J. Biol. Control, 21(Special Issue): 37-43, 2007

Parasitization of aphids on cauliflower seed crop in relation to their population build-up in mid-hills of Himachal Pradesh

P. R. GUPTA, SARIKA MALHOTRA and A. K. VERMA
Department of Entomology and Apiculture
Dr. Y. S. Parmar University of Horticulture and Forestry
Nauni, Solan - 173 230, Himachal Pradesh, India
E-mail: premra_21@yahoo.co.in

ABSTRACT: Continuous monitoring of aphid population on cauliflower seed crop from December to April revealed an increase in infested plants (23 to 48%), aphid population (8 to 131/plant) and parasitization (1 to 3.8%) during January to mid-March, followed by a decline in aphid infestation and further increase in parasitization (to 7.4%) till April 6, despite prominence of coccinellid activity (0.8-9.5 beetles/plant). There was concomitant occurrence of *Brevicoryne brassicae* (Linnaeus) and *Myzus persicae* (Sulzer), the former being predominant (65.3%) and their parasitization varied from 0.7-8.3 (av. 3.6) and 1.8-8.2 per cent (av. 4.4), respectively. Intra-plant distribution indicated that aphid infestation was maximum on inner whorl of leaves, followed by middle and outer whorls, but number of mummified aphids did not vary significantly in respect of position of leaves. During mid-March to early-April also, *B. brassicae* outnumbered *M. persicae* on terminal bolts and their parasitization was 27.4 and 14.5 per cent. From the mummies of aphids collected from the cabbage fields during December, and May-June, the parasitoid *Diaeretiella rapae* (M'Intosh) (Aphidiidae) and the hyperparasitoid *Pachyneuron aphidis* (Bouche) (Pteromalidae) emerged, but the emergence was poor (5.6 and 6.3%, respectively). The mummies from which the parasitoid emerged were bigger with oval and uniform emergence holes around cornicles than the mummies from which hyperparasitoid emerged. The emergence hole of the latter was irregular, smaller and often towards anterior side of the body.

KEY WORDS: *Brevicoryne brassicae*, cabbage, cauliflower, *Diaeretiella rapae*, hyperparasitoid, *Myzus persicae*, *Pachyneuron aphidis*, parasitoid

INTRODUCTION

Cabbage and cauliflower are grown as off-season crops over an area of about 3650 hectare with annual production of 96800 metric tons in Himachal Pradesh (Department of Agriculture, Himachal Pradesh). These crops grown during summer season often fetch a premium price in the market and thus bring lucrative returns to farmers. Cauliflower crop grown for seed also fetches higher returns than the head crop. These crops, however, are attacked by over 20 insect pests (Bhalla and Pawar, 1977) and three key pests have been identified, namely the cabbage aphid, *Brevicoryne brassicae* (Linnaeus), cabbage caterpillar, *Pieris brassicae* (Linnaeus) and diamondback moth, *Plutella xylostella* (Linnaeus). Of the three, the first one is the most persistent and serious, particularly on the winter crops. The other aphid species, which concomitantly infest cauliflower and cabbage, are the mustard aphid, *Lipaphis erysimi* (Kaltenback), and the green peach aphid, *Myzus persicae* (Sulzer). These aphids are also known as vectors of a number of virus diseases of these crops (Bonnemaison, 1965).

Natural enemies play an important role in the suppression of aphid populations on a number of plants. In Himachal Pradesh, *Aphidius* sp. was reported to parasitize the cabbage aphid to the extent of 2.9-38 per

cent at Solan (Kotwal *et al.*, 1984) and at Palampur, *Diaeretiella rapae* (M'Intosh) parasitized *L. erysimi* to the extent of 2.4-36.9 per cent and *B. brassicae* to the extent of 8.7-11 per cent on rapeseed mustard (Raj and Sharma, 1993). In view of sizeable parasitization of aphids infesting cole crops, a study was undertaken at Solan in Himachal Pradesh to work out the extent of parasitization of aphids on seed crop of cauliflower in relation to changes in aphid populations and to determine the association of hyperparasitoid (s) with aphids on this crop.

