# Evaluation of some underutilized fruit and medicinal plants as bee forage

**BY**

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## CERTIFICATE - I

This is to certify that this thesis entitled:**"Evaluation of some underutilized fruit and medicinal plants as bee forage"** submitted for the degree of Doctor of philosophy in the subject of Entomology of the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bonafide research work carried out by **Mrs. Vadde Anoosha,** Admn. No. 2012A17D under my supervision and that no part of the thesis has been submitted by her for any other degree.

All the assistance and help received during the course of investigation have been duly acknowledged.

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## CERTIFICATE - II

This is to certify that this thesis entitled: **"Evaluation of some underutilized fruit and medicinal plants as bee forage"** submitted by **Mrs. Vadde Anoosha,** Admn. No. 2012A17D to the Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfillment of the requirement for the degree of Doctor of philosophy in the subject of Entomology, has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.

**MAJOR ADVISOR** **EXTERNAL EXAMINER**

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**CONTENTS**

## LIST OF TABLES

## LIST OF PLATES

| | |
|---|---|
| 27. | *Coccinella septempunctata* foraging on Aonla flower |
| 28. | *Apis florea* foraging on Baheda flower |
| 29. | *Coccinella septempunctata* foraging on Baheda flower |
| 30. | *Eristalinusobscuritarsus* foraging on Baheda flower |
| 31. | *Eristalinusobliquus* foraging on Baheda flower |
| 32. | *Chrysomya rufifacies* foraging on Baheda flower |
| 33. | *Allorhynchium metallicum* foraging on Baheda flower |
| 34. | *Chrysocoris stolli* foraging on Baheda flower |
| 35. | *Apis florea* foraging on Lasora flower |
| 36. | *Apis cerana* foraging on Lasora flower |
| 37. | *Apis dorsata* foraging on Lasora flower |
| 38. | *Coccinella septempunctata* foraging on Lasora flower |
| 39. | *Eristalinus obliquus* foraging on Lasora flower |
| 40. | *Chilomenes sexmaculata* foraging on Lasora flower |
| 41. | *Chrysomya rufifacies* foraging on Lasora flower |
| 42. | *Mythimna separata* foraging on Lasora flower |
| 43. | *Thysanoplusia orichalcea* foraging on Lasora flower |
| 44. | *Eristalis* sp.foraging on Lasora flower |
| 45. | *Apis florea* foraging on Karonda flower |
| 46. | *Delta esuriens* foraging on Karonda flower |
| 47. | *Apis dorsata* foraging on Karonda flower |
| 48. | *Allorhynchium metallicum* foraging on Karonda flower |
| 49. | *Coccinella septempunctata* foraging on Karonda flower |
| 50. | *Papilio demoleus* foraging on Karonda flower |
| 51. | *Danaus chrysippus* foraging on Karonda flower |
| 52. | *Helicoverpa armigera* foraging on Karonda flower |
| 53. | *Sphaerphoria* sp.foraging on Karonda flower |
| 54. | *Danaus chrysippus* foraging on Bael flower |
| 55. | *Belenois aurota* foraging on Bael flower |

| | |
|---|---|
| 56. | *Papilio demoleus* foraging on Bael flower |
| 57. | *Junonia alomana* foraging on Bael flower |
| 58. | *Venessa cardui* foraging on Bael flower |
| 59. | *Utetheisa pulchella* foraging on Bael flower |
| 60. | *Catopsilia pyranthe* foraging on Bael flower |
| 61. | *Junonia lemonias* foraging on Bael flower |
| 62. | *Pedis* sp.foraging on Bael flower |
| 63. | *Phalanta phalantha* foraging on Bael flower |
| 64. | *Rhynchium oculatum* foraging on Bael flower |
| 65. | *Delta esuriens* foraging on Bael flower |
| 66. | *Mylabris pustulata* foraging on Bael flower |
| 67. | *Amata* sp.foraging on Bael flower |
| 68. | *Apis dorsata* foraging on Bael flower |
| 69. | *Apis florea* foraging on Bael flower |
| 70. | *Megachile cephalotes* foraging on Bael flower |
| 71. | *Monomorium* sp.foraging on Bael flower |
| 72. | *Eristalinus obscuritarsus* foraging on Bael flower |
| 73. | *Eristalinus obliquus* foraging on Bael flower |
| 74. | *Chrysomya* sp.foraging on Bael flower |
| 75. | *Coccinella septempunctata* foraging on Bael flower |
| 76. | *Amata* sp.foraging on Jamun flower |
| 77. | *Chrysomya megacephala* foraging on Jamun flower |
| 78. | *Eristalinus obscuritarsus* foraging on Jamun flower |
| 79. | *Eristalinus obliquus* foraging on Jamun flower |
| 80. | *Chrysocoris stolli* foraging on Sarpagandha flower |
| 81. | *Eristalis* sp. foraging on Sarpagandha flower |
| 82. | *Colotis etrida* foraging on Sarpagandha flower |
| 83. | *Papilio demoleus* foraging on Sarpagandha flower |
| 84. | *Amegilla zonata* foraging on Sarpagandha flower |

