

**Relative abundance and feeding potential of
syrphid fly (Diptera) on cabbage aphid
[*Brevicoryne brassicae* (Lin.)]**

FAROOQ AHMAD DAR

(2005-A-768-M)



**DIVISION OF ENTOMOLOGY
FACULTY OF POSTGRADUATE STUDIES
SHER-E-KASHMIR UNIVERSITY OF AGRICULTURAL SCIENCES &
TECHNOLOGY OF KASHMIR**

2008

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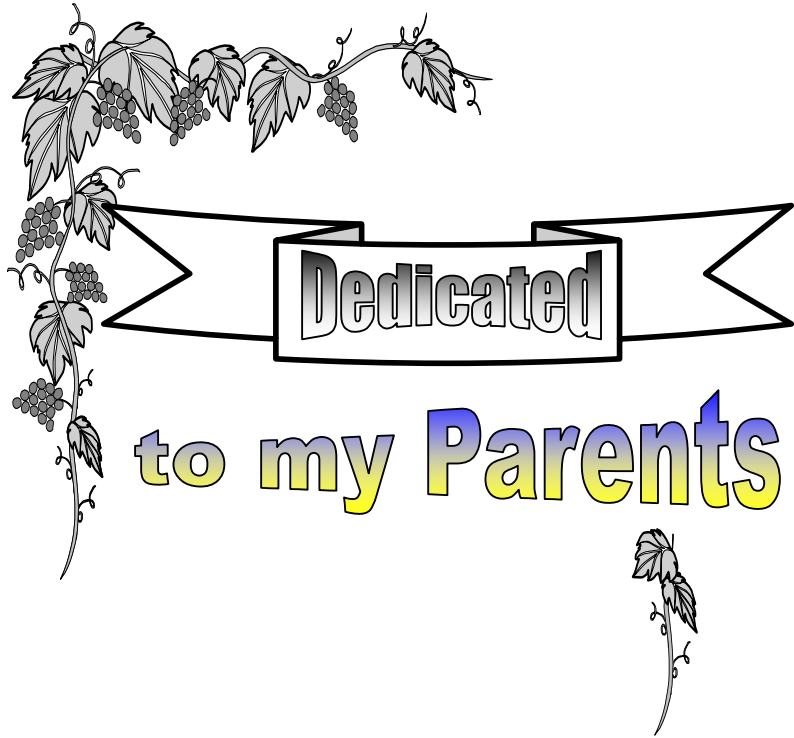
THESIS

Submitted to

**The Faculty of Postgraduate Studies
Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir in
partial fulfilment of requirement for the award of the degree of**

**MASTER OF SCIENCE IN AGRICULTURE
(Entomology)**

2008



Dedicated

to my Parents

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Division of Entomology, Shalimar Campus, Srinagar

-::o::-

Certificate – I

This is to certify that the thesis entitled “**Relative abundance and feeding potential of syrphid fly (Diptera) on cabbage aphid [*Brevicoryne brassicae* (Lin.)]**” submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Agriculture (Entomology)**, to the Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, is a record of bonafide research work carried out by **Mr. Farooq Ahmad Dar (Regd. No. 2005-A-768-M)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that any help or information received during the course of investigation have duly been acknowledged.

(Dr. M. Afzal Bhat)
Chairman
Advisory Committee

Endorsed

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Certificate – II

We, the members of the Advisory committee of **Mr. Farooq Ahmad Dar (Regd. No. 2005-A-768-M)**, a candidate for the degree of **Master of Science in Agriculture (Entomology)**, have gone through the manuscript of the thesis entitled, “**Relative abundance and feeding potential of syrphid fly (Diptera) on cabbage aphid [*Brevicoryne brassicae* (Lin.)]**” and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of degree.

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This is to certify that the thesis, “**Relative abundance and feeding potential of syrphid fly (Diptera) on cabbage aphid [*Brevicoryne brassicae* (Lin.)]**” submitted by **Mr. Farooq Ahmad Dar (Regd. No. 2005-A-768-M)** to the Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, in partial fulfilment of the requirements for the award of the degree of **Master of Science in Agriculture (Entomology)** was examined and approved by his Advisory Committee and external examiner on

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Title of the Thesis : **“Relative abundance and feeding potential of syrphid fly (Diptera) on cabbage aphid [*Brevicoryne brassicae* (Lin.)]”**

ABSTRACT

Investigations on relative abundance, biology and feeding potential of syrphid fly were carried out in the field and PG laboratory of the Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during 2006-07. The results revealed that the maximum number (281) of syrphid flies were found in the month of June and the minimum number (2) were found in the month of January. Among the various species *Helophillus vittatus* (Weid) was found most abundant (23.99%) and *Eristalis* sp. least (3.56%). The order of abundance was *Helophillus vittatus* Weid (23.99%), *Eristalis tenax* Lin. (21.98%), *Helophillus* sp. (19.04%), *Syrphus* sp. (12.69%), *Episyrphus balteatus* DeGeer (9.44%), *Helophilus bengalensis* Weid and *Sphaerophoria Indiana* Bigot (4.64%) and *Eristalis* sp. (3.56%). Observations on the biology of *Episyrphus balteatus* (DeGeer) revealed that incubation period ranged from 2-4 days, with an average of 2 ± 0.6 days. The first larval period was completed in 2-3 (mean 2.2 ± 0.4) days, second in 3-4 (mean 3.4 ± 0.5) days and third in 4-5 (mean 4.5 ± 0.5) days

respectively. Total maggot period ranged from 9-12days with the mean of 10.1 ± 1.3 days. The pre pupal and pupal period ranged from 0-1 and 9-12 days with an average of 1 ± 0 and 10.2 ± 1.03 days respectively. Adult longevity ranged from 21-24 days and 29-33 days with an average of 22.2 ± 1.3 and 31.0 ± 1.5 days for male and female respectively. Egg laying capacity ranged from 187-258 with an average of 215.4 ± 28.9 eggs during entire ovipositional period. Overall male female sex ratio was recorded to be 1:0.95. The maggots of *E. balteatus* were found as predominant bio agents of *Brevicoryne brassicae*. The maggots consumed on an average 11.8 ± 0.56 , 27.99 ± 1.07 and 47.99 ± 1.41 aphids per day during first, second and third instar respectively.

Key words : Relative abundance, syrphid fly, *Brevocoryne brassicae*, predatory potential, biology

Signature of Student
Dated : _____

Signature of Major Advisor
Dated: _____

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**IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST
BENEFICIENT AND THE MOST MERCIFUL**

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Farooq Ahmad Dar

Place : Shalimar, Srinagar

Dated :

CONTENTS

| Chapter | Particulars | Page No. |
|----------------|------------------------|-----------------|
| 1. | INTRODUCTION | 1-3 |
| 2. | REVIEW OF LITERATURE | 4-13 |
| 3. | MATERIALS AND METHODS | 14-19 |
| 4. | EXPERIMENTAL FINDINGS | 20-36 |
| 5. | DISCUSSION | 37-41 |
| 6. | SUMMARY AND CONCLUSION | 42-45 |
| | LITERATURE CITED | i-vi |

LIST OF TABLES

| Table No. | Particulars | Page No. |
|------------------|---|-----------------|
| 1. | Relative abundance of syrphid flies observed in cabbage eco-system during November 2006 to June 2007 in SKUAST-K at Shalimar campus | 21 |
| 2. | Incubation period of <i>Episyrphus balteatus</i> DeGeer under laboratory conditions | 23 |
| 3. | Instar-wise maggot period of <i>Episyrphus balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> under laboratory conditions | 24 |
| 4. | Prepupal and pupal period of <i>Episyrphus balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> under laboratory conditions | 25 |
| 5. | Adult longevity periods of <i>Episyrphus balteatus</i> DeGeer on <i>b. brassicae</i> under laboratory conditions | 27 |
| 6. | Fecundity of <i>Episyrphus balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> infested cabbage leaves under laboratory conditions | 28 |
| 7. | Sex ratio of <i>Episyrphus balteatus</i> DeGeer under laboratory conditions | 30 |
| 8. | Predatory potential of 1 st instar larvae of <i>Episyrphus balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> | 31 |
| 9. | Predatory potential of 2 nd instar larvae of <i>Episyrphus balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> | 33 |
| 10. | Predatory potential of 3 rd instar larvae of <i>E. balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> | 35 |
| 11. | Predatory potential of 1 st , 2 nd and 3 rd instar larvae of <i>Episyrphus balteatus</i> on <i>Brevicoryne brassicae</i> | 36 |

LIST OF FIGURES

| Fig. No. | Particulars | After page No. |
|-----------------|---|-----------------------|
| 1. | Relative abundance of syrphid flies observed in cabbage eco-system in SKUAST-K at Shalimar campus | 20 |
| 2. | Mean consumption of prey during 1 st instar larvae of <i>E. balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> at various treatments | 31 |
| 3. | Mean consumption of prey during 2 nd instar larvae of <i>E. balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> at various treatments | 31 |
| 4. | Mean consumption of prey during 3 rd instar larvae of <i>E. balteatus</i> DeGeer on <i>Brevicoryne brassicae</i> at various treatments | 33 |
| 5. | Predatory potential of 1 st , 2 nd and 3 rd instar larvae of <i>E. balteatus</i> on <i>B. brassicae</i> | 33 |

LIST OF PLATES

| Plate No. | Particulars | After page No. |
|------------------|---|-----------------------|
| 1. | Field view of cabbage trial laid out at SKUAST-K, Shalimar | 14 |
| 2. | Glass chimneys containing adult females of <i>E. balteatus</i> for egg laying | 15 |
| 3. | Different species of syrphid flies observed at cabbage trial | 20 |
| 4. | 1 st , 2 nd and 3 rd larvae of <i>E. balteatus</i> | 22 |
| 5. | Pupa of <i>E. balteatus</i> | 26 |
| 6. | Aphid infested leaf containing syrphid fly eggs | 26 |
| 7. | Adult of <i>E. balteatus</i> | 29 |
| 8. | 1 st , 2 nd and 3 rd instar larvae of <i>E. balteatus</i> preying upon <i>B. brassicae</i> | 29 |

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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner during Viva-Voce examination held on 22.03.2008 have been incorporated in the manuscript entitled “**Relative abundance and feeding potential of syrphid fly (Diptera) on cabbage aphid [*Brevicoryne brassicae* (Lin.)]**” submitted by **Mr. Farooq Ahmad Dar** (Regd. No. 2005-A-768-M).