MATERIALS AND METHODS

In a well-prepared field of about 160 m^2, 400 cauliflower seedlings of 'Pusa Snowball K-1' were transplanted on October 22, 1997. All the recommended cultural practices were followed for raising the crop but no insecticide application was given. The data on per cent plant infestation by the aphids was worked out by monitoring one hundred randomly selected plants at weekly interval and the plant having at least one established colony was considered as infested one. Separate counts of different species of aphids were recorded during February-March on the basis of body colour, waxy deposit on the body and shape of cornicles. Mummified aphids without emergence holes of the parasitoid were also counted to work out the percentage parasitization of the respective species. In order to ascertain suitability of plants for natural colonization of aphids as well as preference of the primary parasitoid to distribute its progeny on the plant, one leaf each from the outer, middle and inner whorl of leaves was excised from 10 randomly observed infested plants during February-March and brought to the laboratory for recording the aphid count and parasitization in each aphid species. Similarly, after bolting of the crop, three infested 10cm terminal shoots from each of 10 randomly selected plants were collected at weekly interval during March-April and brought to the laboratory to record the aphid count and parasitization on each aphid species.

Mummified aphids without parasitoid-emergence holes were collected from cabbage and cauliflower fields and stored in homeopathic glass vials plugged with cotton bungs and maintained at room temperature for adult emergence. Mummified aphids were measured under a stereoscopic microscope by using pre-calibrated micrometer. Observations on size, position and shape of the emergence hole were also recorded. Mummies without emergence hole were dissected after about three weeks of collection to ascertain the reason for failure of parasitoid emergence. Besides, coccinellids encountered on the plants during recording of observations were also counted.

RESULTS AND DISCUSSION

1. Aphid infestation and population build up on cauliflower seed crop

On the cauliflower seed crop transplanted in late October, aphid infestation commenced with the emigration and settling of alates of *B. brassicae* and *M. persicae*, by late December. Consequently, colonization was evident in the first week of January, though climatic conditions were congenial for aphids even during October-December (temperature range: 4.5-21.5°C). According to Chandra and Kushwaha (1987), aphid infestation generally appears on the cole crops within a month of transplanting but further population build up and period of peak activity would depend upon early or late appearance of aphids, the quantum of emigrants and its spread, age or stage of the crop at the time of infestation and prevailing climatic conditions. Atwal *et al.* (1971) reported that early appearance of aphids on mustard was responsible for attaining peak populations early in the season.

Plant infestation increased from 23 per cent in early January to 48 per cent in early March. This increase in infestation was evidently associated with settlement of alates on un-infested plants, though the proportion of alates was low (2.1-4.9% of the population). Along with increase in plant infestation there was increase in total population of aphids, such that peak infestation occurred in March. During January – mid March, the mean minimum and maximum weekly temperature ranged from 0 to 9.5 and 16.2 to 20.8°C and mean relative humidity from 49-68 per cent. The population declined later when the mean minimum and maximum temperature ranged from 7 to 10.5 and 22.9 to 24.7°C. According to Sengonca and Klingauf (1973), activity of *B. brassicae* and *M. persicae* increases as the temperature increases from 8 to 32°C. The mean temperature range of 7 to 24.7°C, prevailing in Solan during mid-March to early-April was, therefore, conducive for the cabbage aphid but even then its population declined. During the same phase, there was appreciable increase in parasitization of aphids and coccinellid predators appeared in sizable numbers. Further, reduction in tenderness of leaves also reduced their suitability for aphid activity. All these factors may have contributed to declining phase of aphid populations on the plants.