| | |
|---|---|
| 85. | *Papilio polytes* foraging on Sarpagandha flower |
| 86. | *Pieris* sp.foraging on Sarpagandha flower |
| 87. | *Polistes olivaceus* foraging on Sarpagandha flower |
| 88. | *Monomorium* sp.foraging on Sarpagandha flower |
| 89. | *Anapheis* sp. foraging on Sarpagandha flower |
| 90. | *Coccinella septempunctata* foraging on Sarpagandha flower |
| 91. | *Pelopidas* sp.foraging on Sarpagandha flower |
| 92. | *Bagrada hiliaris* foraging on Sarpagandha flower |
| 93. | *Eristalinus obscuritarsus* foraging on Sarpagandha flower |
| 94. | Estimation of dry nectar sugars |
| 95. | Pollen grains of research plants |

# CHAPTER – I

## INTRODUCTION

Underutilized plant species are only different from other crops because their economic potentials never commanded great attention from the National and International agencies/centers dealing with improvement, use and conservation. Indigenous communities use these underutilized plants as a source of food, feed, shelter and medicine. Thus, these needs to be acknowledged, employed and explored for today's and future generations. The underutilized plant species of economic importance are the key to sustainable agriculture in most of the developing countries facing resource constraints as well as rapid depletion of natural resources due to ever-increasing population pressure. Hence, diversifying production and/ or consumption of a broader range of plant species including those currently identified as 'underutilized', can therefore contribute significantly to improve health and nutrition, income generation and maintain ecological sustainability (Padulosi, 1998).

Aonla (*Phyllanthus emblica* L.), also known as Indian gooseberry, Amla or Emblic, belongs to the family Euphorbiaceae and is native of tropical south eastern Asia. It is grown commercially in India particularly in Uttar Pradesh (FAO, 1982). The fruits of aonla are generally used in cooking, preserves, sauce, pickles, jams and jellies, etc. The fruits are very rich in vitamin C (500-600 mg/100g pulp) and have great importance in Ayurvedic medicine (Ghosal*et al,* 1996). It is antiscorbutic and used in treatment of ailments associated with digestive system. The emblic is highly branched monoecious shrub or tree growing up to 9-18 m high. The leaves are linear-oblong, obtuse, nearly sessile distichously branched on slender branchlets.The small greenish yellow flowers are borne in compact clusters in the axils of the lower leaves. The male flowers are present usually at the lower end of branchlets with female flowers above them. Occasionally, the trees are dioecious. Fruit is a hard berry,round, indented at base and smooth obscurely 6 lobed. The stone contains 6 small seeds (Brun and Schumacher, 1987).

Baheda (*Terminalia bellirica* Roxb) also known as beddanut, belliric myrobalan, belongs to the family Combretaceae. It is native of Indo-Malaysian region. It is found throughout India in moist situations and in the peninsular deciduous and mixed forests. Baheda is large and tall tree. Flowers are greenish yellow and have offensive smell. Male and bisexual flowers are found in unbranched spikes. Petals are absent. Fruit is roundish, obscurely 5-angled, somewhat fleshy brown coloured drupes covered with brown velvety fur. Fruit pulp is hard enclosing the stone. Stones contain edible kernels and are split into two valves (Hocking, 1993).

Lasora (*Cordia myxa* L.) belongs to the family Boraginaceae. Lasora originates along the Himalayan tract up to 1,500 metres, with its natural habitat extending through the forests of India, Nepal and Myanmar. It is found growing in arid and semi-arid regions of north regions of north India. It can tolerate frost and drought to a great extent. The leaves of lasora are broad, ovate, alternate and stalked, glabrous above and pubescent below. The inflorescence is mostly terminal, white in color. Individual florets are nearly 5 mm in diameter. Being a deciduous plant, the species bears male and female flowers on the same tree (Chandra and Gupta, 1994).