Dr. M. Afzal Bhat
Chairman
Advisory Committee

CHAPTER – 1

INTRODUCTION

Among cruciferous crops, cabbage has a major status, grown in hill and plain regions of India (Hill, 1975). Cabbage is not only grown for seed purposes but also for vegetable purposes. Normally three to four head crops are grown in a year. The total area under this crop in the world is 1628 thousand ha with an annual production of 25238 thousand tons of heads (Bhalla and Verma, 1990). In India total area under cabbage crop is 78 thousand hectares with an annual production of 47 thousand tons of cabbage heads (Kaul, 1998). Cabbage not only serves the important vegetable for Indians, but also generates employment, as the crop is grown through out the year. The seeds of cabbage grown in temperate regions have best surveillance, earn foreign exchange amounting to rupees 100 crores annually (Bose and Som, 1993). In India total area under the seed crop is one thousand hectares with an annual production of 89.5 thousand quintals (Anonymous, 2001).

There are various insect pests, which attack the cruciferous crops and some times infestation is so serious that plants get denuded. The major insect pests that attack the crucifers are; Cabbage butterfly, *Pieris brassicae*. Lin. (Pieridae:Lepidoptera); Cabbage aphid, *Brevicoryne*

brassicae Lin. (Aphididae : Homoptera); Dimond back moth *Plutella xylostella* Lin. (Plutellidae : lepidoptera); Cutworm, *Agrotis ipsilon* Rott. (Noctuidae:lepidoptera); Mustard saw fly, *Athalia proxima* Klug. (Tenthredinidae : Hymenoptera); Cabbage worm, *Hellula undalis* Fab. (Pyralidae:Lepidoptera); Cabbage painted bug, *Bagrada cruciferarum* Kirk. (Hemiptera : Pentatomidae); and Cabbage flea beetle *Phyllotreta striolata* Fab. (coleopteran:chrysomelidae) Sreekanth and Babu (2001). Normally 15 to 20 sprays of pesticides are being used during the crop-growing season in India. This indiscriminate use of pesticides leads to secondary pest outbreak, resistance to insects, environmental pollution and human health hazards (Gupta, 1984) besides being cost intensive, the poor farmers do not have adequate resources at their disposal to carry the schedule of sprays.

Out of the dominant insect pests of cabbage, Cabbage aphid *Brevicoryne brassicae*, a major pest of crucifers is attacking the crop from seedling stage up to the harvest of the crop (Hildenhagen *et al.*, 1997). This pest has the capability to resist the freezing temperatures during winter (Malik *et al.*, 1972). Various bio agents has been found associated with this pest throughout the crop growing period. Out of those bio agents the most common are Syrphid flies commonly known as Hover flies, Sun flies,

Drone flies etc., that constitute 180 genera and 6000 species (Vockeroth and Thompson, 1987)

Syrphid flies have been reported all over the world as well in India and in Kashmir valley (Bhagat and Lone, 1984). Adult syrphid flies resemble bees and wasps. Eggs are usually laid on the leaves of cabbage. Syrphid flies are economically very important as they act as pollinators of crops and also act as bio agents feeding usually on aphids such as *Brevicoryne brassicae*, *Myzus persicae*, *Lipaphis erysimi* etc.

Keeping all above facts in view the present investigations entitled “Relative abundance and feeding potential of syrphid fly on cabbage aphid, *Brevicoryne brassicae*” are aimed at with the following objectives :-

- 1) To study the relative abundance of syrphid flies,
- 2) to study biology of syrphid fly, and
- 3) to study feeding potential of syrphid fly

Chapter – 2

REVIEW OF LITERATURE

In nature, every crop pest has its own natural enemies in the form of parasites, predators and disease causing organisms associating with the crop ecosystem. These natural enemies play a significant role in suppressing population of insect pests of crops, fruits and vegetables. Cabbage aphid *Brevicoryne brassicae* a major pest of cabbage is associated with the crop throughout the year, although the different workers in different states of India and abroad have recorded association of natural enemies with the aphid.

Among various bioagents of aphids, syrphid flies are of prime importance. These are commonly known as “hover flies”, “flower flies”, “sun flies” and “drone flies” and play a vital role in suppressing the population of aphids. The literature pertaining to the objectives of study has been reviewed under the following heads :

2.1 Relative abundance of syrphid flies

2.2 Biology of aphidophagagous syrphids

2.3 Feeding potential of syrphids

2.1 Relative abundance of syrphid flies

Metcalf (1912), Patel and Patel (1969), Raychaudhuri *et al.* (1979), Laska and Stray (1980), Agarwal *et al.* (1981), Ghosh *et al.* (1985),

Makhmoor and Verma (1987), Bhagat and Masoodi (1988) and Kotwal *et al.* (1989) studied the incidence, population build up, relative abundance and predation of syrphid flies and the workers were of the opinion that syrphid flies are the most important predators of aphids .

Kumar *et al.* (1988) reported the population build up and dispersion of immature stages of aphidophagus syrphids (Syrphidae; Diptera) on ray, *Brassicae juncea* Coss. The egg and larval populations of aphidophagus syrphids, *Episyrphus balteatus*, *Ischiodon scutellasis*, *Sphaeropharia Indiana*, *Metasysphus confrater*, *Metasyrphus latilunulatus* and *Scaeva latimaculata* were recorded in *Brassica juncea* fields in Punjab (India) in December-March 1984-85 and 1985-86 at weekly intervals. Dispersion of egg and larval populations was non-aggregated at low and high aphid densities and aggregated at intermediate densities. Bhagat *et al.* (1988) reported that four species of syrphids viz., *Episyrphus balteatus*, *Macrosyrphus confrater*, *Metasyrphus corollae* and *Syrphus pyraisteri* were found as natural enemies of *Aphis pomi* infesting apple trees in Kashmir valley.

Wratten *et al.* (1995) studied the phenology and ecology of hover flies (Diptera : Syrphidae) in New Zealand. The two abundant species recorded were *Melanostoma fasciatum* and *Melangyna novaezelandiae* both

of which are aphidophagus.

Joshi *et al.* (1999) reported species complex, population density and dominance structure of aphidophagus syrphids in cowpea ecosystem. Six species viz. *Paragus serrata* (Fabricius) *Paragus yerburlensts* (Stukenberg) *Ischidon scutellarts* (Fabricius) *Dideopsts aegrota* (Fabricius), *Betasyrphus linga* (Ghorpade) and *Betasysphus fletcheri* (Ghorpade) were identified to form the predatory syrphid complex of *Aphis craccivora* (Koch) in Bangalore. The seasonal abundance of these species showed remarkable variations. *Aphis Craccivora* was found to be preyed upon by three species of syrphids in summer and four species in Kharif season of 1996. Population density and dominance of these species were also influenced by seasonal variations *Ischidon scutellasis* was dominant throughout the crop seasons during both the years. *Syrphus fletcheri* was found to feed on *A. craccivora* infesting pigeon pea during January-Mach. The species remained active in the field throughout the crop season; syrphid larvae were relatively more abundant from mid of April to mid of May. The study demonstrated a prey-dependent syrphid predator ratio of 1:100,

2.2 Biology of aphidophagus syrphids

Syrphid flies have been reported most important predators of *Brevicoryne brassicae*. Their importance has been recognised because of

synchronization of their life cycle with *B. brassicae*.

Khan and Yunus (1970) reported that mean egg, larva, pupa and adult period of *Syrphus balteatus* was 2.0, 7.9, 9-10 and 15.5 days, respectively. It completed its life cycle in 34.9 days when fed on mustard aphid (*Lipaphis erysimi* Kalt.).

Siddiqui and Krishnaswamy (1972) reported that *Episyrphus balteatus* when preyed upon aphid, *Phylloxera quercus*, the egg, larval and pupal period was 2.4, 22.2 and 13.1 days, respectively at 19°C and 2.3, 15.0 and 11.7 days at 22°C. However, the size and longevity of the emerging adults of *Syrphus corollae* (Fab.) is influenced by the quantity of the food eaten by the larvae during its life span (Cornelius and Barlow, 1980).

Sharma (1983) reported that the egg, larval, pupal period and adult longevity of *Episyrphus viridaureus* when preyed upon *B. brassicae* was 3.2, 9.5, 8.4 and 14.0 days, respectively. However, (Kotwal *et al.*, 1989) in the same investigation reported that the egg, larval, pupal period, adult longevity and total life span of this species upon the same aphid was 4.6, 11.4, 9.8, 5.6 and 31.4 days, respectively

Rotheray (1984) studied on the host relations, biology and parasitism on some aphidophagous syrphids (Diptera) and reported that to elicit egg release, females require a stimulus from the host haemolymph.