2. Extent of natural parasitization of aphids on cauliflower

In the present study, one primary parasitoid *Diaeretiella rapae* (Braconidae: Aphidiinae) was reared from the mummified aphids of *B. brassicae* and *M. persicae*. The same species was reported to parasitize cabbage aphid in Solan area by Tandon *et al.* (1977). However, from the same locality, Kotwal *et al.* (1984) reported only *Aphidius* sp. on *B. brassicae* infesting cauliflower. Invariably *Diaeretiella* has been reported as *Diaeretus* prior to sixties (*e.g.* Spencer, 1926) and even later (Singh and Rawat, 1981; Chandra and Kushwaha, 1987), and as *Aphidius* (Dhiman and Kumar, 1985). *Diaeretiella* genus has been in use since 1962 (Stary, 1970). The characters provided by Stary (1970) and Stary and Ghosh (1983) matched the characters of the aphidiid reared from the aphids on cauliflower in the present study and the identity of the parasitoid was thus confirmed. From the mummies of aphids collected from the cabbage fields during December, and May – June (967 in all), *D. rapae* and the hyperparasitoid *Pachyneuron aphidis* (Bouche) (Pteromalidae) emerged but the emergence was poor (5.6 and 6.3%, respectively). In the sample of 100 mummies from which no emergence of parasiotid/ hyperparasitoid took place, dissection revealed the presence of dead larvae (24%), pupae (58%) and adults (4%) of *D. rapae* and in rest (14%), 10 per cent were with dead pupa and 4 per cent with dead adult of *P. aphidis*.

In the first observation recorded in the experimental plot during December on cabbage, some parasitized alates of *M. persicae* and *B. brassicae* were also observed on the plants, revealing thereby that alates helped in bringing the parasitoid into the arena of their settlement. Alates parasitized as last instar nymphs or as freshly formed adults would be able to take flight before the parasitoid larva developed to the fourth instar. However, the chances of synchronization of vulnerable stage of the alate and the parasitoid activity were meager and therefore, only a few parasitized alates were intercepted on the crop. Alates would appear in abundance at the commencement of infestation and late in the season during declining phase of infestation as reported by Chua (1977).

The extent of parasitization of aphids by *D. rapae* on cauliflower varied from 1 to 7.4 per cent during January to April. A similar extent of parasitization of *B. brassicae* was reported by Tandon *et al.* (1977) on cauliflower (0.1-6.2%) from Solan and by Raj and Sharma (1993) on mustard (8.7-11%) from Palampur in Himachal Pradesh. With an increase in infested plants (23 to 48%) during January to mid-March, aphid population (8 to 131/plant) and parasitization (1 to 3.8%) also increased, followed by a decline in aphid infestation and further increase in parasitization (to 7.4%) till April 6, despite prevalence of coccinellid activity (0.8-9.5 beetles/plant). The extent of parasitism at peak period of activity was reported to be as high as 63.4 to 93.0 per cent on mustard, cauliflower and cabbage by Chandra and Kushwaha (1987), and >60 per cent on *L. erysimi* infesting cole crops by Atwal *et al.* (1971). Raj and Sharma (1993) also reported up to 36.9 per cent parasitism of *L. erysimi* on mustard during the peak period of activity. The infestation by *B. brassicae* was very high on cabbage during April – June in Solan and the proportion of mummified aphids was also high during this period. However, from such mummies parasitoid emergence was only 11.9 per cent. The above reports of high parasitization could be explained on the basis that since the mummies without exit hole are securely attached to the plant and often do not get dislodged until disturbed, their repeated counts are likely to be higher and as such will not give the true extent of parasitization on any given day of observation. Mummies without emergence hole contained dead larva, pupa or adult of the primary parasitoid or that of the hyperparasitoid.

While average population of *B. brassicae* (34-84 / plant) and its parasitization (0.7-3.6%) gradually increased during February to mid-March, that of *M. persicae* varied from 28 to 44 per plant with parasitization in the range of 1.8 to 6.5% without any pattern (Fig. 1 and Fig. 2). This may be due to oligophagous nature of *B. brassicae* that it is better adapted to crucifers. Although percentage of alates was more in *M. persicae* than in *B. brassicae*, yet the increase in population was not as evident. The occurrence of *M. persicae* on cauliflower during winter and its carry over till summer on this crop in mid hills, where it does not produce sexual generation on peach as its primary host (Verma, 1993), is of significance for this polyphagous species.

