population ranged from 30.19 to 94.95 aphids per plant. The minimum was on PPC and maximum on PPL at par with PPR. Likewise, during 2005 the mean population ranged from 40.08 to 80.32 per plant. The minimum was on PPC and maximum was on PPL. In the fourth fortnight during 2004 a further rise in population was recorded. The mean population ranged from 45.47 to 158.26 aphids per plant. The minimum was on PPC and maximum was on PPL at par with PPR. During 2005, the mean aphid population ranged 37.32 to 153.26 aphids per plant. Again minimum aphid population was observed on PPC and maximum on PPL. In the fifth fortnight (2004) a decline in the aphid population was evident. The mean aphid population ranged from 40.08 to 65.11 aphid per plant. The minimum was on PPC at par with PK, while maximum was on PPL at par with PPR, KT 5 and PB. In 2005 the mean aphid population ranged 44.12 to 71.24 per plant. The minimum aphid population was observed on PK at par with KT-5, PPR, PB and PPC while maximum on PPL. Observation in the sixth fortnight during 2004 showed a further decline of populations the mean population ranged 18.08 to 39.95 aphids per plant. The

Table 1. Mean aphid, *Aphid gossypii* Glover population on different brinjal varieties during 2004 crop season. Figures in the parentheses are transformed values of " x + 0.5.

Observations		Brinjal varieties					
Fortnight	Date	PPL	PPR	PPC	PK	PB	KT-5
I	26th June	11.40 (3.45)*	7.97 (2.91)	10.00 (3.24)	10.39 (3.30)	8.80 (3.05)	9.36 (3.14)
II	10th July	32.10 (5.71)	28.34 (5.37)	14.63 (3.89)	15.82 (4.04)	17.99 (4.30)	22.16 (4.76)
III	24th July	94.95 (9.77)	74.67 (8.67)	30.19 (5.54)	45.47 (6.78)	40.46 (6.40)	55.15 (7.46)
IV	7th Aug.	158.26 (12.60)	136.86 (11.72)	45.47 (6.78)	65.11 (8.10)	77.82 (8.85)	96.13 (9.83)
V	21st Aug.	65.11 (8.10)	60.03 (7.78)	40.08 (6.37)	45.06 (6.75)	55.30 (7.47)	60.03 (7.78)
VI	4th Sept.	39.95 (6.36)	26.54 (5.20)	18.08 (4.31)	20.11 (4.54)	24.30 (4.98)	21.50 (4.69)
VII	9th Sept.	1.81 (1.52)	8.38 (2.98)	3.46 (1.99)	4.04 (2.13)	7.97 (2.91)	6.31 (2.61)
S. Em. ± 0.22; C.D. at 5% 0.70							

Table 2. Mean aphid, *Aphid gossypii* Glover population on different brinjal varieties during 2005 crop season. Figures in the parentheses are transformed values of " x + 0.5.

Observations		Brinjal varieties					
Fortnight	Date	PPL	PPR	PPC	PK	PB	KT-5
I	28th June	6.16 (2.58)	5.36 (2.42)	4.21 (2.17)	5.60 (2.47)	7.17 (2.77)	7.01 (2.74)
II	12th July	28.12 (5.35)	19.30 (4.45)	12.39 (3.59)	18.68 (4.38)	17.06 (4.19)	21.31 (4.67)
III	26th July	80.32 (8.99)	62.86 (7.96)	40.08 (6.37)	65.27 (8.11)	69.39 (8.36)	60.18 (7.79)
IV	9th Aug.	153.26 (12.40)	118.96 (10.93)	37.32 (6.15)	64.30 (8.05)	73.46 (8.60)	83.77 (9.18)
V	23rd Aug.	71.24 (8.47)	46.70 (6.87)	52.94 (7.31)	44.12 (6.68)	50.05 (7.11)	44.88 (6.81)
VI	6th Sept.	30.75 (5.59)	18.51 (4.36)	9.11 (3.10)	12.10 (3.55)	13.19 (3.70)	14.17 (3.83)
VII	11th Sept.	5.21 (2.32)	4.25 (2.18)	4.34 (2.20)	4.25 (2.18)	3.46 (1.99)	4.47 (2.23)
S. Em. ± 0.27; C.D. at 5% 0.84							

minimum aphid population was observed on PPC at par with PK, KT-5 and PB while maximum was observed on PPL. Similarly, during 2004, the mean population ranged from 9.11 to 30.75 aphids per plant. The minimum aphid population was observed on PPC at par with PK, PB and KT 5 while maximum on PPL. However, in the seventh fortnight (------2004) the aphid population further descended, the mean population ranged from 1.81 to 8.38 per plant. The minimum aphid population was observed on PPL at par with PPC and PK while maximum was on PPR at par with PB and KT-5. Similarly, during 2005 the mean aphid population ranged from 3.46 to 5.21 aphids per plant. The minimum aphid population was recorded on PB and maximum on PPL but statistically there was no difference.

The varieties PPL and PPR were found highly susceptible possibly due to its smooth and soft leaf surface. This provide favourable conditions to the aphid, *A. gossypii* to act upon (Khaire and Lawande, 1986). Whereas, KT-5 was found as moderately susceptible while PPC, PK and PB were categorized least susceptible category in both the years.

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LEARNING ABILITY OF HOST DISCRIMINATION IN *LIPOLEXIS OREGMAE* (GAHAN) (HYMENOPTERA : BRACONIDAE, APHIDIINAE), A PARASITOID OF *APHIS GOSSYPII* GLOVER (HOMOPTERA : APHIDIDAE)

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Abstract : The study reveals that the pre-attack time to hosts is significantly more for inexperienced female parasitoids, *Lipolexis oregmae* (Gahan) (Hymenoptera : Braconidae, Aphidiinae) than the experienced ones. Inexperienced females also require more time in taking decision for oviposition after their first encounter with the hosts *Aphis gossypii* Glover (Homoptera:Aphididae). The results demonstrated that inexperienced parasitoids do superparasitise significantly more hosts than experienced ones, and the former improve her discriminatory ability by adaptive learning as a result of experience or practice. Also, the learning in such parasitoids that contact at first with healthy hosts is quicker than those which contact, at first, with an already parasitised ones. The age of parasitoid does not in any way influence the developmental ability of host discrimination in *L. oregmae*.

Key word : *Lipoexis oregmae*, *Aphis gossypii*, host discrimination, adaptive learning, superparasitism.

INTRODUCTION

Host discrimination is usually defined as the ability of a parasitoid to distinguish unparasitised from parasitised hosts. The aphids parasitised by *Lipolexis oregmae* (Hymenoptera : Braconidae, Aphidiinae) when observed for number of eggs laid inside them, usually only one parasitoid egg per aphid was observed. However, more than one parasitoid egg per aphid had also been observed, although only one adult (parasitoid) emerges from a single aphid as aphids maximally support only one egg for its successful development upto adulthood (Singh and Agrarwala, 1992). Hence, some mechanism(s) must be involved to prevent superparasitism, and/or eliminate supernumerary eggs/larvae of the parasitoid within the host.

Superparasitism in aphids is considered to be advantageous to parasitoid development, particularly when the host is small at the beginning of the parasitism. This is attributed to the fact that superparasitised aphids had higher incorporation efficiency and grew at a faster rate than parasitised ones, thus increasing the potential for parasitoid growth (Cloutier and Mackauer, 1980) and the non-discriminating female sets a greater value in its own survival and future reproduction (Outremana and Pierre, 2005). However, superparasitism results in a wastage of eggs through lethal competition among parasitoid larvae (Waage, 1986; Godfray, 1994; Dorn and Beckage, 2007). In some cases, superparasitism causes direct mortality of hosts, leading also to a waste of parasitoid progeny (Ueno, 1999). Thus, the production efficiency of parasitoids for biological control should decrease when superparasitism occurs frequently in laboratory rearing systems. To produce biological control agents efficiently, we need the knowledge of laboratory environments in which the incidence of superparasitism can be minimised.

Avoidance of superparasitism is also important for parasitoids to be an efficient forager. Superparasitism avoidance is attained by avoiding parasitised hosts directly or by avoiding areas where parasitised hosts are present. Host discrimination, an ability of an ovipositing parasitoid to discriminate between parasitised and unparasitised hosts, is a general mechanism by which parasitoids avoid superparasitism (van Lenteren, 1981; Singh and Sinha, 1981, 1982a, b, 1983; Hofsvang, 1988; van Alphen and Jervis, 1996). Therefore, investigation of host discrimination and superparasitism avoidance in a parasitoid will help uncover to assess whether it can be an efficient forager, or a potentially effective biocontrol agent.

Earlier findings demonstrated that *L. oregmae* is a potent bioagent against the brinjal aphid, *Aphis gossypii* Glover (Singh *et al.*, 2000). Preliminary observations have shown that *L. oregmae* can discriminate between parasitised and healthy hosts (Prasad, 2010) - a trait also exhibited by some other parasitoid species (Singh and Agarwala, 1992). Even so, this capability of the parasitoid cannot completely prevent superparasitism in *L. oregmae.* Therefore, the causes of superparasitism in *L. oregmae* was investigated because host discrimination ability of a parasitoid enhances its biological fitness and as such it is a desirable attribute of potential parasitoids as a bioagent and plays a significant role in their establishment in a particular environment.

There are a number of explanations why superparasitism does take place (Prasad, 2010). In the present study examine whether a female parasitoid learn to discriminate between parasitised and healthy hosts or not. This information will help in improving mass rearing systems of *L. oregmae*.

MATERIALS AND METHODS

The host aphid, *A. gossypii* and the parasitoid *L. oregmae* were obtained as mentioned by Prasad (2008). Only mated (soon after emergence) and naive females, 24 h old and fully fed with 30% honey solution, were utilised for experipments. The most preferred third instar nymphs of the aphid were utilised as hosts. All experiments were performed in Petri dishes (10 cm diam.) having moistened filter paper (Whatman No. 1). After 48 h of their parasitisation, the aphids were treated with a mixture of chloral hydrate-phenol (saturated solution) for 24-36 h to detect the presence of eggs under the light microscope. The parasitoid eggs in each aphid were counted. Because of the large number of trials involved, different cohorts of aphids and parasitoids were used for the above six possible causes of superparasitism.