Ghosh *et al.* (1985) conducted a survey in the North-western Himalayas in India and reported 10 species of syrphids as predators of 34 species of aphids infesting 30 different host plants. Two of these syrphids, *Metasyrphus latifasciatus* and *Syrphus fulvifacies* are reported as aphid phagous species for the first time in India. The syrphid species and their aphid prey are listed together with details of their habitats and season of activity. The syrphids preferred aphid species infesting herbaceous plants and were active from March to October with a peak population in June.

Syrphid fly species have different developmental periods influenced by the environmental factors and food availability (Makhmoor, 1985).

Makhmoor and Verma (1987) reported that incubation, larval and pupal period of *E. balteatus* upon *B. brassicae* was 3.0, 13.4 and 16.2 days, respectively during December-January whereas, the mean duration of 1st, 2nd and 3rd instar was 3.1, 4.5 and 5.8 days, respectively at maximum and minimum temperature of 14.3 and 9.1°C with a relative humidity of 75 per cent. At the same temperature, the longevity of unmated male and female was 44.2 and 54.9 days, while the longevity of mated male and female was 19.8 and 60.2 days, respectively. They also observed that during March-April at a maximum and minimum temperature of 19.4 and 13.6°C with a relative humidity of 65 per cent, the incubation, larval and pupal period of

the same species was 2.0, 11.8 and 11.1 days, respectively, whereas the mean duration period of 1st, 2nd and 3rd instar was 3.2, 4.2 days, respectively. The longevity of unmated and mated male and female at this temperature was 27.4, 31.8 days and 0.7, 35.0 days, respectively.

Kotwal *et al.* (1989) reported the developmental biology and feeding efficiency of four predatory syrphids, *Episyrphus viridaureus*, *Scaeva pyrastris*, *Metasyrphus* sp. and *Metasyrphus confrater* on the cabbage aphid *Brevicoryne brassicae*. *Episyrphus viridaureus* consumed the maximum number of cabbage aphids (464.4), followed by *Syrphus pyrastris* (409.8), *Metasyrphus* spp (353.8) and *Metasyrphus confrata* (298.7).

Sunil *et al.* (1999) carried out studies on the biology and feeding potential of *Betasyrphus fletcheri*, *Betasyrphus linga*, *Dideopsis aegrota*, *Ischiodon scutellasis*, *Paragus serratus* and *Paragus yerbusiensis* feeding on the cowpea aphid, *Aphis craccivora*. Adult mating and larval feeding behaviour were maintained at 26±2°C and 75±2% relative humidity. The developmental period of these predators from egg to adult emergence ranged from 20.1 to 25.8 days. There were three larval instars and the last instar was the most voracious.

Sathe *et al.* (2004) reported the diversity, distribution, seasonal occurrence and biology of syrphids and highlighted their potential in the

biological control of aphids in India.

2.3 Feeding potential of syrphids

Sundby (1966) reported that mere number of aphids are consumed during winter season in comparison to spring season in case of *Syrphus rebesii*.

Roy and Basu (1977) reported predation rates of *Syrphus balteatus* as 22.5, 91.7 and 395.8 aphids of *Lipaphis erysimi* per larva in 1st, 2nd and 3rd instar, respectively. The total consumption being 510 aphids per larva during the total life span at a mean temperature of $27\pm 2^{\circ}\text{C}$ and relative humidity of 89 ± 5 per cent.

Tawfix *et al.* (1974) reported the aphid consumption of *Syrphus corollae*, *Metasysphus corollae*, *Ischiodon scutellaris*, *Syrphus pyrastris*, *Syrphus confrater* and *Macrosysphus confrater* depends upon different species of aphids and environmental factors.

Gorpada (1981) reviewed the published work on *Aphidophagous syrphidae* from India and neighbouring countries and listed 47 species, predated upon a total of 542 species of insects. In this compilation only 16 species of syrphids were reported predated on the mustard aphid.

Sharma (1983) reported two species namely *Metasyrphus corollae*

and *Syrphus Indiana* which were found predating upon *Brevicoryne brassicae* (Lin.). Similarly, Kotwal *et al.* (1984) reported *Syrphus pyrasteri*, *Metasyrphus* sp. predating upon the cabbage aphid.

Sharma (1983) reported that a single larvae of *E. viridauraus* consumed 244.43 individuals of *B. brassicae*.

Bhagat and Lone (1984) reported that three species of syrphids viz., *Episyrphus balteatus*, *Syrphus Indiana* and *Syrphus* spp were found predating on different species of aphids from Kashmir valley. Agarwal *et al.* (1984) while reviewing the published work on aphidophagus syrphidae from India, reported *Betasyrphus serarius*, *Episyrphus balteatus*, *Ischiodon scutellasis* and *Metanostoma orientale* predating upon the mustard aphid.

Laska (1984) reported that the quantitative aphid requirement per day of *E. balteatus* varies between 0.5 to 15.0 mg depending upon the size and instar of larva.

Makhmoor and Verma (1987) reported that *E. balteatus* consumed 218 individuals of *B. brassicae* per larva during December-February at maximum and minimum temperatures of 14.5 and 9.1°C with a relative humidity of 75 per cent and 202 individuals of cabbage aphid during March-April with a corresponding maximum and minimum temperature of 19.4 and 13.6°C with a relative humidity of 65 per cent. Similar

observations for more consumption of aphids during winter season in comparison to spring season in case of *Syrphus rebessi* have also been reported (Sundby, 1966).

Patro and Behera (2002) studied the biology and feeding potential of *Sphaerophoria javana* (Weid) on the bean aphid *Aphis craccivora* (Koch) under laboratory conditions at $27.9\pm 1.1^{\circ}\text{C}$ and 85.7 ± 5.2 per cent relative humidity and found that the egg, larval and pupal stages occupied 1.96 ± 0.07 , 6.30 ± 0.22 and 5.38 ± 0.04 days, respectively. The total life cycle was completed in 14.02 ± 0.2 days. The per day consumption of 1st, 2nd and 3rd instar larvae was 12.7 ± 2.2 , 69.4 ± 7.4 and 112.2 ± 7.7 aphids, respectively.

Verma *et al.* (2006) reported that the four species of syrphids viz., *Episyrphus balteatus*, *Eupeodes frequens*, *Metasyrphus corollae* and *Betasyrphus serarius* were found preying upon *Aphis faba*. They reared these four species under laboratory conditions and found that the average number of aphids consumed per larvae were 416.25, 288.20, 354.40 and 288.75 for all the four predators.

Chapter – 3

MATERIALS AND METHODS

The present investigations were carried out in the field and laboratory conditions during the year 2006-07 at main campus of Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar.

3.1 Raising of cabbage crop

Twenty five days old seedlings of cabbage (var. Uttam) were obtained from Department of Agriculture, Government of Jammu & Kashmir, Srinagar and transplanted on 31st October 2006 at a spacing of 50 x 50 cm (Plate-1). All package of practices recommended by SKUAST-K were followed during the crop growing season, except insecticidal treatments. In order to raise the crop in an insecticide free environment.

3.2 Relative abundance of syrphid fly

The relative abundance of syrphid flies in cabbage ecosystem were recorded by collecting the adult flies with the help of insect collection nets. Collections were carried out at weekly intervals in the morning, afternoon and evening hours, during the crop growing season from 3rd November 2006 upto 11th June 2007. Samples collected were preserved and sent to IARI, New Delhi for identification.

3.3 Studies on biology of *Episyrphus balteatus*

Gravid females of *E. balteatus* were collected from the cabbage crop with the help of a hand net and were confined in glass chimneys for egg laying (20 cm x 15 cm) [Plate-2]. The top of the chimney was covered with musline cloth tied with the help of a rubber band. Aphid infested cabbage leaves, with their petiole dipped in water in a glass vial (50 cm x 2.5 cm) were kept for egg laying among aphid colonies. Flowering shoots of mustard (*Brassica campestris* L. var. sarson L.) and 10 per cent sugar solution soaked in cotton swab were also kept inside each chimney to provide food for the adult flies. Eggs were thereafter transferred to petriplates (15 cm x 15 cm) with the help of fine camel brush for hatching. Following observations were recorded.

3.3.1 Incubation period

Incubation period was studied by using ten freshly laid eggs, obtained from laboratory culture and placed singly over filter paper in close petriplates (15 cm x 15 cm) in the laboratory. Each petriplate represented one replicate. Eggs were examined with the help of a hand lense (10 x magnification) thrice a day, to record the hatching. The time period from laying of an egg to its hatching was computed for each replication to record the incubation period. Mean \pm S.D was worked out to record the average

period of incubation for eggs of *Episyrphus balteatas* DeGeer.

3.3.1.1 Instar-wise larval period

For this purpose, ten numbers of maggots were transferred to petriplates (15 cm x 15 cm). The maggots were provided with aphid infested cabbage leaves and examined twice a day. The presence of cast off integument was taken as the period of cessation of one instar and the start of next. Mean \pm S.D were computed for each instar of maggot to denote the instar-wise maggot period of *Episyrphus balteatus* DeGeer.

3.3.1.2 Pre-pupal and pupal period

Pre-pupal period was recorded when a maggot reduced its feeding to enter into pre-pupal stage and pupal period was recorded when a maggot completely stopped feeding, till an adult syrphid fly emerged out of it. Ten such maggots were transferred individually for prepupation and pupation in petriplates (15 cm x 15 cm) which were provided with additional leaves. The pupae were not disturbed till the adults emerged out.

3.4 Sex ratio

The ratio between the total number of male and the total number of female syrphid flies, emerged out from the same lot of pupae, constituted

sex ratio. One hundred twenty five pupae, in five replications of 25 each were collected from the culture raised in the laboratory kept separately under glass chimneys (20 x 15 cm) and subsequently watched for adult emergence. The flies were sorted out into male and female syrphid flies on the basis of abdominal breadth, presence and absence of ovipositor and general size. Females had broader abdomen, having oviposited and were larger in size than males. Mean sex ratio of *Episyrphus balteatus* was computed.