3. Intra-plant distribution of aphids and their parasitization

The data on aphid population and mummies collected from 3-leaf samples per plant (one each from outer, middle and inner whorl of leaves) (Table 1) indicated that the mean aphid population increased significantly between first week of February and first week of March (7-29.4/plant). Normally the population of *B. brassicae* remained significantly higher (19.7/plant) than *M.*

persicae (17.5/plant). In general, the aphid population was minimum on the outer leaves and significantly higher on leaves from middle whorl and maximum on leaves from inner whorl. As regards the mummified aphids, the per leaf count increased slowly till the last week of February but significantly more number was recorded in the last two observations during March as compared with initial count. Although aphid population was more on leaves from the inner whorl of the plant, yet parasitization did not vary with respect to position of leaves on the plant. Amongst the two aphid species, more number of mummies of *B. brassicae* was recorded than that of *M. persicae*. The population of *B. brassicae* was distinctly more than that of *M. persicae* on leaves from outer (11.9 and 8.1/ leaf) and inner whorl (27.3 and 22.5/ leaf) but marginally less on leaves from middle whorl (20 and 21.8/ leaf). The parasitization of *B. brassicae*, during different dates of sampling, on leaves from outer, middle and inner whorl varied from 3.4-14.5 (6.8 ± 1.6), 0-15.4 (6.9 ± 2.5) and 0.6-13.6 (4.5 ± 2.0) per cent while that of *M. persicae* varied from 1.1-12.0 (5.6 ± 2.0), 1.2-10.9 (3.5 ± 1.6) and 0-2.3 (0.9 ± 0.4) per cent, respectively. The overall parasitization of aphids on leaves from the respective whorl was 3.0-9.1, 1.5-13.7, and 0.6-9.8 percent.

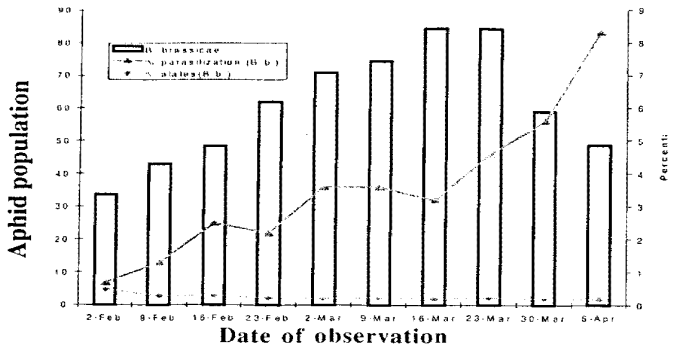

Fig. 1. Population of *B. brassicae* and its parasitization

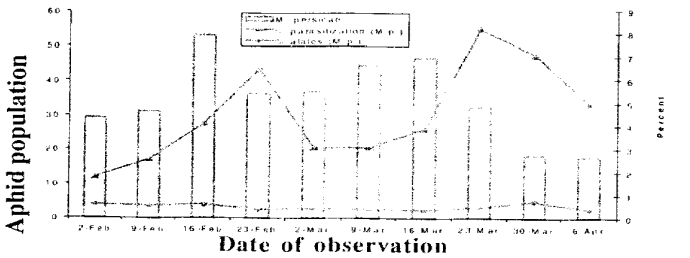

Fig. 2. Population of *M. persicae* per plant and its parasitization

4. Aphid infestation on terminal bolts and their parasitization

After bolting of inflorescence, mature leaves of

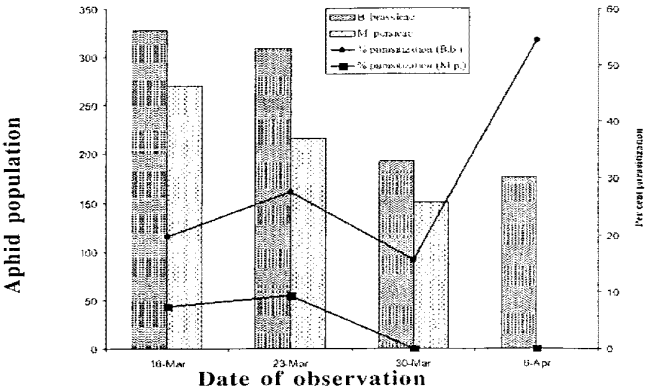

Fig. 3. Population of aphids on 3 terminal bolts (10-cm long) each from 10 plants of cauliflower