Karonda or Christ's thorn (*Carissa carandas* L.) belongs to the family Apocynaceae. It is native of India. Karonda has little potential for cultivation as food crop. It is a very hardy evergreen shrub and can tolerate drought and diverse soil conditions. Fruit is astringent, antiscorbutic and is used as a remedy for biliousness. The leaves are dark green and ovate. It possesses strong axillary spikes, which are often forked. The flowers are white and fragrant and are borne in clusters of two or three. Fruit is an ellipsoid berry and has 2-8 flat brown seeds. On ripening, the fruit turns from green to white or pink and later black (Verheij and Coronel, 1991).

The bael (*Aegle marmelos* (L) Corr.) is indigenous to India and belongs to the family Rutaceae. It is also known as Bengal quince. In India it is known from prehistoric times and has a great mythological significance, enoromous traditional values against various diseases and various bioactive compounds have been isolated (Gupta and Tondon, 2004). It is found growing wild in dry forests on hills and plains of central and southern India and Pakistan, Srilanka, Myanmar, Thailand, Indonesia, Philippines, Vietnam and Bangladesh. It is common in the Indian States of Uttar Pradesh, Orissa, Bihar, West Bengal and Madhya Pradesh. It is also cultivated on a limited scale in North India. Bael fruit is not so popular as a dessert fruit due to its hard shell and the mucilaginous pulp, but it is used for the preparation of products like squash, nectar, slab, toffee etc. Bael tree is deciduous in nature. The leaves are aromatic, alternate and trifoliate. The bisexual flowers are borne in clusters and sweet scented and greenish white. The fruit is globose with thick and hard pericarp filled with soft, yellow and orange, very fragrant and pleasantly flavoured pulp. Numerous seeds are arranged in closely packed tiers in the cells surrounded by transparent mucilage (Morton, 1987; Verheij and Coronel, 1991).

Jamun (*Syzygium cumini* L.) is a member of the family Myrtaceae and is also known as Java plum, Malabar plum. It is a native of India or the East Indies. In India, it is widely grown in larger parts of India from Indo-gangetic plains in north to Tamil Nadu in the south (Verheij and Coronel, 1991). Jamun is fast growing, evergreen tree. Leaves are leathery and have conspicuous yellow midribs. Panicle inflorescences are usually borne on leaflet branches, which are solitary or fascicled and many flowered. Flowers are small, fragrant.

Fruits are oblong. Fruit colour turns from green to light magenta and then dark purple or nearly black on ripening.

Sarpagandha (*Rauvolfia serpentina* (Linn.)Benth., ex Kurz.) belongs to the family Apocynaceae. Sarpagandha grows wild in India, Bangladesh, Srilanka, Myanmar, Thailand, Indonesia and Malaysia. It is grown in almost all parts of India up to an altitude of about 1000m above sea level. Sarpagandha is an erect and evergreen shrub. Leaves are whorled and gradually tapering into short petiole. Flowers are of white and pink colour contains 5 sepals, 5 petals and 5 epipetalous stamens. Style is filiform and stigma is bifid.Bilocular ovary and having two ovules in each locule. Fruit is drupe, ovoid and purplish black in color when it reaches maturity and contains wrinkled seeds (Wadhwa and Sihag, 2012). Five species of sarpagandha have been recorded in India, of which *R. Serpentina* has attained a great importance as medicinal plant (Pullaiah, 2006). Sarpagandha contains several alkaloids, out of those resperine is pharmacologically most important (Blackwell, 1990).

Pollination is one of the principal mechanisms in the maintenance and conservation of biodiversity and in general life of earth. Pollinators provide an ecosystem service that enables plants to produce fruits and seeds. Pollinators are found in varied groups of the animal kingdom, among them insects particularly honeybees; lead in providing pollination services to several plants.

Bees are the primary pollinator of most fruit crops and improve not only crop yield, but also crop quality. Several other pollinators including carpenter bees, bumble bees, megachilids, halictids, sphecids, andrenids, and syrphids are known to occur in the country. Effective pollination is a pre requisite for many plants. The structure of the flowers, their degree of self fertility and their arrangement on the plant determines the extent to which a plant is dependent on insects for pollen transfer (Free, 1993; Williams, 1994; Richards, 2001).

Of the total pollination activities, over 80 per cent is performed by insects and bees (Klien *et al.,* 2007). Around 30 percent of human food is derived from bee pollinated crops (O' Toole1993). Pollinating insects are widely found in orders of Coleoptera, Lepidoptera, Thysanoptera, Diptera and Hymenoptera (Singh and Garg, 2003).