3.4.1 Adult longevity

Adult longevity was denoted by the time an adult syrphid fly emerged from the pupa till its death. For this purpose five pairs of adult syrphid flies immediately after their emergence from the pupa were separated and transferred to glass chimneys containing flowering shoots of mustard (*Brassica campestris* L. var *sarson* L.) and 10 per cent sugar solution soaked in cotton swab, maintained at a temperature of 25-30°C (mean 27.5°C) and relative humidity of 65-70 per cent (mean 67.5%). Periodical observations were recorded after every 24 hours to compute the average period of survival of flies (sex-wise) for each replication.

3.5 Fecundity of *Episyrphus baltealus* DeGeer

To know the fecundity of *E. baltealus* five pairs of flies were

released in glass chimneys containing flower shoot of mustard (*Brassica campestris* L. var sarson L.), 10 per cent sugar solution soaked in cotton swab and aphid infested cabbage leaves for egg laying. Each chimney represented one replicate. Infested cabbage leaves were removed and examined twice a day to mark the freshly laid eggs. The total number of eggs laid by each female during each day were examined with the help of a hand lense (10 x magnification) and were recorded to compute the fecundity.

3.6 Predatory potential of *Episyrphus balteatus* DeGeer

The predation potential of the larvae of *E. balteatus* was studied by providing counted number of aphids (*Brevicoryne brassicae* L.) on fresh cabbage leaves. Total number of aphids consumed by each of the larval instar were recorded after every 24 hours. The predatory maggots just after hatching were transferred and confined individually in petriplates (15 x 15 cm) and provided with hosts of different densities viz., 20, 40, 80 and 160. Each density with one predator was replicated thrice and the petriplates were examined after every 24 hours and the number of prey consumed were observed. The number of aphids left unpreyed were removed and a known number of fresh aphids were provided in all treatments daily. The predation potential was worked out on the basis of total number of aphids consumed

per larva during its entire larval period.

3.7 Statistical analysis

The statistical analysis was done in consultation with the Division of Agri-Statistics and Economics, SKUAST-K in R-Software, which is the implementation of Box, Hunta and Hunter (1978). Various degrees of predatory potential of *Episyrphus balteatus* DeGeer were obtained under the statistical model i.e. Completely Randomized Design and a complete inference and conclusions were drawn between the predatory potential and the host density levels.

CHAPTER – 4

Experimental findings

The findings of the present investigation on the “Relative Abundance and Feeding Potential of Syrphid fly (Dip) on Cabbage Aphid *Brevicoryne brassicae*” are presented under the following heads :

4.1 Relative abundance of syrphid flies

The syrphus species collected in the cabbage ecosystem belonged to family syrphidae and sub-family syrphinae (Table-1). A total of 646 syrphid flies from five genera and 5 species were collected during the crop growing season (Plate-3). *Helophilus vittatus* Weid was found to be the most abundant species (23.99%) and the least abundant (3.56%) was *Eristalis* sp. The order of abundance was *Helophilus vittatus* Weid (23.99%), *Eristalis tenax* Lin. (21.98%), *Helophilus* sp. (19.04%), *Syrphus* sp. (12.69%), *Episyrphus balteatus* DeGeer (9.44%), *Helophilus bengalensis* Weid and *Sphaerophoria Indiana* Bigot (4.64%) and *Eristalis* sp. (3.56%) [Fig. 1].

The syrphid population showed a decreasing trend from November to January and from January onwards it increased upto June. The least number (2) was recorded in the month of January and the highest (281) was found in the month of June.

4.2 Incubation period

The results presented in Table-2 depicts that the incubation period of eggs varied between 2-4 days, with an average of 2.8 ± 0.635 days.

4.3 Instar-wise larval period

The maggots of *E. balteatus* passed through three developmental stages by two moultings and three instars and each instar occupied different duration (Table-3). The instar-wise maggot period of *E. balteatus* DeGeer was studied under laboratory conditions at the temperature of 25-30°C (mean 27.5°C) and the relative humidity of 65-70 per cent (mean 67.5%). The three consecutive maggot periods were completed in 2-3 (mean 2.2 ± 0.422 days), 3-4 (mean 3.4 ± 0.516 days) and 4-5 (4.5 ± 0.527 days), respectively with the total maggot period of 9-12 days having an average of 10.1 ± 1.286 days (Plate-4).

4.4 Prepupal and pupal period

The full grown maggot of *E. balteatus* began to show slight decrease in movements and the body length got stretched and swelled up, prior to entering into pre-pupa.

The pupae are whitish to greyish white in colour, broad and round at the anterior part and narrower at the posterior part. The posterior end was somewhat oval in shape (Plate-5). The pupation took place on the under surface of the leaves. The total pre-pupal period was observed to be one day while the total pupal period ranged from 9-12 days, with an average of 10.2 ± 1.033 days (Table-4).

4.5 Adult longevity

The adult longevity of both sexes of *E. balteatus* DeGeer was studied

under laboratory conditions at the temperature of 25-30°C (mean 27.5°C) and the relative humidity of 65-70 per cent (mean 67.5%). The results presented in Table-5 revealed that the female syrphid flies had longer life span than males. The female flies lived for 29-33 days, with an average of 31 ± 1.581 days while as male lived for 21-24 days with an average of 22.2 ± 1.304 days.

4.6 Pre-oviposition and fecundity period

The data collected on pre-oviposition period of *E. balteatus* DeGeer revealed that the female started egg laying 5-7 days (average of 5.8 ± 0.832 days) after emergence. The oviposition period ranged from 21-26 days with an average of 24 ± 2 days. The eggs were laid singly in the aphid colonies (Plate-6) in a scattered form.

The results enumerated in Table-6 indicated that the egg laying capacity of each female ranged from 187-258 with an average of 215.4 ± 28.88 eggs during the oviposition period.

4.7 Sex ratio

The results presented in Table-7 for female-male sex ratio of *E. balteatus* DeGeer revealed that out of 225 pupae taken for observation in 25 batch each, 117 adult syrphid flies emerged out. Out of 117 adult flies, 60 were females (Plate 7) and 57 were males. The overall female-male sex ratio was recorded as 1:0.95 and the per cent adult emergence worked out to be 93.6 per cent.

4.8 Predatory potential of *Episyrphus balteatus* DeGeer on *Brevicornye*

brassicae

The *Episyrphus balteatus* DeGeer larva were found to be potentially important biocontrol agents of *Brevicornye brassicae*. The predation phenomena of *E. balteatus* was conspicuously observed in different instars (Plate-8).

The consumption of 1st instar maggot of the predator ranged from 10.66-13.33 aphids, with an overall mean predation of 11.82 ± 0.56 aphids per day (Table-8). It was observed that the predator trend increased day by day. At the predator prey ratio of 1:160, the highest mean consumption of 13.33 aphids was observed. The rate of prey consumption decreased with the increase in prey density as it was 53.3 per cent at the predator prey ratio of 1:20 but 8.33 per cent at the predator prey ratio of 1:160.

The functional response showed positive correlations. It was observed that the predation increased with increased prey density (Fig. 2). Biotic and abiotic factors including increased availability of food showed significantly higher influence on the predator to the varying number of prey. Different days had fluctuating different environments, but continuous increase of the prey density was available all the days that indicated correlation between the prey and the predator.

The 2nd instar maggot revealed that throughout the prey density of 20, the predator potential was 100 per cent but it decreased with the increase of prey density viz., at 160, the predator potential computed to be 20.83 per cent. The

mean consumption of the prey increased from 20.00 to 33.33 at the predator prey ratio of 1:20 to 1:160 (Table-9). A gradual increase in the mean consumption could be found by the 2nd instar maggot of *E. balteatus* contrary to 1st instar maggot which showed regular pattern of mean consumption of prey. However, 2nd instar maggot on comparing with the 1st instar maggot, showed an increase of 11.82 ± 1.139 in 1st instar to 27.99 ± 5.91 in 2nd instar, while drawing the regression plot the regression line was the same (Fig. 3).

While interpreting the data (Table-10) regarding the predatory potential of 3rd instar maggot of the predator it could be seen that almost 100 per cent consumption of the prey was registered. The mean consumption ranged between 20.00 to 68.08 at the predator prey ratio of 1:20 to 1:160. The overall mean and standard error of predation was computed to be 47.99 ± 1.41 . Again increase in prey density showed the positive functional response by the predator (Fig. 4).

Table-11 shows the feeding potential of all the three instars together. It depicts that the mean consumption ranged between 16.88 to 38.25 at the predator prey ratio of 1:20 to 1:160. The overall mean and standard error of predation was computed to be 29.26 ± 9.810 . Fig. 5 shows comprehensive predation potential of 1st, 2nd and 3rd instar together.

CHAPTER – 5

Discussion

The recent history of insect resistance, resurgence of pests, and outbreak of secondary pests pronouncedly suggest that pest management requires a holistic approach. It has now been admitted that use of chemicals do not often hold down pest numbers because of pest resurgence and secondary pest outbreak. It is, therefore, imperative that more attention has to be paid to understand the strategies of survival by the bio-control agents so that these are counter acted effectively and more consistently.