Following hypotheses was tested to see whether the female parasitoid learn discrimination behaviour after gaining experience during host searching : (a) inexperienced female parasitoids differ largely among themselves in the pre-attack time of their host searching behaviour (pre-attack time of encounter with host, of parasitisation, and time taken between the above process) in contrast to experienced ones; and, (b) Inexperienced parasitoids have difficulties to discriminate between healthy and parasitised hosts but they improve themselves by maturation and/or experience (learning) whereas, the experienced ones are able to discriminate the hosts excellently.

Test : 1

To determine the pre-attack time of encounters, of parasitisation and time taken between the above processes of inexperienced and experienced *L. oregmae,* 5 third instar nymphs of *A. gossypii* were put on a host plant's leaf (*Solanum melongena* L.) and placed in a Petri dish having a moistened filter paper. One inexperienced female parasitoid was released into it. The time when the female encounters and parasitises the host for the first time was recorded with two stop-watches. 15 replicates were carried out. The above mentioned females were re-introduced in a separate Petri dish having about 250 aphids for 24 h. On the expiry of this period, these females (now experienced) were again introduced individually in similar set up as stated for the inexperienced females. Similar observations as recorded for inexperienced females was taken. The data are presented in Table 1 and illustrated by Figure 1A, B.

Test : 2

To determine the extent of superparasitism in the parasitoids, the experimental design of Singh and Sinha (1983) was followed. The experiment was carried out simultaneously with inexperienced and experienced female parasitoids. Four Petri dishes each having 50 hosts were set up and 1, 2, 3 and 4 female parasitoids were introduced in each set for 15, 30, 45 and 60 min, respectively. The female parasitoids were not released simultaneously but intermittently at an interval of 15 min after withdrawing the earlier introduced female parasitoid. To ascertain the extent of tendency of egg laying of the female parasitoids which might have influenced the superparasitisation, the following controls were arranged. Four female parasitoids (inexperienced/experienced) were introduced singly into 4 Petri dishes each having 50 hosts for 15, 30, 45 and 60 min, respectively. The entire experiments were replicated 5 times. The data are presented in Table 2 and illustrated by Figure 2A, B, 3A, B.

Test : 3

Direct observations were also made to see the development of the ability of the host discrimination of inexperienced *L. oregmae.* Four sets of experiments were carried out as follow:

Experiment 1. An inexperienced female parasitoid was introduced into a Petri dish having 20 parasitised (P) hosts for 15 min 6 times in a succession at an interval of 30 min between 2 successive steps. The number of encountered, parasitised and rejected hosts were recorded. In all 10 replicates were performed, 5 with 12 h aged female parasitoids and 5 with 4 day aged female parasitoids. The data are presented in Table 3 -4 (upper boxes).

Experiment 2. In this set, the inexperienced female parasitoid was offered 20 healthy (H) hosts for 15 min 6 times in a succession at an interval of 30 min between 2 successive steps. In all 10 replicates were performed, 5 with 12 h aged female parasitoids and 5 with 4 d aged female parasitoids. The data are presented in Table 3 -4 (lower boxes).

Experiment 3. In this set of experiment, the inexperienced female parasitoid was offered at first 20 healthy and then 20 parasitised hosts for 15 min each 6 times in a succession (3 times healthy hosts and 3 times parasitised hosts) at an interval of 30 min between 2 successive steps. In all 10 replicates were performed, 5 with 12 h aged and 5 with 4 d aged female parasitoids. The data are presented in Table 5-6 (upper boxes).

Experiment 4. In this set of experiment, the sequence of kinds of host offered was changed. The inexperienced female parasitoid was offered at first 20 parasitised and then 20 healthy hosts for 15 min each 6 times in a succession (3 times with parasitised hosts and 3 times with healthy hosts) at an interval of 30 min between 2 successive steps. In all 10 replicates were performed, 5 with 12 h aged and 5 with 4 d aged female parasitoids. The data are presented in Table 5-6 (upper boxes).

RESULTS

i. Determination of the pre-attack time of encounters, of parasitisation and time taken between the above processes of inexperienced and experienced *L. oregmae*

Table 1 displays the pre-attack time of the inexperienced and experienced female parasitoid, *L. oregmae*. The data was pooled for each minute and is illustrated by Figure 1A, B. Inexperienced female parasitoids encounter the host randomly and the time taken by them between introduction and the first contact with host highly varied between the individuals from 95 to 542 seconds (296.2 ± 50.6 SE) whereas the variation is less marked amongst experienced ones (20-260 seconds, 113.8 ± 24.5 SE). Both the means differ significantly ($t = 8.58$, $P < 0.001$) indicating that the inexperienced female parasitoids needed more time to reach the host than the experienced ones. Also, the inexperienced female parasitoids required significantly more time (396.7 ± 46.8 SE seconds) to begin oviposition than the experienced ones (177.9 ± 34.5 SE seconds). Both the means differ significantly ($t = 11.26$, $P < 0.001$) indicating that the inexperienced female parasitoids needed more time to begin the oviposition than the experienced ones (Table 1). Further the time from first contact to egg deposition was double in

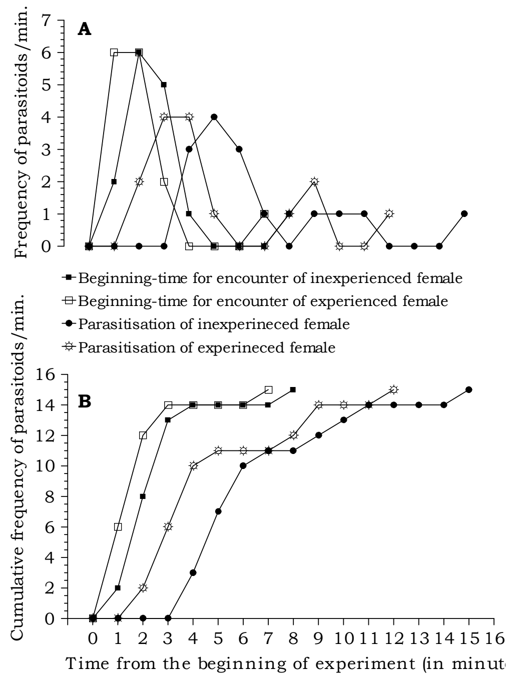

Fig 1. Pre-attack time of encounter with and parasitisation of *A. gossypii* by *L. oregmae.* A. Points show the frequencies of inexperienced and experienced females/min. B. Points show the cumulative frequencies of inexperienced and experienced females/min.

Table 1. Mean pre-attack time of the inexperienced and experienced *Lipolexis oregmae* for encounter to and parasitisation of *A. gossypii.* Values are expressed as mean ± S.E.

Responses of parasitoid	Inexperienced female	Experienced female
Pre-attack time of encounter (second)	296.2 ± 50.6a	113.8 ± 24.5b
Pre-attack time of parasitisation (second)	396.7 ± 46.8a	177.9 ± 34.5b
Time-lapse between encounter and parasitisation (second)	112.3±8.8a	57.3 ± 7.7b
Mean values followed by common letter (row-wise) are not significantly different at P < 0.001 (t-test)		

case of inexperienced female parasitoids (112.3±8.8 SE seconds) than experienced ones (57.3±7.7 SE seconds) and differ significantly ($t = 12.36$, $P < 0.001$; Table 1). Figure 1A showed that the peak period of encounter among inexperienced female parasitoids was attained at the third minute and is maintained during succeeding minutes and then slopes down which indicate that most of the inexperienced female parasitoids make their first encounter with hosts within 4 min of their release (Figure 1B) and oviposit within 6 min. On the contrary, 80% (12 out of 15) experienced female parasitoids encounter the host within 2 min of their release and 86% (13 out of 15) oviposit within 3 min; the time needed is just half of the former. Figure 1B also reflected that 69% inexperienced female parasitoids encounter the host and only 20% individuals begin to oviposit within 4 min, whereas, 92% experienced ones encounter the host and all oviposited within the above duration.

ii. Determination of the extent of superparasitism in inexperienced and experienced *L. oregmae*

The results presented in Table 2 and illustrated by Figure 2 clearly show that the inexperienced female parasitoids did superparasitise significantly more hosts than experienced ones when introduced intermittently, each one (1-4 female parasitoids) for only 15 min. The inexperienced female parasitoids also parasitised fewer hosts within the first 15 min of their introduction than the experienced ones (Fig. 2A, 3A). This response may be on account of longer time of host-finding and a lower acceptance amongst the inexperienced female parasitoids.

Superparasitisation by the experienced female parasitoids seemed to be due to their egg laying-urge since its values did not significantly differ from the control series (Table 2, Fig. 3B); whereas, the inexperienced female parasitoids behave otherwise, as the contribution of second, third and fourth female parasitoids

Table 2. Total number of eggs per host and contribution of individual female parasitoid, *Lipolexis oregmae* in increase of eggs per aphid, *A. gossypii* under different experimental conditions.

Number of female parasitoids	Total exposure period (min)	Number of eggs per host (Mean ± S.D.)		Number of eggs per host by individual female		Percentage of superparasitisation	
		Inexperienced female	Experienced female	Inexperienced female	Experienced female	Inexperienced female	Experienced female
1	15	0.91±0.16	1.01±0.11	0.83	0.92	0.82	0.05
2	30	1.15±0.13	1.05±0.10	0.27	0.04	6.50	0.83
3	45	1.34±0.12	1.14±0.09	0.21	0.09	12.20	6.40
4	60	1.43±0.13	1.17±0.09	0.11	0.04	24.00	8.32
1	15	0.85±0.15	1.06±0.14	0.73	0.90	0.86	0.06
1	30	0.90±0.10	1.13±0.17	0.08	0.04	4.30	0.17
1	45	0.93±0.08	1.19 ±0.19	0.05	0.12	4.60	6.24
1	60	0.98±0.09	1.24±0.19	0.07	0.04	5.31	14.40

Parasitoids were not released simultaneously but intermittently with the interval of 15 min. At the end of each 15 min the earlier introduced female parasitoid was withdrawn.