Evaluation of nectar and pollen of economically important crops have been worked out. Their roles in sustaining number of colonies per hectare have been developed. Lot of work has been done in India and abroad on commercial fruit crops as bee forage but scanty information is available on underutilized fruit and medicinal plants such as *Phyllanthus emblica* L.(Aonla), *Terminalia bellirica* Roxb.(Baheda),), *Cordia myxa* L. (Lasora), *Carissa carandas*L.(Karonda), *Aegle marmelos* L.(Bael), *Syzygium cumini* L.(Jamun)*and Rauvolfia serpentina* L. (Sarpagandha) have not been worked out very much. The information on these plants as bee forage is need of the hour as in some areas they serve as good source of nectar and/or pollen. Keeping this idea in view, the present investigation entitled "Evaluation of

some underutilized fruit and medicinal plants as bee forage" was carried out with the following objectives:

1. To study the diversity and abundance of insects visitors/pollinators of some underutilized fruit and medicinal plants
2. To study the foraging behaviour and pollination efficiency of major insect pollinators
3. To estimate the dry nectar sugars in flowers of different plants
4. To study the effect of different modes of pollination on fruit set/yield

# CHAPTER - II

# REVIEW OF LITERATURE

A large number of underutilized edible fruits exist in tropic and subtropics of the world. Many of such fruit species are identified, domesticated and are being utilized for various purposes, but their full potential has not been exploited. These underutilized plants can help to make diets more balanced and hence can play an important role in combating silent hunger (Swaminathan, 1999). Scanty information on the plants/crops selected for the present studies are available. Therefore work done in India and abroad on the various other similar/related crop plants has also been reviewed here as under the following headings/sub headings:

2.1. Diversity and Abundance

2.2. Foraging Behaviour and Pollination Efficiency

2.3. Dry Nectar Sugars in Flowers

2.4. Effect of Modes of Pollination on Fruit set/Yield

## 2.1. Diversity and Abundance

Wadhwa and Sihag (2012) reported that foraging rates of lepidopterous insects were significantly higher than those of the hymenopterous insects. *Papilio demoleus* had highest fraging rate followed by *Pieris brassicae*, *Xylocopa fenestrata*, *Megachile* sp. Based on this psychophilous mode of pollination seemed to be more prevalent in Sarpagandha. Among the hymenopterous insects, *Mellisodes* sp. was most abundant (24.71%), followed by *Xylocopa fenestrata* (18.52%) and *Megachile* sp. (7.64%). Among the lepidopterous insects, *Papilio demoleus* was most abundant (32.17%) followed by *Pieris brassicae* (9.66%). The proportion of remaining 14 species was very low (7.27%).

Saini (2011) recorded the hymenopterous insect visitors of amla namely, *Apis dorsata*, *A. mellifera*, *A. florea* and *Polisteshebraeus*. The dipterans were *Sarcophaga* sp., *Chrysoma bezziana*, *Eristalinus*, *Episyrphus*, *Syrphus* and *Syritta*. The lepidopteran species was *Psichotoe duvauceli*.

Saini (2011) reported that abundance of *Apis dorsata* (7.26 bees/$m^2$) was maximum followed by *A. mellifera* (4.49 bees/$m^2$), *A. florea* (3.65 bees/$m^2$), *Sarcophaga* (2.07 insects/$m^2$) and other insect pollinators (1.0 insects/$m^2$) in amla.

Singhal *et al*. (2011) stated that eight insect species were recorded on the flowers of bael trees growing in Patiala region. Those species were *Apis dorsata*, hover fly, *Amata cyssea*, *Anaphaeisaurota*, *Pieris brassicae*, *Polestis herbreus*, *Solenopsis geminata*, *Xylocopa pubescens*. On the other hand in Kangra region, only six insect species namely, *Apis dorsata*,

Apis sp., hover fly, *Amata cyssea*, *Solenopsis geminata* and an unidentified weevil were recorded.

Martins (2010) recorded the pollinators of *Euphorbia brevitorta* whichwere true flies (Diptera), ants, bees and wasps (Hymenoptera) and beetle (Coleoptera). Flies, wasps and honeybees were found to be the major pollen transporters between different individual plants and carried the highest volumes of pollen.

Rianti *et al*. (2010) observed that ants (*Prenolepis*), and bees (*Xylocopa confusa*, *Apis cerana* and *A. dorsata*) were the frequent visitors of *Jatropha curcas* flowers whereas butterflies (*Junonia oritya*, *Graphium agamemnon* and *Ariadne ariadne*) and flies (*Eristalinus tenax*) were infrequent visitors.