The procedure may include scanning the bio-control agents from the organisms point of view to ascertain functional relationship and attributes of pest population. The present investigation is discussed under the following headings :

5.1 Relative abundance of syrphid flies

The relative abundance of syrphid flies showed decreasing trend from November to January due to decrease in temperature and from mid of February when the temperature stabilises, it showed increasing trend up to June. The maximum number (281) of syrphid flies were found in the month of June and the minimum number (2) were found in the month of January. Among the various species *Helophilus vittatus* (Weid) was found most abundant (23.99%) and *Eristalis sp.* was found least abundant (3.56%). These findings are in close conformity with the results of Jennifer and Gilbert (1989) who observed that syrphid flies are less abundant in harsh months due to unfavourable weather

conditions and their number increases when the conditions become favourable.

5.2 Biology of *Episyrphus balteatus* DeGeer

Observations on the biology of *E. balteatus* found predated upon *Brivicoryne brassicae* under laboratory conditions are as under :

5.2.1 Incubation period

The incubation period ranged from 2-4 days, with an average of 2 ± 0.6 days. These findings are in close agreement with the results of, Makhmoor and Verma (1987) reported the incubation period of 2.0 days during March-April and that of Khan and Yunus (1970) recorded the mean incubation period of 2.0 days in *E. balteatus*. Siddiqui and Krishnaswamy (1972) reported the incubation period ranged from 2-5 days, and Sharma (1983) reported mean incubation period of 3.2 days in *E. balteatus*.

5.2.2 Larval period

The three larval instars of *Episyrphus balteatus* (DeGeer) were completed in 2-3 (mean 2.2 ± 0.4), 3-4 (mean 3.4 ± 0.5) and 4-5 (mean 4.5 ± 0.5) days with a total maggot period of 9-12 (mean 10.1 ± 1.3) days at the mean temperature of 27.5°C and relative humidity 67.5 per cent. These findings are in close agreement with the results of Makhmoor and Verma (1987), who reported the mean duration of 1st, 2nd and 3rd instar as 3.1, 4.5 and 5.8 days. Sharma (1983), recorded the mean larval period of 9.6 days in *E. balteatus*. Khan and Yunus (1970), reported

that the mean larval period of *E. balteatus* was 7.9 days.

5.2.3 Prepupal and pupal period

The prepupal period ranged from 0 to 1 day with an average of 1 ± 0 days at the mean temperature of 27.5°C and relative humidity of 67.5 per cent.

The pupal period ranged from 9-12 days with an average of 10.2 ± 1.03 days. These findings are in corroboration with the observations of Khan and Yunus (1970), who reported the average pupal period of 9-10 days, Roy and Basu (1977) also reported the mean pupal period of 10.00 days, however, Siddiqui and Krishnaswamy (1972), reported the mean pupal period of 13.15 days.

5.2.4 Adult longevity

The findings revealed that the female adult fly lived longer than the male adult fly. The female lived for 29-33 days with a mean of 31 ± 1.6 days, while the male lived for 21-24 days, with a mean of 22.2 ± 1.3 days at the mean temperature of 27.5°C and relative humidity of 67.5 per cent. These findings are in close conformity with the results of Makhmoor and Verma (1987), who reported that the longevity of male and female syrphid fly was 27.4 and 31.8 days.

5.2.5 Fecundity

The egg laying capacity ranged from 187-258 with an average of 215.4 ± 28.9 at the mean temperature of $27\pm 1^{\circ}\text{C}$ and relative humidity of 65.5 per cent. These findings are in close conformity with the findings of Makhmoor and Verma (1987), who recorded 245 eggs per female of *Eupeodes confrater* and 400

eggs per female of *Episyrphus balteatus*.

5.2.6 Sex ratio

The overall female male sex ratio has been recorded to be 1:0.95 which is in close conformity with the findings of Chanyuvadza (1976), who recorded sex ratio of 1:1 in *Chilocorus bijugus*.

5.3 Predatory potential of *Episyrphus balteatus* on *Brevicoryne brassicae*

The present study revealed that the *Episyrphus balteatus* was undoubtedly a potential and important biocontrol agent of cabbage aphid, *Brevicoryne brassicae*. The data in Table-8 revealed that 1st instar maggot on an average consumed 11.82 ± 0.56 aphids per day at an average temperature of $27 \pm 1^\circ\text{C}$ and 65 per cent relative humidity. These findings are in close conformity with Roy and Basu (1977), who reported mean consumption of 1st instar larva as 11.25 aphids per day.

The 2nd instar maggot of *Episyrphus balteatus* on an average consumed with 27.99 ± 1.07 aphids per day as also reported by Roy and Basu (1977), who computed mean consumption of 30.3 aphids per day.

The predatory potential of 3rd instar larva was found 47.99 ± 1.09 per day. These findings are in close conformity with Makhmoor and Verma (1987), who also reported that the mean consumption of 3rd instar larva of *Episyrphus balteatus* was 53 larvae per day. Roy and Basu (1977) reported the mean consumption of 3rd instar larvae of *E. balteatus* 49 larvae per day.

CHAPTER – 6

Summary and Conclusion

The present studies on “Relative abundance and feeding potential of syrphid fly, *Episyrphus balteatus* on cabbage aphid, *Brevicoryne brassicae* were carried out during 2006-2007 in field as well as in the PG laboratory of the Division of Entomology, SKUAST-K, Shalimar.

The findings with respect to the relative abundance, biology and feeding potential of *Episyrphus balteatus* (DeGeer) has been summarized as under :

- ▶▶ Phenologically, the predatory *Episyrphus balteatus* (DeGeer) maggot and its host *Brevicoryne brassicae* remain together in natural habitat. The predator which is an effective and predominant biocontrol agent and underwent through several metamorphic stages, viz., egg, three maggot instars, pupa and adult plays a vital role in suppressing the population of aphids
- ▶▶ Maximum number of flies were found in the month of June and minimum number in the month of January. *Helophilus vittatus* (Weid) was found most abundant and the least was found *Fristalis species*.
- ▶▶ Incubation period ranged from 2-4 days with an average of 2.8 ± 0.63 days.
- ▶▶ The three grub periods were completed in 2-3 (mean 2.2 ± 0.4), 3-4 (mean 3.4 ± 0.5) and 4-5 (mean 4.5 ± 0.5) days. The total maggot period ranged from

9-12 days, with an average of 10.1 ± 1.3 days.

- ▶▶ The prepupal and pupal periods ranged from 0-1 and 9-12 days, with an average of 1 ± 0 and 10.2 ± 1.03 days, respectively.
- ▶▶ The adult longevity ranged between 21-24 days for male and 29-33 days for female. The female flies lived longer than male. The overall adult longevity period was 22.2 ± 1.3 days for male and 31.0 ± 1.6 days for female flies.
- ▶▶ Females of *Episyrphus balteatus* laid 187-258 eggs with an average of 215.4 ± 28.8 eggs during its entire ovipositional period. Eggs were laid singly among aphid colonies.
- ▶▶ The overall mean female to male sex ratio was computed to be 1:0.95.
- ▶▶ The maggots of *Episyrphus balteatus* were found as predominant and important biocontrol agents of *Brevicoryne brassicae*. Only three maggot instars were found predated upon the aphids, whereas adults were found to suck nectar from flowers. Studies on the functional response of almost all the three maggot instars of the predator with different densities of prey of *Brevicoryne brassicae* revealed that with the increase in prey density, there was also an increase in the predation.
- ▶▶ The 1st instar maggot consumed on an average 11.8 ± 0.56 aphids per day.
- ▶▶ The 2nd instar maggot consumed on an average 27.99 ± 1.07 aphids per day.
- ▶▶ The 3rd instar maggot consumed on an average 47.99 ± 1.41 aphids per day.

Conclusion

- ⇒ Syrphid flies were more abundant during the spring and summer months and are less abundant during winter. Total of 5 genera and 5 species of syrphid flies have been identified. Their abundance was found in the order of *Helophillus vittatus* Weid (23.99%), *Eristalis tenax* Lin. (21.98%), *Helophillus* sp. (19.04%), *Syrphus* sp. (12.69%), *Episyrphus balteatus* DeGeer (9.44%), *Helophilus bengalensis* Weid and *Sphaerophoria Indiana* Bigot (4.64%) and *Eristalis* sp. (3.56%).
- ⇒ *Episyrphus balteatus* (DeGeer) observed to complete its metamorphosis through four developmental stages viz., egg, maggot, pupa and adult.
- ⇒ The total developmental period ranged from 51-62 days.
- ⇒ The average adult longevity period recorded was 31 ± 1.58 for female and 22.2 ± 1.3 days for male of *Episyrphus balteatus*.
- ⇒ *Episyrphus balteatus* (DeGeer) is a potentially important predator of the notorious pest *Brevicoryne brassicae* which is found almost on all cole crops in India.
- ⇒ Only the three maggot instars were observed to attack the pest and adults feed on pollen and nectar of flowers.

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* Original not seen.