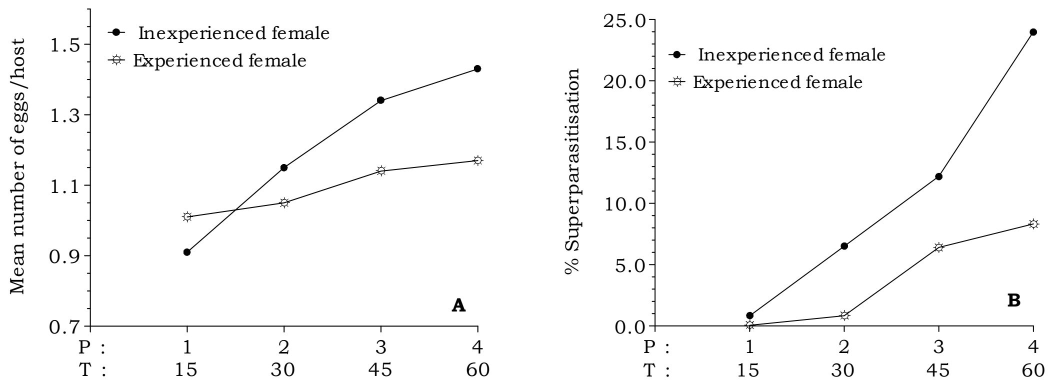

Fig. 2. Amount of parasitisation of *A. gossypii* reached after 15, 30, 45 and 60 min (T) of parasitisation by *L. oregmae*. A. Parasitation by 1, 2, 3 and 4 successive parasitoids (P) and B. Percentage of superparasitisation reached after 1, 2, 3 and 4 successive parasiroids (P).

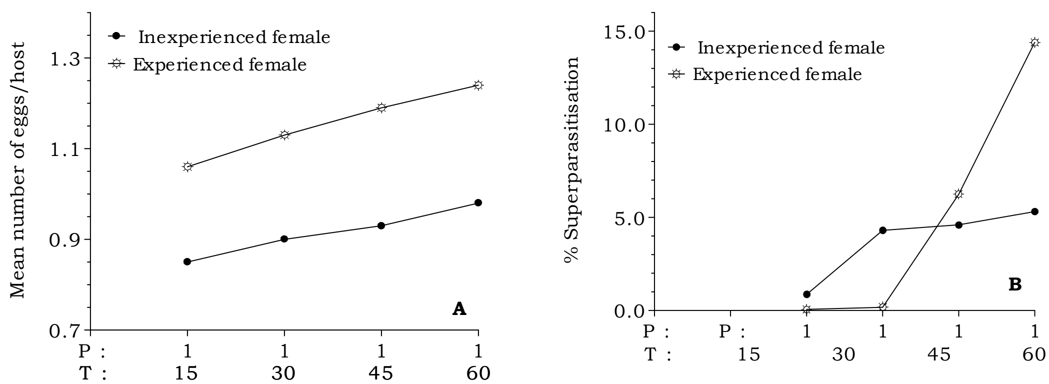

Fig. 3. Amount of parasitisation of *A. gossypii* reached after 15, 30, 45 and 60 min (T) of parasitisation by *L. oregmae*. A. Parasitisarion by a single female and B. Percentage of superparasitisation reached after 15, 30, 45 and 60 min (T) of parasitisation by a single female parasitoid (P).

(introduced in a succession, each for 15 min) was considerably and significantly more than that of experienced ones and was positively not due to their egg laying-urge, since the extent of hosts superparasitised in this case exceeded that of the control ones. The values for percentage of superparasitisation in the controls (45-60 s) of inexperienced female parasitoids are not absolute as an inexperienced female parasitoids which stayed for 15 min or 30 min parasitising about 50 hosts began to learn to discriminate the kinds of hosts - a process which manifests itself by adaptive changes in individual behaviour as a result of experience. Due to this the inexperienced female parasitoids do not superparasitise more and more. This indicated that if an inexperienced female had an opportunity to parasitise about 50 hosts or so, she can learn as well to discriminate among hosts within a period of 30 min or so.

iii. Direct observations on the development of the host discrimination in inexperienced *L. oregmae*

When parasitised hosts were offered

Table 3. Differential behavioural responses of inexperienced female parasitoids, *L. oregmae* when introduced into different experimental sets-up haviing healthy [H] or parasitised [P] *A. gossypii.*

Experimental sets	Kinds of hosts offered in succession	% of encountered (E), accepted (A) and rejected (R) hosts by								
		12 h old female (1)			4 day old female (2)			Sum total of (1+2)		
		E	A	R	E	A	R	E	A	R
A	P	94.0	35.1	64.9	86.5	30.8	69.2	90.3	33.0	67.1
	P	97.1	29.9	70.1	94.3	32.3	67.7	95.7	31.1	68.9
	P	80.3	30.0	70.0	90.9	28.3	71.7	85.6	29.2	70.9
	P	91.2	29.7	70.3	94.6	21.8	78.2	92.9	25.8	74.3
	P	84.0	31.8	68.2	89.6	33.5	66.5	86.8	32.7	67.4
	P	92.2	36.1	63.9	84.5	33.0	67.0	88.4	34.6	65.5
B	H	84.5	80.2	19.8	90.5	80.3	19.7	87.5	80.3	19.8
	H	94.4	84.8	15.2	89.0	84.2	15.8	91.7	84.5	15.5
	H	88.2	87.4	12.6	91.0	89.4	10.6	89.6	88.4	11.6
	H	85.0	88.3	11.7	91.6	91.7	8.3	88.3	90.0	10.0
	H	96.0	93.5	6.5	90.2	91.6	8.4	93.1	92.6	7.5
	H	92.3	94.5	5.5	93.4	97.0	3.0	92.9	95.8	4.3

Table 4. Encounter and rejection ratio of inexperienced female parasitoid, *L. oregmae* when introduced into different experimental sets-up (as Table 16) having healthy (H) or parasitised (P) *A. gossypii* as host.

Experimental sets	Kinds of hosts offered in succession	Encounter and rejection ratio (E/R)	χ^2 comparing with first step	Pooled E/R	χ^2
A	P	1.35	-	1.62a	6.214b
	P	1.39	0.019a		
	P	1.21	0.117a		
	P	1.25	0.510a		
	P	1.29	0.002a		
	P	1.35	0.023a		
B	H	4.43	-	10.12b	
	H	5.92	0.834a		
	H	7.72	3.930b		
	H	8.83	4.786b		
	H	12.50	9.982c		
	H	21.85	17.639d		

a - Not significant. b, c, d - significant at the level of P = 0.05, P = 0.005, P = 0.001, respectively.

Table 5. Differential behavioural responses of inexperienced female parasitoid, *L. oregmae* when introduced into different experimental sets-up having healthy (H) or parasitised (P) *A. gossypii* as host.

Experimental sets	Kinds of hosts offered in succession	% of encountered (E), accepted (A) and rejected (R) hosts by								
		12 h old female (1)			4 day old female (2)			Sum total of (1+2)		
		E	A	R	E	A	R	E	A	R
C	H	91.0	80.8	19.2	86.0	78.8	21.2	88.5	79.8	20.2
	P	96.0	20.1	79.9	93.0	21.5	78.5	94.5	20.8	79.2
	H	91.0	88.3	11.7	81.0	85.2	14.8	86.0	86.8	13.3
	P	92.0	13.4	86.6	96.0	9.4	90.6	94.0	11.4	88.6
	H	90.0	86.8	13.2	84.0	88.2	11.8	87.0	87.5	12.5
	P	89.0	1.8	98.2	79.0	1.4	98.6	84.0	1.6	98.4
D	P	86.0	27.6	72.4	90.0	33.8	66.2	88.0	30.7	69.3
	H	92.0	69.6	30.4	85.0	74.4	25.6	88.5	72.0	28.0
	P	90.0	18.4	81.6	95.0	19.6	80.4	92.5	19.0	81.0
	H	88.0	72.4	27.6	93.0	87.0	13.0	90.5	79.7	20.3
	P	96.0	8.0	92.0	97.0	9.0	91.0	96.5	8.5	91.5
	H	89.0	83.7	16.3	95.0	78.5	21.5	92.0	81.1	18.9

Table 6. Encounter and rejection ratio of inexperienced female parasitoid, *L. oregmae* when introduced into different experimental sets-up having healthy (H) or parasitised (P) *A. gossypii* as host.

Experimental sets	Kinds of hosts offered in succession	Encounter and rejection ratio (E/R)	χ^2 comparing with first step
C	H	4.38	-
	P	1.19	-
	H	6.49	2.45
	P	1.06	1.74
	H	6.96	4.12
	P	0.85	4.15
D	P	1.27	-
	H	3.16	-
	P	1.14	1.10
	H	4.46	2.17
	P	1.05	3.31
	H	4.87	2.84

a - Not significant. b, c, d - significant at the level of P = 0.05, P = 0.005, P = 0.001, respectively.

for 15 min to inexperienced *L. oregmae* successively 6 time (with 30 min rest period between 2 successive introduction) more than 65% parasitised hosts were rejected for oviposition (Table 3, *Exp. 1*; Fig. 4A). There was no trend of the development of avoidance response in the female parasitoids against parasitised hosts (Table 4, Fig. 4A). Moreover, their percentage of rejection was independent of the age of the female parasitoids.

It was observed that when an inexperienced female parasitoid was exposed to healthy hosts 6 times in a succession, the female parasitoids accepted the hosts in a large degree (Table 3, *Exp. 2,* Fig. 4B). The results demonstrated that the encounter and rejection ratio (E/R) continuously increased in the successive steps, however, significantly from the third step onwards (Table 4) possibly indicating that the female had started learning to discriminate the hosts.

The findings of the two experiments explicitly demonstrated that inexperienced female parasitoids accepted fewer parasitised hosts than healthy ones and the average E/R ratio for healthy and parasitised hosts differ significantly ($E/R_{exp.1}=1.62$, $E/R_{exp.2}=10.12$, $\chi^2=6.214$, $P<0.05$).