Wadhwa and Sihag (2012) reported that ninteen insect species belonging to two orders were observed visiting the blossoms of *Rauvolfia serpentina.* Among the visitors, 11 were hympenopterans ( *Xylocopa fenestrata*, *X. pubescens*, *Xylocopa* sp., *Mellisodes* sp., *Pithitis smargdula*, *Megachile bicolor* and *Megachile* sp., *Apis dorsata*, *A. mellifera*, *A. florea* and *Polistes hebreaus*) and 8 were lepidopterous insects (*Papilio demoleus*, *P. polytes*, *Danaus aglea creamer*, *Danaus chrysippus*, *Pieris brassicae,Eurema hecabe*, cabbage butterfly and *Pedis* skipper). Among them lepidopterous butterflies and some of hymenopterous bees were important pollinators.

Phalsa flowers visited by *Apis florea*, *A. mellifera*, *A. dorsata*, *Megachile bicolor* and *Chalicodoma cephalotes* were observed foraging for both nectar and pollen, while other foraged for nectar only (Gill *et al*., 2001).

Kumar (1990) reported in 'ber' that among different insect visitors, *Apis* spp. were found foraging on both nectar and pollen while dipteran and lepidopteran insects foraged for nectar only. He also reported that *A. florea* was the most efficient pollinator of 'ber' flowers followed by *A. mellifera* and *A.dorsata* under Hisar conditions. All the insect visitors were top workers except *Camponotus* sp. and lepidopteran insects which were side workers (nectar robbers).

Reddi and Reddi (1983) observed that major pollinators of *Euphorbia geniculata* were ants (*Camponotus*), wasps (*Vespa, Polistes, Ropalidia*) and beetles (*Coccinella*). Ants were more abundant.

Honeybees and other hymenopteran insects on jujube (*Zizyphus mauritiana* Lamk.) were more active on upper branches while housefly and other dipteran insects were abundant on middle and lower branches (Singh, 1984).

Manzoor-ul-haq and Inayatullah (1979) found 27 species of Hymenoptera, Lepdoptera and Diptera visiting phalsa flowers. *Apis florea* and several species of *Halictus* (Halictidae) and *Andrena* (Andrenidae) were the most common visitors.

Parmar (1976) observed that honey bees were the most abundant visitors, and pollinated the flowers while collecting nectar and found that 30 bee species visited phalsa flowers. The most abundant among them were the Africanised honey bees (32.5%), *Melipona* scutellaris (28.1%), *Exomalopsis* (*Phanomalopsis*) sp.1 (18.1%) and *Xylocopa* (*Neoxylocopa*) *suspecta* (6.6%) and can be considered the potential pollinators of phalsa flowers.

**2.2. Foraging Behaviour and Pollination Efficiency**

Pollinators play significant role to increase the yield as duration and frequency of visits of the pollinators are positively correlated to pollination rate, which itself is number of fruits produced and the dimensions of the fruit. The utilisation of pollinators especially honeybees is considered as one of the cheapest eco-friendly approaches in maximising the yield of the cross-pollinated crops. The time spent per flower and number of flowers visited per minute decides the foraging speed and rate, respectively (Free, 1993).

Saini (2011) observed the foraging rates of *Apis dorsata*, *A. mellifera*, A. *florea*, *Sarcophaga* and other pollinators on different varieties of amla and stated that foraging rate of *A. dorasta* were maximum on all the three varieties (NA-7, NA-10 AND Chakaiya) and foraging rate of all the insect pollinators at diferent hours of the day was significantly different. Foraging rates were maximum at 0800 hrs and minimum at 1400 hrs.

Saini (2011) reported that major pollinators were *Apis dorsata*, *A. mellifera*, *A. florea*, *Sarcophaga* sp. and other insect pollinators from diptera and hymenoptera visiting amla flowers from their front and all these followed sternotribic mode of pollen transfer.

Singhal *et al*. (2011) observed that *Apis* bees, carpenter bees, moths and butterflies landed directly on anthers of Bael flower. For collection of pollen grains bees landed over the flower and grasped the anther filaments with their mandibles and in the process some pollen grain attached with the body parts. Hover fly and weevil insect first sit on the petals, moved slowly toward the anthers and then made contact with stigma.

Singhal *et al.* (2011) revealed that *Apis dorsata* was the most active and frequent visitor of bael flowers during peak blooming and stated that *A. dorasta* carried 5–8 visits/flower/hour and also approximated that around 240–384 bees visited during the functional life of each flower of Bael.