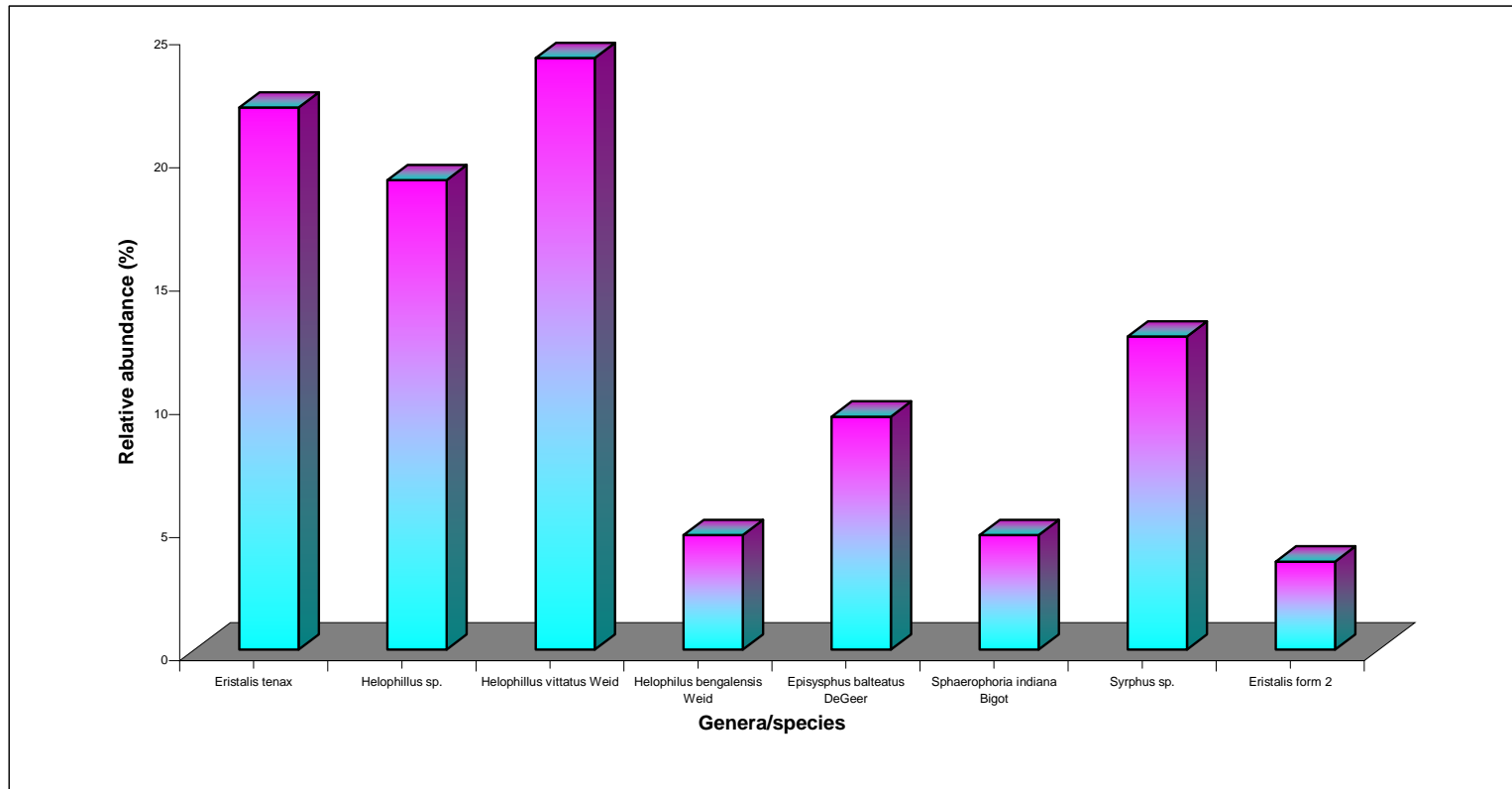


Fig. 1 : Relative abundance of syrphid flies observed in cabbage eco-system in SKUAST-K at Shalimar campus

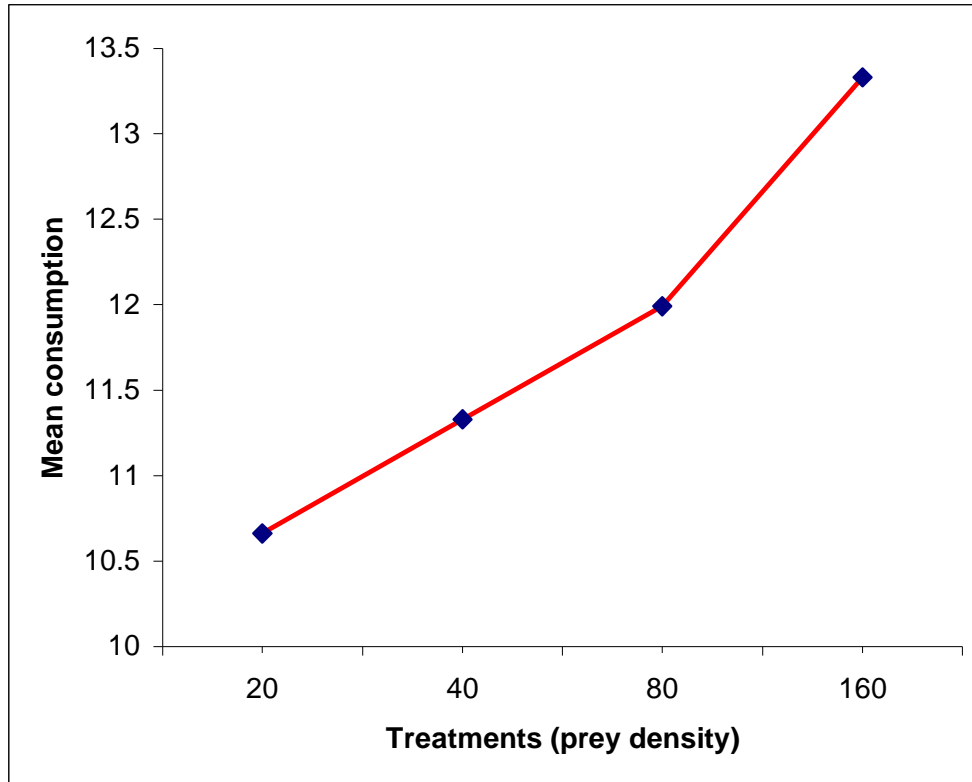


Fig. 2 : Mean consumption of prey during 1st instar larvae of *E. balteatus* DeGeer on *Brevicoryne brassicae* at various treatments

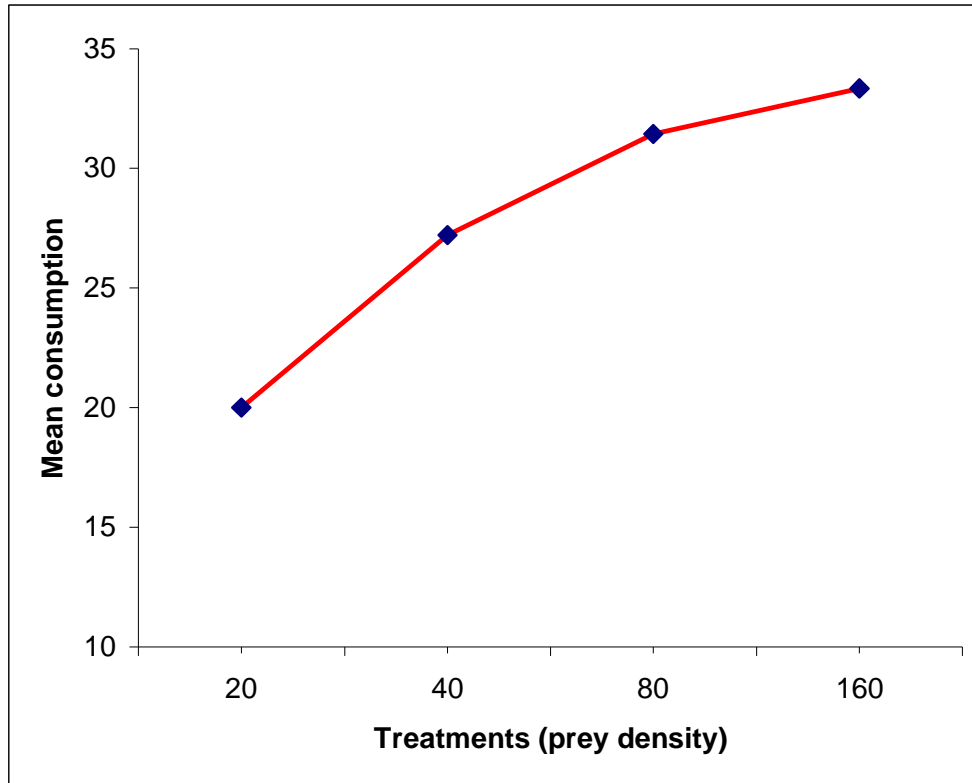


Fig. 3 : Mean consumption of prey during 2nd instar larvae of *E. balteatus* DeGeer on *Brevicoryne brassicae* at various treatments

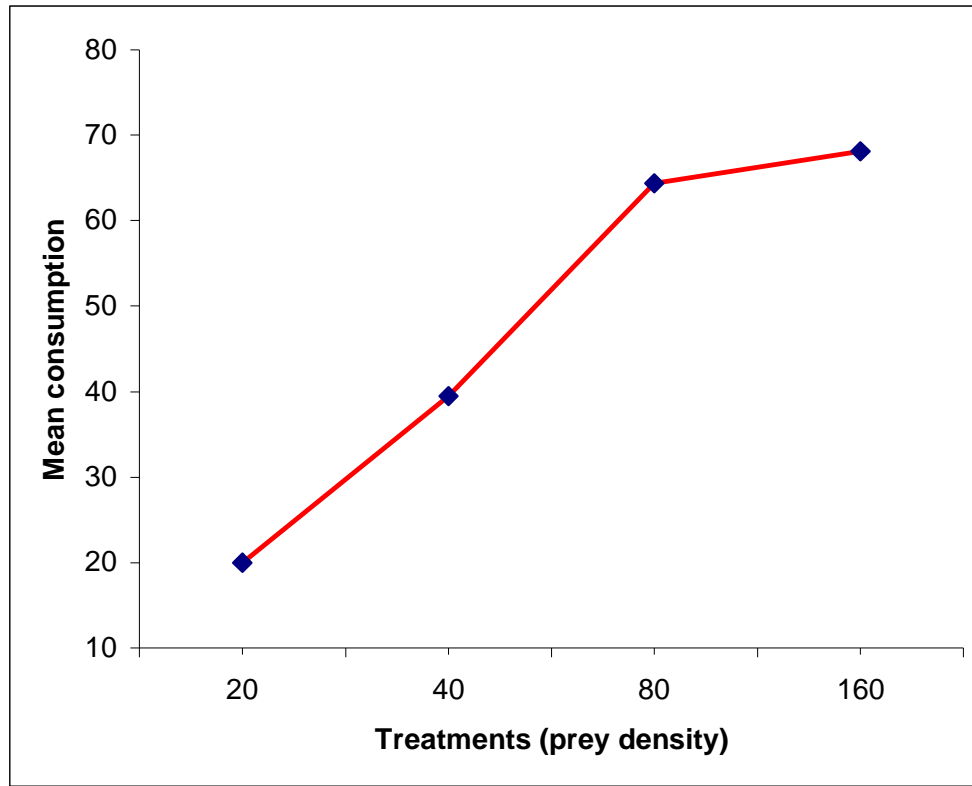


Fig. 4 : Mean consumption of prey during 3rd instar larvae of *E. balteatus* DeGeer on *Brevicoryne brassicae* at various treatments