Data of *Test 2* is displayed in Table 5 and Fig. 4C) showed that when an inexperienced female was introduced into a population of parasitised hosts after she had first spent 15 min time with the healthy ones and had rested for 30 min, she rejected more hosts (parasitised) than if she was kept along with parasitised host first (Table 3, 5). Although E/R ratio in both cases is not significantly different ($\chi^2_{exp.3.1}=2.45$; $\chi^2_{exp.3.4}=1.66$), it indicates that the inexperienced female parasitoids are not able to develop their ability of host discrimination within 15 min of their encounter with 20 healthy hosts. Again, when 20 healthy hosts were alternated with the equal number of parasitised hosts, she rejected more hosts than in earlier instances, but the result was still not significantly different from that when she encounters the parasitised hosts for the first time $\chi^2_{exp.4.1}=1.10$, $\chi^2_{exp.4.4}=1.74$). This indicates that though the inexperienced female parasitoids are trying to increase their avoidance ability for the parasitised ones as the time passed on till 45 min (excluding inactive resting period and cases where she had encountered 40 healthy and 20 parasitised hosts), even then she had not significantly learnt to discriminate. Again, when she was offered 20 healthy hosts for 15 min and thereafter alternated with the same number of parasitised ones, she significantly rejected them and E/R falls significantly (Table 6, $\chi^2_{exp.3.1}=4.12$, $\chi^2_{exp.4.4}=4.15$; $P<0.05$). These findings provide sufficient evidence that the inexperienced female parasitoids improve their ability of host discrimination by gaining experience if first healthy hosts are offered.

The results of *Experiment 4* are displayed in Table 5 and illustrated by Fig.

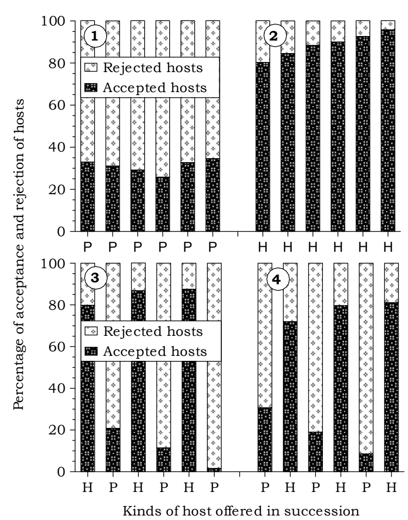

Fig. 4: Percentage of acceptance and rejection of parasitised (P) and healthy (H) hosts, *A. gossypii* offered for 6 times in successive bouts to inexperienced female parasitoid, *L. oregmae.*

4D. During the initial period of the experiment with parasitised hosts, the inexperienced female parasitoids accepted 30.7% of the host (Table 5), which was similar to that of *Experiment 1* (33.0%, Table 4). The healthy hosts provided to the female parasitoid on the expiry of the first step were greatly accepted (72.0 %). However, when the parasitised hosts were exposed to the parasitoid's attack at the third step, they were mostly rejected, though the difference in E/R from the first step did not differ significantly (Table 6). In the fifth step when the parasitoid was put along with the parasitised hosts, though their rejection had increased but not significantly (Table 6, Fig. 4D).

DISCUSSION

The developmental ability of host discrimination amongst parasitic Hymenoptera has not attracted the attention of the biologists in past. Samson-Boushuizen *et al.* (1974), van Lenteren and Bakker (1975), and van Lenteren (1976) observed that this factor is more important for causing superparasitism in a cynipid wasp than others. During the study of host discrimination of *Binodoxys indicus* (Subba Rao & Sharma), Singh and Sinha (1982b, 1983) have observed that the inexperienced parasitoids (those which have never been in contact with hosts) begin host-searching in an irregular manner (in terms of pre-attack time, direction and distance), whilst experienced ones started the search more or less in regular ways.

The results demonstrated that the inexperienced female parasitoids do superparasitise significantly more hosts than experienced ones when introduced intermittently, each one (1-4 female parasitoids) for only 15 min (Table 2). The inexperienced female parasitoids also parasitise fewer hosts within the first 15 min of their introduction than the experienced ones. This response may be on account of longer time of host-finding and a lower acceptance amongst the inexperienced female parasitoids.

Superparasitisation by the experienced female parasitoids is due to their tendency of egg laying since its values do not significantly differ from the control series whereas, the inexperienced female parasitoids behave otherwise. The values for percentage of superparasitisation in the controls of inexperienced female parasitoids are not absolute as an inexperienced females which stays for 15 min or 30 min parasitising about 50 hosts begins to learn to discriminate the kinds of hosts - a process which manifests itself by adaptive changes in individual behaviour as a result of experience (Thorpe, 1963) and also involves a change in behaviour, often a long-lasting one (Manning, 1979). Due to this the inexperienced females do not superparasitise more and more. This indicate that if an inexperienced females had an opportunity to parasitise about 50 hosts or so, she can learn as well to discriminate among hosts within a period of half-an hour or so.

The results shown in Table 3-6 that the learning in female parasitoids which contact at first healthy hosts is quicker as compared to such members which at first contact with parasitised ones. Parasitoid's age does not in any way influence the developmental ability of host discrimination.

The above findings furnish enough evidence that the phase during which the female parasitoids has not yet learnt to discriminate is responsible for a considerable amount of superparasitisation. This type of parasitoid's behaviour may also be responsible for superparasitism at high parasitoid densities (Sinha and Singh, 1980), because under such circumstances the probability to meet parasitised hosts would be higher, and the chances that inexperienced female parasitoids will superparasitise easily will also be greater.

The present findings give an insight about the cause of superparasitm in *A. gossypii* by *L. oregmae* and the parasitoid, *L. oregmae* develops ability to discriminate between healthy and parasitised host through experience.

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PREDATION AND SEARCHING EFFICIENCY OF *HARMONIA EUCHARIS* (MULSANT) (COLEOPTERA : COCCINELLIDAE)

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Abstract : The predation and searching efficiency of fourth instar larva of *Harmonia eucharis* (Mulsant) (Coleoptera : Coccinellidae) at increasing densities of oak aphid, *Cervaphis quercus* Takahashi (Homoptera : Aphididae) was studied under laboratory conditions (25.35 ± 0.90°C and 78.56±3.08% R.H.). The feeding rate of predator decreased at increased prey and predator densities. Highest per cent (94.40%) of prey consumption was observed at initial prey density and lowest per cent (41.15 %) prey consumption at highest prey density, though the total prey consumption increased with increase in either prey or predator densities. Similarly, the individual prey consumption was also highest at initial predator density (1 predator) and lowest at highest predator densities (8 predators) owing to the mutual interference between the predators at higher densities. The area of discovery (searching efficiency) also decreased with increase in prey (50 – 800 aphids) and predator (1 – 8 predators) densities. Handling time of predator was highest at lower prey densities, which decreased with increased prey densities. The results revealed that 1 : 50 predator-prey ratio was the best to reduce the pest population.

Key words : *Cervaphis quercus*, *Harmonia eucharis*, predation, searching efficiency, prey density.

INTRODUCTION

The oak tree, *Quercus serrata* Thunberg (Fagaceae) grows abundantly in the foothills of Manipur. It is the major food plant of the tasar silkworm, *Antheraea proylei* Jolly (Singh and Nigam, 1982) and has high economic value. Under natural conditions the oak plant is attacked by a number of insect pests, of which the oak aphid, *Cervaphis quercus* Takahashi (Homoptera: Aphididae) is considered a predominant one. The shoots and young leaves of the oak plants are seriously attacked by nymphs and adults of *C. quercus*. Heavy infestation results in several morphological and physiological changes thereby damaging the food plant of the oak tasar silkworm. Hence, there is an immense need for paying special attention to effective management of oak aphids. Biological control utilising predators has received wide attention and is a viable component of integrated pest management. Ladybeetles are important aphidophagous predators which control aphid population to a great extent in nature (Hodek, 1973). The ladybeetle, *Harmonia eucharis* (Mulsant) (Coleoptera: Coccinellidae) polyphagous aphid predator (Satpathi, 2009) and is a voracious feeder of *C. quercus* occurring abundantly in sericultural fields

(Shantibala, 1993). The present study thus aims to evaluate the predatory potential related to varying prey density and searching efficiency of fourth instar *H. eucharis* on the aphid *C. quercus* under laboratory conditions to provide a better experimental support in evaluation of predatory efficiency in open environment condition.

MATERIALS AND METHODS

Two sets of experiments (functional response and aggregative numerical response) were designed for the study of predation and searching efficiency of 12 h starved fourth instar of *H. eucharis* against *C. quercus*. The first set of experiments was purposed to study the effect of prey densities on the rate of consumption and searching efficiency of the predator (Holling, 1959) and the second set of experiment (aggregative numerical response) to study the effect of different predator densities on the rate of prey consumption (Ofuya and Akingbohungbe, 1988). For the first set of experiment (functional response), fourth instars of *H. eucharis* were kept singly in separate glass beakers (10 cm high and 6.5 cm diameter) for 12 h starvation. A single 12 h starved predator was introduced in each of the beakers containing 50, 100, 200, 400, 600 and 800 of third instar nymphs of *C. quercus* for 24 h and open ends of the beakers were covered with muslin cloth. To provide the accurate number of prey third instar nymphs but not gravid females were selected because the gravid females may reproduce and cause error in the counting of prey. After 24 h of exposure the predators were taken out from the beakers and unconsumed aphids were counted to find out the number of aphids consumed. The experiment was replicated 10 times. The second set of experiments was designed to evaluate its aggregative numerical response. Fifteen fourth instars of *H. eucharis* (due to highest prey consumption) were kept separately in different beakers (10 cm high and 6.5 cm diameter) for 12 h starvation to standardise their level of hunger and to avoid cannibalism. One, two, four, and eight numbers of fourth instars larvae of *H. eucharis* were introduced in separate beakers having 200 third instar nymphs of *C. quercus* on *Q. serrata* twigs. After 3 h unconsumed aphids were counted to evaluate the predation. The experiment was replicated 10 times. Handling time of prey (*i.e.,* time taken by the predator for pursuing, subduing, consuming and digesting the prey) was calculated by taking the ratio of time duration and number of prey consumed by the predators. The area of discovery, *i.e.* searching efficiency (Hassell and Varley, 1969) was calculated by the formula given below:

$$a = 1/P \log_e N/S$$

where, a - area of discovery; N - prey density exposed for predation; P - predator density released for predation; and S: number of prey surviving predation).

Data so obtained from both the experiments were subjected to one-way ANOVA and linear regression analysis. Linear regression analysis was applied between (i) log prey consumption and log prey density, (ii) prey consumption and predator density, (iii) area of discovery and initial number of prey, and (iv) area of discovery and initial number of predator(s) using PC with SPSS - 10 Software.