cauliflower became unsuitable for aphid development and the aphids tended to aggregate on newly formed bolts. The population of *B. brassicae* (1.6 fold of *M. persicae*) and its parasitization, on the whole, was more on three 10cm bolt-samples / plant (Fig. 3). With respect to date of sampling, parasitization was 8.8-54.4 per cent in the case of *B. brassicae* and 0-9.3 percent for *M. persicae*. These observations thus indicated that assessment of the extent of parasitization tended to vary with respect to species of aphid, and time and method of sampling. Therefore, observations on whole-plant basis are expected to give a true and accurate picture of parasitization in these crops. Incidentally, very high parasitization of 54.3 per cent was observed in the first week of April. This may be attributed to low aphid count and relatively more number of aphid mummies from which the parasitoid failed to emerge and probably remained attached to the plants since the earlier observations. Other reasons for high degree of parasitization on terminal bolts (24.4%) rather than on whole plant (5.6%) during the same period could be higher colonization by aphids on tender terminal bolts/shoots, greater frequency of parasitoid visits on the terminal sites offering more number of aphids for parasitization and presence of flowers that acted as a source of nectar.

5. Characteristics of parasitoid and hyper-parasitoid emergence holes on mummified aphids

Since all the morphological characters of aphids, like cornicles, cauda, body pattern, etc. were well preserved in the mummies, this facilitated identification of the parasitized aphid. Only a few mummies of alates of both species were observed on cauliflower plants and majority of parasitized aphids was apterae. Adult

Table 1. Distribution of aphids and their mummies (in parentheses) on cauliflower crop during 1998 at Solan

Date of observation	Outer leaf			Middle leaf			Inner leaf			Aphids (D x A)		Date (D)
	B. B	*M. p.*	Both aphids	*B. b*	*M. p.*	Both aphids	*B. b.*	*M. p.*	Both aphids	*B. b.*	*M. p.*	
February, 02	3.0(0.2)	5.0(0.1)	4.0(0.2)	5.0(0.4)	7.0(0.1)	6.0(0.7)	8.0(0.1)	14.1(0.1)	11.1(0.1)	5.3(0.2)	8.7(2.4)	7.0(0.3)
09	7.0(0.4)	9.1(0.1)	8.1(0.3)	7.6(0.3)	13.0(0.3)	10.3(0.3)	16.0(0.1)	18.8(0.1)	17.4(0.1)	10.2(0.3)	13.6 (0.2)	11.9(0.2)
16	14.5 (0.6)	7.2(0.9)	10.9 (0.8)	23.7(0.6)	26.6(0.9)	25.2(0.8)	24.2(0.6)	21.2(0.5)	22.7(0.6)	20.8(0.6)	18.3 (0.8)	19.6(0.7)
23	19.7 (0.7)	14.9 (0.9)	17.3 (0.8)	18.2(0.7)	35.5(0.9)	26.9(0.8)	32.8(1.0)	30.9(0.4)	31.9(0.7)	23.6(0.8)	27.1 (0.7)	25.3(0.8)
March 02	20.5 (1.6)	6.6(0.9)	13.6 (1.3)	35.0(1.6)	31.0(0.6)	33.0(1.1)	48.6(3.0)	34.5(0.3)	41.6(1.7)	34.7(2.1)	24.0 (0.6)	29.4(1.3)
09	6.5(1.2)	5.5 (0.0)	6.0 (0.6)	30.3(1.1)	17.9(0.1)	24.1(0.6)	34.2(5.4)	15.4(0.0)	24.8(2.7)	23.7(2.6)	12.9 (0.0)	18.3(1.3)
(A x P)	11.9 (0.8)	8.1(0.5)	(D x P)	19.2(0.8)	21.8(0.6)	(D x P)	27.3(1.7)	22.5(0.2)	(D x P)	19.7(1.1)	17.5 (0.5)	(A)
Position of leaf (P)	10.0(0.6)			20.9(0.7)			24.9(1.0)					