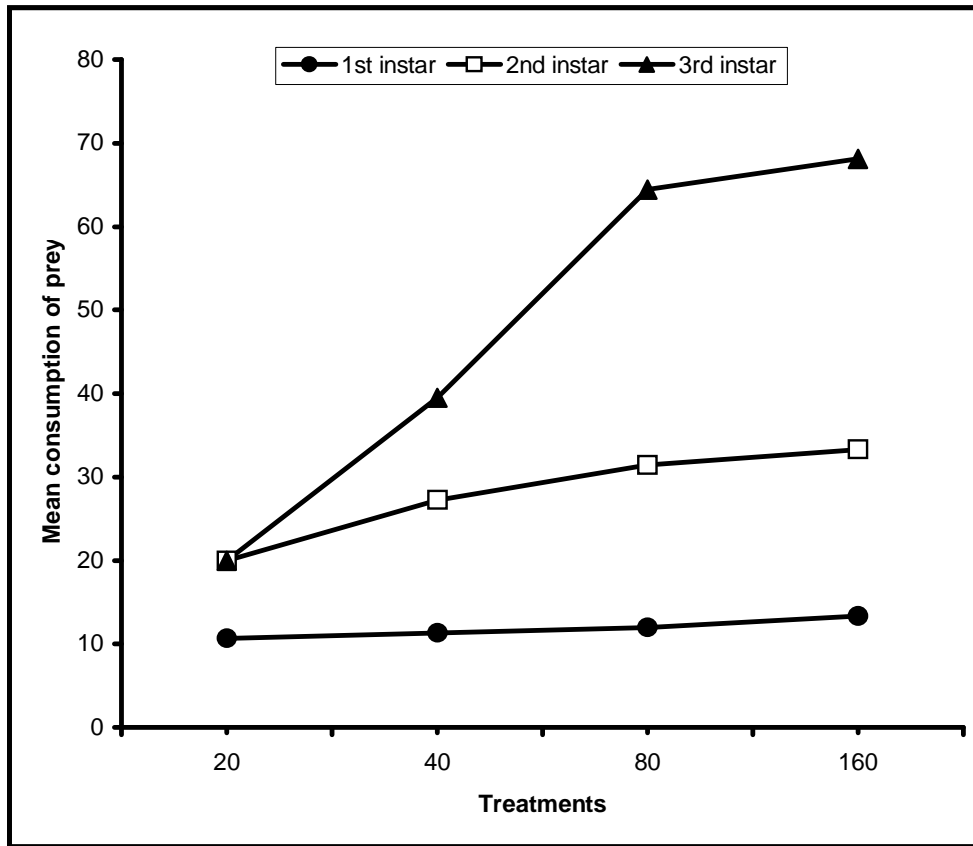


Fig. 5 : Predatory potential of 1st, 2nd and 3rd instar larvae of *E. balteatus* on *B. brassicae*

Table-1 : Relative abundance of syrphid flies observed in cabbage eco-system during November 2006 to June 2007 in SKUAST-K at Shalimar campus

| Genera/species | Month | | | | | | | | Total | Relative abundance (%) |
|------------------------------------|----------|----------|----------|----------|-----------|------------|------------|------------|------------|------------------------|
| | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | | |
| <i>Eristalis tenax Lin.</i> | 2 | 1 | 1 | 1 | 6 | 19 | 45 | 67 | 142 | 21.98 |
| <i>Helophilus sp.</i> | 1 | 0 | 1 | 2 | 7 | 17 | 43 | 52 | 123 | 19.04 |
| <i>Helophilus vittatus Weid</i> | 1 | 1 | 0 | 0 | 6 | 31 | 47 | 69 | 155 | 23.99 |
| <i>Helophilus bengalensis Weid</i> | 1 | 0 | 0 | 0 | 0 | 5 | 11 | 13 | 30 | 4.64 |
| <i>Episyrphus balteatus DeGeer</i> | 3 | 1 | 0 | 1 | 5 | 17 | 21 | 13 | 61 | 9.44 |
| <i>Sphaerophoria indiana Bigot</i> | 0 | 1 | 0 | 1 | 2 | 7 | 8 | 11 | 30 | 4.64 |
| <i>Syrphus sp.</i> | 0 | 1 | 0 | 1 | 3 | 14 | 21 | 42 | 82 | 12.69 |
| <i>Eristalis sp.</i> | 0 | 0 | 0 | 1 | 1 | 2 | 5 | 14 | 23 | 3.56 |
| Total | 8 | 5 | 2 | 7 | 30 | 112 | 201 | 281 | 646 | 100 |
| No. of species | 5 | 5 | 2 | 5 | 7 | 8 | 8 | 8 | | |

Table-2 : Incubation period of *Episyrphus balteatus* DeGeer under laboratory conditions

| REPLICATION | Date of egg-laying | Date of hatching | Incubation period (days) |
|-----------------|--------------------|------------------|--------------------------|
| R ₁ | 30.03.2007 | 02.04.2007 | 3.0 |
| R ₂ | 30.03.2007 | 02.04.2007 | 3.0 |
| R ₃ | 30.03.2007 | 01.04.2007 | 2.0 |
| R ₄ | 30.03.2007 | 03.04.2007 | 4.0 |
| R ₅ | 30.03.2007 | 02.04.2007 | 3.0 |
| R ₆ | 30.03.2007 | 02.04.2007 | 3.0 |
| R ₇ | 30.03.2007 | 02.04.2007 | 3.0 |
| R ₈ | 30.03.2007 | 01.04.2007 | 2.0 |
| R ₉ | 30.03.2007 | 01.04.2007 | 2.0 |
| R ₁₀ | 30.03.2007 | 02.04.2007 | 3.0 |
| Range | | 2-4 | |
| Mean | | 2.0 | |
| ±S.D | | 0.635 | |

Table-3 : Instar-wise maggot period of *Episyrphus balteatus* DeGeer on *Brevicoryne brassicae* under laboratory conditions

| Replication | Date of hatching | Date of 1 st moult | No. of days | Date of 2 nd moult | No. of days | Date of 3 rd moult | No. of days | Total maggot period |
|-----------------|------------------|-------------------------------|--------------|-------------------------------|--------------|-------------------------------|--------------|---------------------|
| R ₁ | 02.04.2007 | 04.04.2007 | 02 | 07.04.2007 | 03 | 11.04.2007 | 04 | 09 |
| R ₂ | 02.04.2007 | 05.04.2007 | 03 | 09.04.2007 | 04 | 14.04.2007 | 05 | 12 |
| R ₃ | 01.04.2007 | 03.04.2007 | 02 | 06.04.2007 | 03 | 10.04.2007 | 04 | 09 |
| R ₄ | 03.04.2007 | 05.04.2007 | 02 | 08.04.2007 | 03 | 12.04.2007 | 04 | 09 |
| R ₅ | 02.04.2007 | 04.04.2007 | 02 | 08.04.2007 | 04 | 13.04.2007 | 05 | 11 |
| R ₆ | 02.04.2007 | 04.04.2007 | 02 | 07.04.2007 | 03 | 11.04.2007 | 04 | 09 |
| R ₇ | 02.04.2007 | 04.04.2007 | 02 | 07.04.2007 | 03 | 12.04.2007 | 05 | 10 |
| R ₈ | 01.04.2007 | 04.04.2007 | 03 | 08.04.2007 | 04 | 13.04.2007 | 05 | 12 |
| R ₉ | 01.04.2007 | 03.04.2007 | 02 | 07.04.2007 | 04 | 12.04.2007 | 05 | 11 |
| R ₁₀ | 02.04.2007 | 04.04.2007 | 02 | 07.04.2007 | 03 | 11.04.2007 | 04 | 09 |
| Range | | | 2-3 | | 3-4 | | 4-5 | 9-12 |
| Mean | | | 2.2 | | 3.4 | | 4.5 | 10.1 |
| ±S.D | | | 0.422 | | 0.516 | | 0.612 | 1.286 |