RESULTS AND DISCUSSION

Functional response

The prey consumption of fourth instar of *H. eucharis* increased from 47.20 ± 0.37 to 329.20 ± 3.55 aphids/predator ($F = 574.52$; $P < 0.02$) when the prey density increased form 50 to 800 (Table 1). Regression analysis between the log prey consumption and log prey density of fourth instar exhibited a linear relationship ($Y = 0.545 + 0.692 \log X$, $r = 0.993$, $P < 0.001$). Per cent prey consumption decreased from 94.40 to 41.15 aphids/predator with the increase in prey density. The prey handling time of fourth instar larvae decreased from 30.15 to 4.37 min as the prey density increased from 50 to 800 aphids. The number of prey consumed by *H. eucharis* initially increased rapidly with the increase in prey density, but gradually declined with further increase in prey supplied. Thus the functional response exhibited by fourth instar larvae of *H. eucharis* suggests type II functional response and is in conformity with other instances of predaceous coccinellids (Hassell, 1978).

Table 1: Number of prey consumed, percent prey consumption and handling time of fourth instar of *H. eucharis* at various prey densities of *C. quercus*. Values are expressed as mean ± S.E.

Prey density	No. of prey consumed	% of prey consu-mption	Handling time (min)
50	47.2 ± 0.37	94.40	30.51
100	90.4 ± 1.08	90.40	15.93
200	151.2 ± 2.42	75. 60	9.52
400	237.6 ± 1.99	59.40	6.06
600	284.4 ± 4.26	47.40	5.06
800	329.2 ± 3.55	41.15	4.37

The increase in prey consumption by the predatory stages with increase in prey densities may be due to factor like greater interaction between prey and predator, handling time, limited area of searching and the level of starvation. Increased prey density resulted in the reduction of the searching arena of predators, thus increasing the chances of prey-predators interaction (O'Neil and Stimac, 1988). At low prey densities, aphids were spaced out due to which the predators spent most of their energy and time in foraging. The prey handling time was relatively lower at higher densities for the fourth instar predator ranging from 4.37 to 30.51 min. Akhtaruzzaman and Ahmad (1998) reported that handling time of predators was higher with low foraging rate of lower prey density.

Aggregative numerical response

Table 2 displayed that prey consumption by fourth instar larvae increased from 99.25 ± 2.10 to 187.39 ± 0.61 individuals of *C. quercus* ($F = 1770.86$, $P < 0.017$) when predator density increased from one to eight. Thus, there was a curvilinear increase in the prey consumption with the increase in predator density. The regression equation for predator density and prey consumption was $Y = 97.32 \pm 11.84 \log X$; $r = 0.992$; $P < 0.001$). A linear declination in the rate of prey consumption per predator with the increase in predator density was observed. This resulted in reduction in individual prey consumption of fourth instar from 99.25 ± 2.10 to 23.42 ± 0.10 individuals of *C. quercus* with an increase in predator density from one to eight. In the limited time and space of predation, the predators had to face the hindrances caused by the increased prey and predators densities and thus the prey consumption decreased. At higher prey-predator densities, consumption amongst predators also increased due to which decrease in prey consumption took place.

Table 2: Prey consumption (numerical response) of fourth instar of *H. eucharis* of various predator densities and constant density of *C. quercus*. Values are expressed as mean ± S.E.

Predator density	Total number of prey consumed	Prey consumed per predator
1	99.25 ± 2.10	99.25 ± 2.10
2	126.56 ± 1.01	63.28 ± 0.51
4	153.71 ± 0.43	38.43 ± 0.11
8	187.39 ± 0.61	23.42 ± 0.10

The area of discovery of a single fourth instar predator decreased from 2.8824 to 0.5302 when the prey density increased from 50 to 800 (Table 3). Similarly, the area of discovery decreased from 0.6857 to 0.3455 when the predator density increased from one to eight, at the constant prey density of 200 (Table 3).

The decrease in the area of discovery of fourth instar with increased prey and predator densities may be ascribed to the fact that with increase in prey and predator densities, the predator switches over from extensive to intensive search, which leads to the decrease in the area of discovery. Highest area of discovery at lowest prey density suggests that prey scarcity stimulates the foraging behaviour of the ladybird beetle. The availability of aphid was easy therefore searching efficiency increased with higher prey densities. The higher densities of prey and predator have an inverse effect on the searching efficiency of the predators (Hassell and Varley, 1969; Ofuya and Akingbohungbe, 1988) and to overcome the prey population more predators are required.

Table 3: Area of discovery (searching efficiency) of searching of *H. eucharis* at different *C. quercus* and at its different densities

Prey density	Area of discovery	Predator density	Area of discovery
50	2.8824	1	0.6857
100	2.3434	2	0.5009
200	1.4106	4	0.3658
400	0.9014	8	0.3455
600	0.6424		
800	0.5302		

The aphid population determines the predator population (Wagiman, 1996). The highest percentage of prey consumption at the lowest prey density (50 aphids), the highest individual consumption at the lowest predator density and the highest area of discovery (searching efficiency) in both the conditions indicate that the predator and prey ratio of 1 : 50 may prove to be the best prey-predator ratio (Table 1) with reference to *H. eucharis* against *C. quercus*.

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DIVERSITY OF APHIDS (HOMOPTERA : APHIDIDAE) ON THE FIELD CROPS IN TERAI OF EASTERN UTTAR PRADESH

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Abstract : The aphids were inspected on different plants as cereals, pulses, vegetables, fruits, oilseed, sugarcane, orchard and ornamental plants, grasses, weeds and wild plants in different localities in different season and were collected. A list of 48 species of aphids attacking these plants are given that includes 62 medicinal, 23 ornamental, 20 vegetable, 11 fruit, 8 pulse and 7 cereal, 6 oil-seed plants etc.

Key words : Aphids, crops, diversity.

INTRODUCTION

The aphid damage is most noticeable on a variety of crops such as cereals, ornamental, fruit and shade trees, vegetables, fibre yielding crops etc (Singh and Ghosh, 2002; Singh *et al.*, 2003). The aphid colonies are mostly on the underside of leaves, the tips of branches or anywhere there is new growth. An initial infestation of aphids is usually localised, but can spread quickly if allowed to develop unchecked. Aphids damage plants by sucking the sap from leaves, twigs, stems or roots and can sometimes transmit plant virus diseases in the process. Leaves attacked by aphids have spotty yellow discolourations, usually on the undersides. The leaves may later dry out and wilt or curl. Some species of aphids cause plants to form galls (swellings of plant tissues that are globe or spindle-shaped). The galls, which often turn brown, contain many aphids in all stages of development. Depositon of honeydew on leaf surface also allows the growth of black mould which in turn proves detrimental to the normal activity of plant life (Raychaudhuri, 1980). Honeydew produced by aphids has been observed to reduce the effectiveness of fungicides as well as fertiliser (Choudhary, 1985). Out of 620 plant viruses known, about 200 are transmitted by the aphids (Kennedy *et al.*, 1962; Eastop, 1977). The damage of plants, and in particular commercial crops, has resulted in large amounts of resources and efforts being spent attempting to control the activities of aphids.

All of these attributes of the aphids make it a major pest of crops. Earlier, Singh *et al.*¸(1999) and Agrawal and Singh (2005) surveyed the area for aphid fauna. The present survey updates the records of aphids on various crops in terai of eastern Uttar Pradesh.

MATERIALS AND METHODS

The aphids were inspected on different plants as cereals, pulses, vegetables, fruits, oilseed, sugarcane, orchard and ornamental plants, grasses, weeds and wild plants in different localities in different season and were collected on plant material as tender leaves, apical portion, stem, flower, twigs, fruits, inflorescence, root, bark, bud by cutting that part and placed in a plastic bags and tightened with a rubber bands or plastic vials of standard width with cotton plug and were brought back to the laboratory. Then, some aphids were transferred to the glass vials (4x0.5 cm) containing a mixture of 70% ethanol and glycerol (5:1) for taxanomical studies. After clearing, the aphids were mounted in Berless medium. Aphids were identified and confirmed by Dr. L.K. Ghosh, Ex-Deputy Director, Zoological Survey of India, Kolkata.

RESULTS AND DISCUSSION

Following is the list of crops in the target area and aphids recorded on them.

1. On cereal crops : Cereal crops are the major source of food material for human consumption. In the terai area of eastern Uttar Pradesh, in some pockets (Kushinagar, Piparaich and Shoharatgarh), wheat was observed to be damaged by aphids, particularly by *Sitobion miscanthi* (Takahashi) and *Rhopalosiphum maidis* (Fitch). Similarly, the corn, millets and sorghum was observed to have heavy infestation of *Melanaphis sacchari* (Zehntner) and *R. maidis* (Singh *et al.*, 1999). Following is the complete list of aphids infesting cereal crops in the target area (Table 1). Other species are not of much importance.

Table 1. List of aphids infesting cereal crops in the terai of eastern Uttar Pradesh.

Crops/Aphids

Avena sativa L. (Oat): *Rhopalosiphum padi* (Linn.), *S. miscanthi*

Hordeum vulgare L. (Barley): *Hysteroneura setariae* (Thomas), *R. maidis*, *R. padi, R. rufiabdominalis* (Sasaki), *Schizaphis graminum* (Rondani), *S. miscanthi*

Oryza sativa L. (Paddy): *R. padi, R. rufiabdominalis*, *S. graminum*, *Tetraneura nigriabdominalis* (Sasaki)

Pennisetum glaucum (L.) R. Br. (Pearl-millet): *Aphis gossypii* Glover, *M. sacchari*, *R. maidis*, *R. padi, S. graminum*, *S. miscanthi*

Sorghum bicolor (L.) Moench subsp. *bicolor* (Sorghum): *M. sacchari*, *R. maidis*

Triticum aestivum L. (Wheat): *Myzus persicae* (Sulzer), *R. maidis*, *R. padi, S. graminum*, *S. miscanthi*

Zea mays L. (Maize, corn): *H. setariae*, *M. sacchari*, *R. maidis*, *R. padi, R. rufiabdominalis*, *S. graminum*, *T. nigriabdominalis*

2. On sugar-yielding crop : In the target area, only sugarcane (*Saccharum officinarum* L.) is cultivated for sugar as well as for juice consumption. This plant is infested heavily by *Ceratovacuna lanigera* Zehntner in western Uttar Pradesh and Uttarakhand (Pandey *et al.,* 2004) but in eastern Uttar Pradesh, during the present survey, it was not observed at all. However, three aphid species were encountered feeding the leaf juice of the sugarcane, viz. *M. sacchari* , *R. maidis* and *R. rufiabdominalis.* All these species were not found damaging the sugarcane as no noticeable injury to the plant was observed.