B. b. = *Brevicoryne brassicae*, *M. p.* = *Myzus persicae*

	CD (P = 0.05)		
Date (D)	3.4 (0.7)	(D x P)	5.9 (1.3)
Aphids (A)	2.0 (0.4)	(A x P)	3.4 (0.7)
Leaf (P)	2.4 (0.5)	(D x A x P)	8.4 (0.8)
(D x A)	4.8 (1.1)		

Table 2. Dimensions of mummified aphids of *B. brassicae* and *M. persicae* and of the exit hole made by the parasitoid and hyperparasitoid on mummies (mm)

Attributes	Parasitoid emerged Mean ± SE(Range)	Hyperparasitoid emerged Mean ± SE(Range)	't' calculated
B. brassicae			
Body			
Length	1.609 ± 0.058 (1.222-2.077)	1.427±0.054(1.246-1.613)	18.21*
Breadth	1.08± 0.040(0.733-1.393)	1.0291±0.46(0.904-1.222)	2.395*
Exit hole[a]			
Length	0.529±0.018(0.391-0.708)	0.476±0.023(0.342-0.562)	2.384*
Breadth	0.408±0.015(0.317-0.537)	0.320±0.030(0.195-0.415)	3.76*
M. persicae			
Body			
Length	1.815±0.054(1.222-2.346)	1.503±0.073(1.222-1.830)	3.188*
Breadth	1.250± 0.030(0.977-1.637)	1.016±0.040(0.879-1.222)	4.85*
Exit hole[a]			
Length	0.567±0.013(0.415-0.684)	0.464±0.014(0.360-0.580)	3.84*
Breadth	0.458±0.013(0.317-0.586)	0.408±0.015(0.260-0.510)	3.70*

Significant at P=0.05; [a] Dimension of exit holes of the parasitoid or the hyperparasitoid *B. brassicae* and *M. persicae* do not differ significantly in t-test.

parasitoid and hyperparasitoid escaped from the mummified aphid by cutting a small hole on it. The emergence hole of *D. rapae* was oval and uniform with smooth margin and often with a circular lid attached to it whereas that of hyper-parasitoid was with irregular margins and without a lid. The emergence hole of *D. rapae* was located between the cornicles, generally towards the posterior side (in 63.4% cases), or just above the cornicles (mesad or slightly laterad in 29.3% cases). Thus, in majority of cases (92.7%) the emergence hole of the primary parasitoid was around the cornicles with a flap-like lid covering it. Contrary to this, in case of *P. aphidis*, the emergence hole was mostly towards the anterior side, posterior to the head (in 48% cases), or around the cornicles (in 28% cases) and was not covered by the lid.

Mummies of *B. brassicae* (apterae and alatae) with emergence hole were light to dark creamish-brown with small dark spots on the abdomen and had small uniformly dark cornicles, slightly swollen in apical half. The average length and breadth of mummies from which the parasitoid had emerged ranged 1.222-2.077 and 0.733-1.393mm, while those with exit hole of the hyperparasitoid measured 1.246-1.613 and 0.904-1.222mm, respectively (Table 2). The mean size of the mummies with emergence hole of the parasitoid (1.609mm x 1.08mm) and that of the hyperparasitoid (1.427mm x 1.03mm) differed significantly and usually the mummy with emergence hole made by the parasitoid was bigger than that of the hyperparasitoid. Even the size of emergence hole of the parasitoid (0.529mm x 0.408mm) was significantly bigger than the hyper parasitoid (0.476mm x 0.320mm). Mummified aphids of *M. persicae* were lighter in colour than that of *B. brassicae* and cornicles of both apterae and alates were longer and slightly clavate in apical half. The mummies of *M. persicae* with emergence hole of the parasitoid were 1.222-2.346mm (av. 1.815mm) in length and 0.977-1.637mm (1.25mm) in breadth. As in the case of *B. brassicae*, in this species also mummies with emergence hole of the hyper-parasitoid were significantly smaller in size (1.22-1.83mm in length and 0.88-1.22 mm in breadth) and with bigger emergence hole of the parasitoid (0.567mm x 0.458mm) that of the hyper-parasitoid (0.464mm x 0.361mm).