Table-4 : Prepupal and pupal period of *Episyrphus balteatus* DeGeer on *Brevicoryne brassicae* under laboratory conditions

| Replication | Date of pre-pupation | Date of pupal formation | Total pre-pupal period (days) | Date of emergence of adults | Total pupal period (days) |
|-----------------|----------------------|-------------------------|-------------------------------|-----------------------------|---------------------------|
| R ₁ | 10.04.2007 | 11.04.2007 | 01 | 22.04.2007 | 11 |
| R ₂ | 13.04.2007 | 14.04.2007 | 01 | 24.04.2007 | 10 |
| R ₃ | 09.04.2007 | 10.04.2007 | 01 | 22.04.2007 | 12 |
| R ₄ | 11.04.2007 | 12.04.2007 | 01 | 21.04.2007 | 09 |
| R ₅ | 12.04.2007 | 13.04.2007 | 01 | 23.04.2007 | 10 |
| R ₆ | 10.04.2007 | 11.04.2007 | 01 | 22.04.2007 | 11 |
| R ₇ | 11.04.2007 | 12.04.2007 | 01 | 22.04.2007 | 10 |
| R ₈ | 12.04.2007 | 13.04.2007 | 01 | 22.04.2007 | 09 |
| R ₉ | 11.04.2007 | 12.04.2007 | 01 | 23.04.2007 | 11 |
| R ₁₀ | 10.04.2007 | 11.04.2007 | 01 | 20.04.2007 | 09 |
| | Range | | 1-1 | | 9-12 |
| | Mean | | 1 | | 10.2 |
| | ±S.D | | 0 | | 1.033 |

Table-5 : Adult longevity periods of *Episyrphus balteatus* DeGeer on *B. brassicae* under laboratory conditions

| Replication | Date of emergence | Date of death | | Adult longevity period (days) | |
|----------------|-------------------|---------------|------------|-------------------------------|--------------|
| | | Male | Female | Male | Female |
| R ₁ | 22.04.2007 | 15.05.2007 | 22.05.2007 | 23 | 30 |
| R ₂ | 22.04.2007 | 13.05.2007 | 21.05.2007 | 21 | 29 |
| R ₃ | 22.04.2007 | 14.05.2007 | 23.05.2007 | 22 | 31 |
| R ₄ | 22.04.2007 | 16.05.2007 | 25.05.2007 | 24 | 33 |
| R ₅ | 22.04.2007 | 13.05.2007 | 24.05.2007 | 21 | 32 |
| Range | | | | 21-24 | 29.33 |
| Mean | | | | 22.2 | 31 |
| ±S.D | | | | 1.304 | 1.581 |

Table-6 : Fecundity of *Episyrphus balteatus* DeGeer on *Brevicoryne brassicae* infested cabbage leaves under laboratory conditions

| Replication | Date of adult emergence | Date of egg laying | Pre-oviposition period (days) | Oviposition period (days) | Total No. of eggs laid |
|----------------|-------------------------|--------------------|-------------------------------|---------------------------|------------------------|
| R ₁ | 22.04.2007 | 28.04.2007 | 06 | 23 | 193 |
| R ₂ | 22.04.2007 | 29.04.2007 | 07 | 21 | 187 |
| R ₃ | 22.04.2007 | 27.04.2007 | 05 | 25 | 210 |
| R ₄ | 22.04.2007 | 29.04.2007 | 06 | 26 | 258 |
| R ₅ | 22.04.2007 | 27.04.2007 | 05 | 25 | 229 |
| | Range | | 5-7 | 21-26 | 187.258 |
| | Mean | | 5.8 | 24 | 215.4 |
| | ±S.D | | 0.836 | 2 | 28.88 |

Table-7 : Sex ratio of *Episyrphus balteatus* DeGeer under laboratory conditions

| REPLICATION | NO. OF PUPAE OBSERVED | No. of adults emerged | | Total No. of adults emerged |
|----------------|-----------------------|-----------------------|-----------|-----------------------------|
| | | Male | Female | |
| R ₁ | 25 | 11 | 12 | 23 |
| R ₂ | 25 | 12 | 12 | 24 |
| R ₃ | 25 | 12 | 13 | 25 |
| R ₄ | 25 | 12 | 10 | 22 |
| R ₅ | 25 | 10 | 13 | 23 |
| Total | 125 | 57 | 60 | 117 |

Mean sex ratio :- Female : Male = 1 : 0.95

Mean adult emergence (%) = 93.6

Table-8 : Predatory potential of 1st instar larvae of *Episyrphus balteatus* DeGeer on *Brevicoryne brassicae*

| Treatments (prey density) | Predatory prey ratio | Prey consumed during 24 hours/predator | |
|------------------------------|----------------------|--|---|
| | | Mean consumption | Date of prey consumption with increase in prey density (%) |
| 20 | 1:20 | 10.66 | 53.3 |
| 40 | 1:40 | 11.33 | 28.32 |
| 80 | 1:80 | 11.99 | 19.98 |
| 160 | 1:160 | 13.33 | 8.33 |
| Overall mean | | 11.82 | |
| LSD | | 1.139 | |

Table-9 : Predatory potential of 2nd instar larvae of *Episyrphus balteatus* DeGeer on *Brevicoryne brassicae*

| Treatments (prey density) | Predatory prey ratio | Prey consumed during 24 hours/predator | |
|------------------------------|----------------------|--|---|
| | | Mean consumption | Rate of prey consumption with increase in prey density (%) |
| 20 | 1:20 | 20.00 | 100.00 |
| 40 | 1:40 | 27.22 | 68.05 |
| 80 | 1:80 | 31.44 | 39.30 |
| 160 | 1:160 | 33.33 | 20.83 |
| Overall mean | | 27.99 | |
| LSD | | 1.07 | |

Table-10 : Predatory potential of 3rd instar larvae of *E. balteatus* DeGeer on *Brevicoryne brassicae*

| Treatments (prey density) | Predatory prey ratio | Prey consumed during 24 hours/predator | |
|------------------------------|----------------------|--|--|
| | | Mean consumption | Rate of prey consumption with increase in prey density (%) |
| 20 | 1:20 | 20.00 | 100.00 |
| 40 | 1:40 | 39.50 | 98.75 |
| 80 | 1:80 | 64.41 | 80.51 |
| 160 | 1:160 | 68.08 | 42.54 |
| Overall mean | | 47.99 | |
| LSD | | 1.41 | |

| Predator prey ratio | 1 st instar (prey consumed during 24 hours) | | 2 nd instar (prey consumed during 24 hours) | | 3 rd instar (prey consumed during 24 hours) | | Mean consumption of 1 st , 2 nd and 3 rd instar | Rate of prey consumed with increase in prey density |
|---------------------|--|---|--|---|--|---|--|---|
| | Mean consumption | Rate of prey consumed with increase in prey density (%) | Mean consumption | Rate of prey consumed with increase in prey density (%) | Mean consumption | Rate of prey consumed with increase in prey density (%) | | |
| 1:20 | 10.66 | 53.30 | 20.00 | 100.00 | 20.00 | 100.00 | 16.66 | 84.4 |
| 1:40 | 11.33 | 28.32 | 27.22 | 68.85 | 39.50 | 98.75 | 26.01 | 65.02 |
| 1:80 | 11.99 | 19.90 | 31.44 | 39.30 | 64.41 | 80.51 | 35.09 | 44.87 |
| 1:160 | 13.33 | 8.33 | 33.33 | 20.83 | 68.08 | 42.54 | 38.25 | 23.90 |
| Overall mean | 11.82 | | 27.99 | | 47.99 | | 29.26 | |
| LSD | 0.56 | | 1.07 | | 1.41 | | 1.09 | |

Table-11 : Predatory potential of 1st, 2nd and 3rd instar larvae of *Episyrphus balteatus* on *Brevicoryne brassicae*



Sample-1 : *Eristalis tenax*



Sample-3 : *Helophllus* sp.



Sample-4 : *Helophllus vittatus* W.



Sample-6 : *Helophllus bengalensis* W.



Sample-7 : *Helophllus* sp.

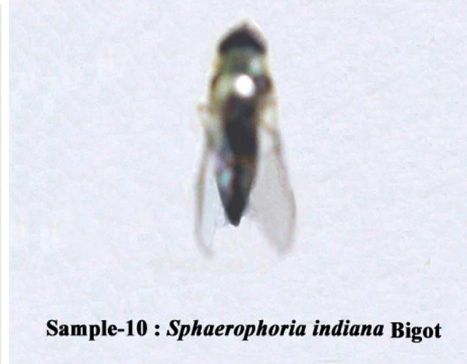


Sample-8 : *Helophllus* sp.

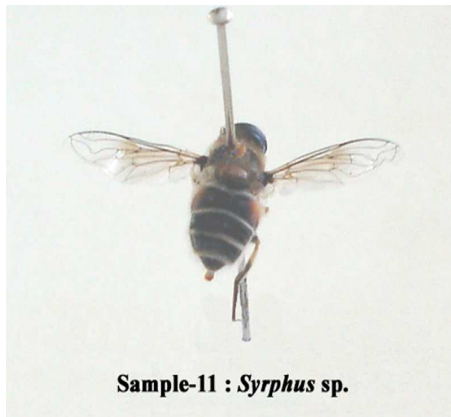
Plate-3 : Different species of syrphid flies observed at cabbage trial Contd...



**Sample-9 : *Episyrphus balteatus*
De Geer**



Sample-10 : *Sphaerophoria indiana* Bigot



Sample-11 : *Syrphus* sp.



Sample-12 : *Syrphus* sp.



Sample-13 : *Eristalis* sp.



Sample-14 : *Helophillus* sp.



Plate-2 : Glass chimneys containing adult females of *E. balteatus* for egg laying



Plate-6 : Aphid infested leaf containing syrphid fly eggs



Plate-8 : 1st, 2nd and 3rd instar larvae of *E. balteatus* preying upon *B. brassicae*



Plate-4 : 1st, 2nd and 3rd larvae of *E. balteatus*



Plate-5 : Pupa of *E. balteatus*



Plate-7 : Adult of *E. balteatus*



Plate-1 : Field view of cabbage trial laid out at SKUAST-K, Shalimar