3. On pulse crops : Main pulse crops of the terai of north eastern Uttar Pradesh are pea (*Pisum sativum* Linn.), pigeonpea (*Cajanus cajan* (L.) Millsp.), chickpea (*Cicer arietinum* L.), cowpea or lobia (*Vigna unguiculata* (L.) Walp. ssp. *unguiculata* (=*Vigna sinensis* (L.) Savi ex Hassk.)) and urad bean (*Vigna mungo* (L.) Hepper var. *mungo*). All these crops are infested with either *Aphis craccivora* Koch or *A. gossypii* or *Acyrthosiphon pisum* (Harris) or few of them. All these aphids are pest in the survey area and require control measures. The list of aphid species (Table 2) infesting pulse crops in the survey area is given below:

Table 2. List of aphids infesting pulse crops in the terai of eastern Uttar Pradesh.

Crops/Aphids

Cajanus cajan (L.) Millsp. (Pigeonpea): *A. craccivora, A. gossypii, Aphis spiraecola* Patch, *M. persicae*

Cicer arietinum L. (Chickpea): *A. craccivora*

Lathyrus sativus L. (Khesari): *A. pisum, A. craccivora*

Lens culinaris Medik. (Masoor): *Acyrthosiphon pisum* (Harris)

Pisum sativum Linn. (Pea): *A. pisum, A. craccivora, M. persicae*

Vigna mungo (L.) Hepper var. *mungo* (Urad): *A. craccivora*

Vigna radiata (L.) R. Wiczek var. *radiate*: *A. craccivora*

Vigna unguiculata (L.) Walp. ssp. *unguiculata* (Cowpea): *A. craccivora*

4. On vegetable crops : Both summer and winter vegetable crops are infested by a number of aphid species as they belong to different taxa of plants. Usually, four species of aphids, *A. craccivora, A. gossypii, Brevicoryne brassicae* (L.), *M. persicae* infest the vegetable crops and cause economic damage to them. *M. persicae* attacks chilli and potato severely while *B. brassicae* and *Lipaphis erysimi* (Kalt.) sometimes ruin the brassica vegetables like cabbage, cauliflower and radish. Following is the list of aphids infesting various vegetable crops in the terai of eastern Uttar Pradesh (Table 3).

Table 3. List of aphids infesting vegetable crops in the terai of eastern Uttar Pradesh.

Crops/Aphids

Abelmoschus esculentus (L.) Moench (Lady's finger): *A. craccivora, A. gossypii, M. persicae*

Beta vulgaris L. (Sugar beet): *A. craccivora, M. persicae*

Brassica oleracea L. var. *botrytis* L. (Cauliflower): *A. gossypii, B. brassicae, L. erysimi, M. persicae*

Brassica oleracea L. var. *capitata* L. (Cabbage): *A. spiraecola, B. brassicae, L. erysimi, M. persicae*

Brassica oleracea var. *gongylodes* L. (Kohlrabi, knoll-khol): *L. erysimi, M. persicae*

Coccinia grandis (L.) Voigt. (Ivy gourd): *A. craccivora, A. gossypii*

Colocasia esculenta (L.) Schott. (Taro): *A. gossypii*

Cucumis sativus L. (Cucmber): *A. gossypii*

Cucurbita maxima Duchesne (Pumpkin): *A. craccivora, A. gossypii, Aulacorthum magnoliae* (Essig & Kuwana)

Daucus carota L. (Carrot): *A. craccivora, Aphis fabae solanella* Theobald, *A. gossypii, M. persicae*

Lagenaria siceraria (Molino) Standl. (Bottle gourd): *A. craccivora, A. gossypii*

Luffa acutangula (L.) Roxb. (Ridge gourd): *A. gossypii*

Luffa aegyptiaca Mill. (Smooth gourd): *A. craccivora, A. gossypii, Aphis nasturtii* Kalt.

Lycopersicon esculentum Mill. (Tomato): *A. craccivora, A. gossypii, Brachycaudus helichrysi* (Kaltenbach), *L. erysimi, M. persicae, R. rufiabdominalis*

Momordica charantia L. (Bitter gourd): *A. craccivora, A. gossypii, A. nasturtii, M. persicae*

Raphanus sativus L. (Radish): *A. gossypii, B. brassicae, L. erysimi, M. persicae*

Solanum melongena L. (Brinjal, egg plant): *A. craccivora, A. fabae solanella, A. gossypii, A. nasturtii, Aphis nerii* (B.d.Fonsc.), *A. spiraecola, M. persicae*

Solanum tuberosum L. (Potato): *A. gossypii, L. erysimi, M. persicae, R. rufiabdominalis*

Spinacia oleracea L. (Spinach): *M. persicae*

Vicia faba L. (Broad bean, faba bean): *A. pisum, A. craccivora, A. fabae* *solanella, A. gossypii, A. spiraecola, Myzus ornatus* (Laing), *M. persicae*

5. On oil seeds : The main oil-seed crop of the area is mustard (*sarsoon*). In some pocket near Khalilabad, sunflower is cultivated. The yield of *Brassica* crops are often jeopardized by the attack of *L. erysimi* and *M. persicae* found usually together on the same plant and in the same colony, the latter forms a small population and, therefore, *L. erysimi* plays major role in decimating the yield of *Brassica* seeds. Plantwise list of aphids is given below (Table 4):

Table 4. List of aphids infesting oil seed crops in the terai of eastern Uttar Pradesh.

Crops/Aphids

Brassica juncea L. Czern. (Indian mustard, leaf mustard): *A. gossypii, L. erysimi, M. persicae*

Brassica napus L. (Rapeseed, canola): *B. brassicae, L. erysimi*

Brassica nigra (L.) W.D.J. Koch (Black mustard): *L. erysimi, M. persicae*

Brassica rapa subsp. *campestris* (L.) A.R. Clapham (Mustard): *B. brassicae, L. erysimi, M. persicae*

Glycine max (L.) Merrill. (Soybean): *A. craccivora*

Helianthus annuus L. (Sunflower): *A. craccivora, A. gossypii, M. persicae*

6. On fibre crops : The major fibre yielding crop of the area is *Hibiscus cannabinus* L. (Mesta, jute). Cotton, the main fibre crop of the country is not cultivated in this are, but they are found in gardens. Only one species *A. gossypii* infest them.

7. On fruit plants : There are a number of aphid species attacking fruit yielding plants. However, none of the plant was observed injured from the attack of the aphids, therefore, for fruit yielding plants, aphids are not menace in the target area. The aphids infesting fruit plants of the area are listed below (Table 5).

Table 5. List of aphids infesting fruit plants in the terai of eastern Uttar Pradesh.

Crops/Aphids

Carica papaya L. (Papaya): *A. craccivora*

Citrus aurantiifolia (Christm.) Swingle (Key lime): *Toxoptera aurantii* (B.d. Fonsc.)

Citrus aurantium L. (Bitter orange): *A. craccivora, A. gossypii, A. spiraecola, Sinomegourae citricola* (v.d.Goot), *T. aurantii*

Citrus maxima (Burm.) Merr. (Pomelo, sheddock): *T. aurantii*

Eugenia jumbolana Lamk. (Java plum): *Greenidea ficicola* Takahashi

Mangifera indica L. (Mango): *A. gossypii, Toxoptera odinae* (v. d. Goot)

Musa paradisiaca L. (Banana): *A. gossypii*

Prunus dulcis (Mill.) D. A. Webb (Almond): *craccivora*

Psidium guajava L. (Guava): *A. craccivora, A. nasturtii, G. ficicola, Greenidea himansui* Raychaudhuri *et al.*, *Greenidea longirostris* Basu, *Greenidea psidii* van der Goot, *Greenidea decaspermi* Takahashi

Punica granatum L. (Pomegranate, anar): *A. fabae solanella, Aphis punicae* Passerini

Vitis vinifera L. (Grape): *A. punicae*

8. Plants yielding spices : The main spice yielding crops in this area are coriander (*Coriandrum sativum* L.) and chilli (*Capsicum annuum* L., *Capsicum frutescens* L.) and florence fennel or saunf (*Foeniculum vulgare* Mill.). The crop of the chilli is sometimes ruined by the infestation of *A. gossypii* and *M. persicae*. Similarly, the coriander crop was also damaged by *Hyadaphis coriandri* (Das). Following is the list of aphids attacking these crops in the survey area (Table 6).

Table 6. List of aphids infesting plants yielding spices in the terai of eastern Uttar Pradesh.

Crop/Aphids

Capsicum annuum L. (Hot pepper): *A. gossypii, A. nasturti*

Capsicum frutescens L. (Chilli pepper): *A. fabae solanella, A. gossypii, A. nasturtii, M. persicae*

Coriandrum sativum L. (Coriander): *A. gossypii, A. spiraecola, H. coriandri, M. persicae*

Foeniculum vulgare Mill. (Fennel, saunf): *A. gossypii*

9. On medicinal plants : Potentially all plants have medicinal value, but few of them are very popular and are used by even a lay person to cure some sort of diseases. Ghosh and Singh (2000) and Singh *et al.* (2003) listed the aphids attacking medicinal plants of India. Most of the medicinal plants are attacked by *A. gossypii.* Following is the list of aphids infesting some medicinal plants of the survey area (Table 7).

Table 7. List of aphids infesting medicinal plants in the terai of eastern Uttar Pradesh.