REFERENCES

Atwal, A. S., Chaudhary, J. P. and Ramzan, M. 1971. Mortality factors in the natural population of cabbage aphid, *Lipaphis erysimi* (Kalt.) (Hemiptera: Aphididae), in relation to parasites, predators and weather conditions. *Indian Journal of Agricultural Sciences*, **41**: 507-510.

Bhalla, O. P. and Pawar, A. D. 1977. *A Survey Study of Insect and Non-insect Pests of Economic Importance in Himachal Pradesh*, Tiku and Tiku, Kitab Mahal, Bombay, 80 p.

Bonnemaison, L. 1965. Insect pests of crucifers and their control. *Annual Review of Entomology*, **10**: 233-256.

Chandra, S. and Kushwaha, K. S. 1987. Impact of environmental resistance on the aphid complex of cruciferous crops under the agroclimatic conditions of Udaipur. II. Biotic components. *Indian Journal of Entomology*, **49**: 86-113.

Chua, T. H. 1977. Population studies of *Brevicoryne brassicae* (L.), its parasites and hyperparasites in England. *Researches on Population Ecology*, **19**: 125-139.

Dhiman, S. C. and Kumar, V. 1985. First record of two hyperparasites of *Lipaphis erysimi* (Kalt.) (Homoptera: Aphididae). *Journal of Bombay Natural History Society*, **82**: 681-682.

Kotwal, D. R., Bhalla, O. P. and Verma, A. K. 1984. Natural enemies of the cabbage aphid, *Brevicoryne brassicae* (Linn.) in the mid-hill region of Himachal Pradesh. *Indian Journal of Agricultural Sciences*, **54**: 1011-1012.

Raj, D. and Sharma, G. D. 1993. Prevalence of *Diaeretiella rapae* (Hymenoptera: Aphidiidae) on aphid complex infesting rapeseed. *Journal of Insect Science*, **6**: 285-287.

Sengonca, C. and Klingauf, F. 1973. Behaviour of an aphid parasite and its hosts in relation to ecological factors. *Zoologische Jahriurcher, Systematik Okologie und Geographid der Tiere*, **100**: 81-106.

Singh, O. P. and Rawat, R. R. 1981. New record of *Diaeretus rapae* (M'Intosh) as an endo-parasite of *Lipaphis erysimi* (Kalt.) from Madhya Pradesh, India. *Science and Culture*, **47**(8): 288-290.

Spencer, H. 1926. Biology of the parasites and hyperparasites of aphids. *Annals of the Entomological Society of America*, **19**: 119-157.

Stary, P. 1970. *Biology of aphid parasites (Hymenoptera: Aphidiidae) with respect to integrated control*. Dr. W. Junk, N. V., The Hague. 643 p.

Stary, P. and Ghosh, A. K. 1983. *Aphid parasitoids of India and adjacent countries (Hymenoptera: Aphidiidae)*. Technical Monograph No. 7, Zoological Survey of India, Calcutta. 96 p.

Tandon, P. L., Bhalla, O. P. and Verma, A. K. 1977. A note on the seasonal population fluctuation of cabbage aphid on seed cauliflower. *Vegetable Science*, **4**: 145-147.

Verma, K. D. 1993. Aphids - biology and virus transmission, pp. 575-589. In: Chadha, K. L. and. Grewal, J. S. (Eds.). *Advances in Horticulture*, Volume 7 – Potato. Malhotra Publishing House, New Delhi, India.