Crops/Aphids

Abutilon indicum (L.) Sweet (Country mallow, atibala, kanghi): *A. spiraecola*

Acalypha indica L.: *A. gossypii*

Ageratum conyzoides L. (Billygoat-weed, chick weed, goatweed, whiteweed): *A. craccivora, A. gossypii, A. spiraecola, B. helichrysi, M. ornatus, M. persicae*

Allium sativum L (Garlic): *R. rufiabdominalis*

Amaranthus caudatus L. (Love-lies-bleeding, pendant amaranth, velvet flower): *L. erysimi*

Amaranthus spinosus L. (Spiny amaranth, prickly amaranth, thorny amaranth): *A. craccivora*

Amaranthus viridis Desf. (Slender amaranth, green Amaranth.): *A. gossypii, M. persicae*

Anethum graveolens L. (Garden dill, dill): *M. persicae*

Asclepias curassavica L. (Mexican butterfly weed, blood-flower, scarlet milkweed): *A. nerii*

Basella alba L. (Phooi leaf, red vine spinach, creeping spinach, climbing spinach): *A. gossypii, M. persicae*

Bauhinia variegata L. (Barial, Kachnar, Kandan): *A. gossypii*

Benincasa hispida (Thumb.) Cogn. (wax gourd, white gourd, petha kaddu): *A. craccivora, A. gossypii*

Bidens pilosa L. (Spanish needle): *A. gossypii, A. spiraecola*

Bougainvillea spectabilis Willd. (Bougainvillea): *A. craccivora, A. spiraecola, M. ornatus, T. aurantii*

Calotropis gigantea (L.) W.T. Aiton (Milkweed, giant swallow-wort): *A. nerii*

Calotropis procera (Aiton) W.T. Aiton (Milkweed, swallow-wort): *A. nerii, L. erysimi, M. persicae*

Cassia fistula L. (Amaltas): *A. craccivora*

Catharanthus roseus (L.) G. Don (Rose periwinkle, sadabahar): *A. gossypii*

Chenopodium album L. (Pigweed, bathua): *A. gossypii, Aphis rhamniphila* David, Narayanan & Rajasingh, *L. erysimi, M. persicae*

Cissampelos pareira L. (Velvet leaf, abuta, pereira root, barbasco): *Aphis glycines* Matsumura

Cynodon dactylon (L.) Pers. (Doorva grass): *H. setariae, R. maidis, R. rufiabdominalis, S. graminum*

Cyperus rotundus L. (Nut grass, motha): *H. setariae, M. ornatus, R. maidis, R. rufiabdominalis, S. graminum*

Dactyloctenium aegypticum (L.) Willd. (Crowfoot grass): *H. setariae*

Datura metel L. (Angel's trumpet, dhatura): *A. fabae solanella*, *A. gossypii*, *M. persicae*

Dichrocephala integrifolia (L.f.) Kuntze (Haadchhun jar): *Eutrichosiphum pyri* Chakrabarti *et al.*

Fagopyrum esculentum Moench (Buckwheat): *A. gossypii*

Ficus benghalensis L. (Indian banyan): *G. ficicola*

Ficus heterophylla L.f. (Climbing stream fig): *T. aurantii*

Ficus religiosa L. (Bodhi tree, peepal): *A. gossypii*

Gomphrena globosa L. (Globe amaranth or bachelor button): *A. craccivora*

Hibiscus rosa-sinensis L. (China rose): *A. craccivora, A. gossypii, A. nasturtii, A. spiraecola, M. persicae, Schoutedenia emblica* (Patel & Kulkarni), *T. aurantii*

Lantana camara L. (Lantana): *A. fabae solanella, A. gossypii, A. nasturtii, A. spiraecola*

Launaea nudicaulis (Linn.) Hook. f.: *A. pisum, A. achyranthi* Theobald, *A. craccivora, A. gossypii, A. polygonacea* Matsumura, *A. spiraecola, Hyperomyzus carduellinus* (Theob.)

Lawsonia inermis L. (Henna, mehandi): *A. gossypii, A. spiraecola*

Medicago sativa L. (Alfalfa): *A. gossypii, A. pisum, A. craccivora, Therioaphis trifolii* (Monell)

Melilotus indicus (L.) All. (Indian sweet-clover): *A. gossypii*

Mentha arvensis L. (Field mint, pudina): *A. nasturtii*

Mimosa pudica L. (Touch-me-not, chhuyee-muyee): *A. craccivora*

Morus alba L. (Mulberry, shahtoot): *M. persicae*

Mussaenda sp. (Mussaenda, bedina): *A. craccivora*

Nerium oleander L. (Oleander): *A. gossypii, A. nerii, R. rufiabdominalis*

Nicotiana tabacum L. (Tobacco): *M. persicae*

Nyctanthes arbor-tristis L. (Night-flowering jasmine): *A. fabae solanella*, *A. spiraecola, M. persicae*

Ocimum americanum L. (Hoary basil): *A. gossypii*

Ocimum basilicum L. (Sweet basil): *A. gossypii*

Ocimum tenuiflorum L. (Holy basil, tulasi): *A. gossypii*

Oplismenus burmannii (Retz.) P. Beauv. (Wavy-leaf basketgrass, venupatrika): *H. setariae*

Papaver somniferum L. (Opium poppy): *A. gossypii*

Phyllanthus emblica L. (Indian goose-berry, aonla): *A. craccivora, S. emblica*

Sida cordifolia L. (bala, country mallow): *A. gossypii, A. spiraecola*

Solanum nigrum L. (Black nightshade, makoi): *A. craccivora, A. fabae solanella, A. gossypii, A. spiraecola, M. persicae*

Sonchus arvensis L. (Corn sow thistle, field sowthistle): *H. carduellinus*

Sonchus asper (L.) Hill (Spiny sow thistle): *A. craccivora, A. spiraecola, H. carduellinus*, *M. persicae*

Tabernaemontana divaricata (L.) R. Br. ex Roem. & Schult. (Milkwood pinwheel): *Aphis rumicis* Linnaeus

Tecoma stans (L.) Juss. Ex Kunth (Yellow trumpetbush): *A. fabae solanella*, *A. gossypii*

Tamarindus indica L. (Tamarind): *A. gossypii,*

Tridax procumbens L. (Coatbuttons): *A. gossypii, M. persicae*

Trifolium alexandrinum L. (Egyptian clover, berseem): *H. coriandri, T. trifolii*

Trigonella foenum-graecum L. (Fenugreek, menthi): *A. pisum, A. gossypii, M. persicae*

Trigonella polycerata L. (Trigonella): *A. craccivora*

Verbena officinalis L. (Verbena): *A. gossypii, M. persicae*

Vitex negundo L. (Nirgudi, nirgund): *A. gossypii*

10. Ornamental plants: A number of flowering and foliage plants are cultivated as ornamental crop not only in houses but also in fields for trade purposes. Among the aphids listed below some appear in pest seasonally and cause damage to their host plants, *e.g., A. gossypii* infests most of the winter flowering plants and presents a shabby look to them or cause early decay of the flowers, particularly of those belonging to Asteraceae. Identical effects are produced on chrysanthemums by *Macrosiphoniella sanborni* (Gill). Some times, roses are heavily infested by 5 species of aphids. Following is the list of aphids attacking ornamental plants of the area of survey (Table 8).

Table 8. List of aphids infesting ornamental plants in the terai of eastern Uttar Pradesh.

Plants/Aphids

Alcea rosea L. (Hollyhock): *A. gossypii*

Callistemon lonceolatus (Sm.) Sweet (Red bottlebrush): *A. gossypii*

Cestrum nocturnum L. (Queen of night, raat rani): *A. craccivora, A. fabae solanella, A. gossypii, A. spiraecola, T. aurantii*

Chrysanthemum indicum L. (Chrysanthemum, chandramukhi): *A. gossypii, A. nasturtii, M. sanborni*

Clerodendrum inerme (L.) Gaertn. (Glory bower, Indian privet): *A. gossypii, A. nasturtii*

Clerodendrum infortunatum L. (Hill glory bower, titabhamt, bhant): *A. gossypii*

Clerodendrum viscosum Vent. (glory bower, thuner, bhant): *A. fabae solanella, A. gossypii, A. nasturtii*

Cosmos bipinnatus Cav. (Mexican aster): *A. gossypii, A. spiraecola*

Dahlia pinnata Cav. (Dahlia): *A. craccivora, A. gossypii, A. spiraecola, G. psidii*

Delonix regia (Bojer ex Hook) Raf. (Flame tree, gulmohar): *M. sanborni*

Dieffenbachia seguine (Jacq.) Schott var. *seguine* (Dumb cane): *Rhopalosiphum nymphaceae* (Linn.)

Hibiscus rosa-sinensis L. (China rose): *A. craccivora, A. gossypii, A. nasturtii, A. spiraecola, M. persicae, S. emblica, T. aurantii*

Iberis amara *L. (Candytuft):* A. spiraecola

Impatiens balsamina L. (Balsam, lady spinner): *A. fabae solanella, A. gossypii, A. nasturtii, A. spiraecola*

Ixora coccinea L. (Jungle geranium, flame of the woods): *A. gossypii, A. nasturtii, M. sanborni*

Kalanchoe pinnata (Lam.) Pers. (Air plant, life plant, miracle leaf, goethe plant): *A. nerii, M. persicae*

Lagerstroemia indica L. (Crape myrtle): *Tinocallis kahawaluokalani* (Kirkaldy)

Lathyrus odoratus L. (Sweet pea): *A. pisum, A. gossypii*

Mussaenda frondosa L. (Mussaenda, bedina): *A. fabae solanella, T. odinae*

Nymphaea lotus L. (Lotus): *R. nymphaceae*

Rosa indica L. (Indian rose): *A. fabae solanella, A. gossypii, Macrosiphum rosae* (Linn.), *M. persicae, Sitobion rosaeiformis* (Das)

Tagetes erecta L. (Marigold, genda): *A. craccivora, A. fabae solanella, A. gossypii, A. spiraecola*

Thuja occidentalis L. (Arbor vitae): *Cinara tujafilina* (del Guercio)

11. On wood trees: Only two tree plants yielding commercial wood are infested with three species of aphids. *Dalbergia sisso* Roxb. ex DC and *Tectona grandis* L.f. are infested by *A. craccivora* and *A. gossypii,* and *A. nasturtii*, respectively. However, injury to these plants are negligible.

12. On bamboos : Two species of aphids, *Astegopteryx bambusae* (Buckton) and *Melanaphis donacis* (Passerini) were found on bamboo (*Bambusa bambos* (L.) Voss) without causing any visible harm to the plant.

13. Rubber yielding plant: *Ficus elastica* Roxb. ex Hornem. is a rubber yielding plant but in the target area, it is cultivated as ornamental crop. Only *A. gossypii* was observed on it without causing any harm to the plant.

On the above account, the most notorious aphid species that need control attention are *A. craccivora, A. fabae solanella*, *A. gossypii, A. spiraecola, B. brassicae*, *L. erysimi, M. persicae, R. maidis*, *M. sanborni*, *M. sacchari*, *S. miscanthi* and are considered as pest aphids and future work is needed on their bionomics, population dynamics on each and every crop for their population management.

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IMPACT OF DIFFERENT INSECTICIDES AND INTER CROPPING AGAINST *LIPAPHIS ERYSIMI* (KALT.) (HOMOPTERA : APHIDIDAE) ON CAULIFLOWER

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Abstract : Efficacy of six insecticides {viz. Cascade 10 DC (flufenoxuron) 200, 300, and 400 ml/ha, Ripcord 10EC (cypermethrin) 400ml/ha, Dermet 20EC (chlorpyriphos) 1000ml/ha, Dipel 8L (*Bacillus thuringiensis*) 800 ml/ha, Caldan 50 SP (cartap hydrochloride) 400g/ha and Rakshak Gold 1% (azadirachtin) 800 ml/ha) with two incessant spray at the interval of 15 days; two repellant crop (coriander and garlic) and a trap crop (mustard) were evaluated against the aphid, *Lipaphis erysimi* (Kalt.) in the vicinity of Birsa Agricultural University, Kanke, Ranchi (Jharkhand) on Cauliflower crop. All the tested insecticides and repellant crop minimized effectively the population of aphids. Dermet and Ripcord application comparatively resulted better control than other insecticides and intercrops. Most of the treatments showed more than 50% reduction in aphid's population after 5 days of insecticide application. In mustard intercropped plot and control plot, population of aphids increased throughout the investigation.

Key words : *LIpaphis erysimi*, cabbage, intercropping, pest management, insecticides.

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is one of the most important vegetable crops grown in India. Cauliflower is grown for its white tender head or curd. It is a delicate crop and needs more care to grow successfully than the most of the other vegetable crops. It has high quality proteins and peculiar in stability of Vitamin C after cooking. It is rich in minerals such as potassium, sodium, iron, phosphosus, calcium etc. it also contains Vitamin A. Cauliflower crop is damaged by a number of pests, among which aphid, *Lipaphis erysimi* (Kalt.) is one of the serious pest. The indiscriminate use of broad spectrum insecticide has resulted in reduction in biodiversity of natural enemies, outbreak of secondary pests, development of resistance to pesticide, pesticide induced resurgence and contamination of food and ecosystems. The evolution of crop protection through different phases (subsistence to disaster) finally led to the IPM concept. In spite of this, the application of insecticides cannot be abolished completely in order to combat the problems in the crop production system. Insecticide should be used judiciously up to the possible minimum level by supplementing with the simultaneous adoption of compatible and modified cultural practices such as intercropping resulting into the desirable suppression of the pest population for increasing the yield of the crop quantitatively and qualitatively. With the above background keeping in view, the present investigation has been conducted.

MATERIALS AND METHODS

The field experiment was conducted at the farm of Birsa Agricultural University, Kanke, Ranchi (Jharkhand) during winter season in RBD with 4 replications. The plot size was 2.0 X 2.7m. Efficacy of six insecticides, viz. Cascade 10 DC (flufenoxuron) 200, 300, and 400 ml/ha, Ripcord 10EC (cypermethrin) 400ml/ha, Dermet 20EC (chlorpyriphos) 1000 ml/ha, Dipel 8L (*Bacillus thuringiensis*) 800 ml/ha, Caldan 50 SP (cartap hydrochloride) 400g/ha and Rakshak Gold 1% (azadirachtin) 800 ml/ha. In addition, two repellent crops, viz. local variety of coriander and garlic and a trap crop, viz. mustard var. *varuna*, were tested against the aphid, *L. erysimi*. A control plot (without any insect management practice) was also kept for

Table 1. Percentage of reduction in aphid (*Lipaphis erysimi*) population as influenced by insecticides and intercropping after first spray of insecticides.

Treatments	Dose ml/ha	Percentage reduction in aphid Population per plant after first spraying					
		Days after treatment					
		1	3	5	7	10	14
T1-Cascade 10 DC	200	31.59	42.32	53.48	64.64	74.64	71.01
T2-Cascade 10 DC	300	46.09	55.51	66.52	77.39	81.88	78.26
T3-Cascade 10 DC	400	54.34	63.72	74.07	85.38	88.97	86.21
T4-Ripcord 10EC	400	80.00	83.33	86.67	93.33	93.33	86.67
T5-Dermet 20EC	1000	86.67	89.60	92.40	92.40	94.53	90.00
T6-Dipel 8L800	37.99	44.32	58.13	71.80	85.61	78.42	
T7-Caldan 50 SP	400	42.63	49.28	58.67	68.06	71.10	67.49
T8-Rakshak Gold 1%	800	28.70	35.07	53.91	58.12	69.42	68.12
T9-Cauliflower + garlic		33.51	34.75	37.53	42.20	54.42	55.56
T10-Cauliflower + coriander		35.06	50.00	56.79	63.41	65.99	66.67
T11-Cauliflower + mustard		+3.77	0.0	+1.23	+7.56	+3.97	+6.00
T12-Control		10.00	+14.29	+15.71	+17.14	+26.00	+28.57
CD AT 5%		0.40	0.44	0.44	0.47	0.37	0.41
CV %		12.86	14.90	16.32	18.49	15.03	16.25
S.Em. ±		0.14	0.15*	0.15*	0.16*	0.13*	0.14*

\+ = Percent increase in the populationAphid population before 1st spray:- T1= 6.90, T2= 6.90, T3= 7.25, T4= 7.50, T5= 7.50, T6= 6.95, T7= 6.92, T8= 6.90, T9= 7.00, T10= 7.95, T11= 7.92, and T12= 7.00

the comparison. Insecticidal treatments were applied twice at 15 days interval as soon as aphid appeared in the field. The population of aphids was counted a day before treatment and also 1, 3, 5, 7, 10 and 14 days after first and second spray of insecticide from 10 randomly selected plants after treatment.

RESULTS AND DISCUSSION

Aphid population in all insecticide treated plots was reduced drastically after 5 days of insecticide spray and onward up to 14th days as compare to untreated control plot. Data obtained during observation displayed in Table1and 2 revealed that among the all 11 treatments including trap crop and repellent crop, Dermet-20EC gave highest reduction of the population of aphids on cauliflower plant throughout the observation, i.e. (86.67% to 94.53% after 1st spray and 78.67 to 86.67% after 2nd spray) closely followed by Ripcord-10EC (80% to 93.33% after1st spray and 80% to 90% after 2nd spray). All the rest 6 insecticidal treatment also showed comparatively better result, i.e. more than 50% reduction in aphids' population after 5 days and onward of first and second spray except Dipel-8L [viz. Cascade-10DC (400 ml) (74.07% after 1st spray to 94.00% after 2nd spray; Cascade-10DC (300 ml) (66.52% after 1st to 92.67% after 2nd spray); Cascade-10DC (200ml) (53.48% after 1st spray to 89.50% after 2nd spray}; Dipel- 8L (34.00% after 1st spray to 86.67% after 2nd spray); Rakshak gold - 1% (53.91% after 1st spray to 72.73% after 2nd spray) and Caldan-50SP (53.78% after

Table 2. Percentage of reduction in aphid (*Lipaphis erysimi*) population as influenced by insecticides and intercropping after second spray of insecticides.

Treatments	Dose ml/ha	Percentage reduction in aphid Population per plant after second spraying					
		Days after treatment					
		1	3	5	7	10	14
T1-Cascade 10 DC	200	25.00	49.50	59.50	69.00	89.50	79.00
T2-Cascade 10 DC	300	33.33	46.67	79.33	86.00	92.67	92.67
T3-Cascade 10 DC	400	67.00	74.00	81.00	89.00	94.00	94.00
T4-Ripcord 10EC	400	80.00	84.00	90.00	90.00	90.00	90.00
T5-Dermet 20EC	1000	78.67	84.00	86.67	85.33	85.33	86.67
T6-Dipel 8L800	2.00	12.00	34.00	55.33	77.33	86.67	
T7-Caldan 50 SP	400	36.00	43.56	53.78	64.44	85.33	85.33
T8-Rakshak Gold 1%	800	29.55	35.91	54.55	72.73	72.73	72.73
T9-Cauliflower + garlic		66.67	70.00	66.67	72.73	77.27	79.17
T10-Cauliflower + coriander		72.22	75.00	73.81	77.27	79.55	81.25
T11-Cauliflower + mustard		+11.11	+20.00	+14.29	0.00	+9.09	+8.33
T12-Control		0.00	+11.11	+16.67	+22.22	+22.22	+33.33
CD AT 5%		0.38	0.31	0.31	0.26	0.19	0.20
CV %		16.60	13.66	13.76	12.04	9.10	9.78
S.Em. ±		0.13*	0.11*	0.11*	0.09*	0.06*	0.07*
+ = Percent increase in the population							

1st spray to 71.10% after 2nd spray).

So far impact of intercropping on the aphid population is concerned, both the repellent crops, i.e. coriander (56.79% after 1st spray to 81.25% after 2nd spray) and garlic (37.53% after 1st spray to 79.17% after 2nd spray) found to be equally effective in reducing the aphid population as compared to trap crop, i.e. mustard and untreated control plot which harbored higher aphid population throughout the investigation. In mustard intercropped plot aphid population was in increasing order which might be due to similar host and small plot size. Therefore, as insecticidal treatment, Dermet-20EC and Ripcord-10EC can be used for quick knock down effect against the aphid, *L. erysimi*. Coriander and garlic are also suggested to use as intercrop against the aphid.

The results supported the findings of earlier workers such as Brar and Sandhu (1981) who reported that foliar spraying of insecticides, viz . chlorpyriphos, dicrotophos, monocrotophos, phosalone, dimethoate and oxydemeton-methyl were found very effective in controlling mustard aphid, *L. erysimis*. Maximum yield of cabbage was obtained by the foliar application of cypermethrin (0.002%) followed by monocrotophos (0.05%), phosphamidon (0.04%) and cypermethrin (0.015%), respectively in Rajsthan (Gera and Bhatnagar, 1992). Wilken (1972) stated that intercropping affect the micro-climate of the agro-ecosystem, ultimately producing an unfavourable environment for the pests.

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