Singhal *et al*. (2011) reported that Hover fly was noticed to be the most sluggish insect in its movement over the flower. Honey bees were most active and carried a complete revolving circle on the anthers.

Qing *et al*. (2007) recorded that *Apis mellifera*,*A.cerana* and *Catopsila pomona* were most effective pollinators of *Jatropha curcas* due to their higher visiting frequencies.

Wadhwa and Sihag (2012) stated that lepidopterous insects had higher foraging rates than those of hymenopterous insects visiting *R. serpentina.* Among the lepidopterous insects *Papilio demoleus* had highest foraging rate (20.1flowers/min) as compared to *Pieris*

*brassicae*(17.8). Among the hymenopterous insects *Xylocopa* (13.5) had highest foraging rate followed by *Megachile* sp. (10.4) and *Mellisodes* sp. (9.3).

Wadhwa and Sihag (2012) revealed that among the flower visitors, *Apis dorsata*, *A. mellifera*, *A. florea*, *Pithitis smargdula* and *Polistes hebreaus* were non pollinators, side foragers and nectar robbers. *Papilio demoleus*, *P.polytes*, *Danaus aglea creamer*, *Pieris brassicae*, *Danaus chrysippus*, *Eurema hecabe*, Pedia skipper and cabbage butterfly were the pollinators, front foragers and also act as pollen and nectar gatherers.

Foraging rates of insect pollinators in carrot were very high at afternoon when compared to morning and evening. Among all insect visitors, *Apis florea* had highest foraging rate. Foraging rates of bees were higher than those of flies (Priti and Sihag, 1998).

Wadhwa and Sihag (2012) reported that *Mellisodes* species carried maximum number of pollen grains (5087.66) followed by *Megachile* sp. (4780.33), *Xylocopa fenestrata* (4471), *Papilio demoleus* (2730) and *Pieris brassicae* (2513) among the flower visitors of sarpagandha. Wadhwa and Sihag (2012) reported that *Papilio demoleus* was ranked as best pollinator with relatively lower ranking in pollinating efficiency were *Mellisodes* sp., *Xylocopa fenestrata* and *Megachile* sp. in descending order among the pollinators of Sarpagandha.

Average number of loose pollen grains was maximum (6538.80) on body o*f A. dorasata* followed by *A. mellifera* (4608.03), *A. florea* (4320.20), *Sarcophag*a (3247.63) and other insect pollinators (760.26) in amla (Saini, 2011).

Singhal *et al*. (2011) observed that *Apis dorsta* visited the flower more frequently, for more duration than other pollinators and carried the highest pollen load of 20–38 pollen grains on their legs, thorax, mouth parts and wings. Hover fly, *Amata cyssea*, *Anaphaeis aurota*, *Pieris brassicae* and *Xylocopa pubescens* carried less pollen load. *Polestis herbreus* and *Solenopsis geminata* were merely the visitors as no pollen grains were recorded from their body parts.

On the basis of pollination index, *A. florea* was found to be the most competent pollinator (22989.2) of phalsa (*Grewia subinequalis*) followed by *A. dorsata* and *A.mellifera* with a pollination index of 18634.0 and 2286.0, respectively (Gill *et al*., 2001).

**2.3. Dry nectar sugars in flowers**

Girdher (2008) reported that on the basis of flower density and nectar sugar concentration order of preference among pollinators was *A.florea* >dipterans>*P hebraeus* >*A. mellifera* >*A. dorsata* in ber.

Sajjanar *et al*. (2003) observed the different peaks for different pollinators on *Ocimum* sp. and stated these peaks of foraging activity related to availability of nectar and pollen during mid-morning hours.

Rama devi*et al*. (1989) reported that on an average *Zizyphus mauritiana* flower secreted 2.5 µl/nectar/flower.

**2.4. Effect of Modes of Pollination on Fruit set/Yield**

Saini (2011) recorded that fruit set was best with *Apis dorsata* as a pollinator followed by *A*. *mellifera*, *A*. *florea*, *Sarcophaga* and other insect pollinators in amla and revealed that these flowers were highly benefited from insect visits and insect pollination greatly enhanced its fruit yield and further revealed that it is a cross-pollinated and entomophilus plant.

Saini (2011) revealed that per cent fruit set was maximum for hand pollination (95.67), followed by open pollination (83.33) and wind pollination (18.00).

Saini (2011) revealed that fruit retention was maximum for hand pollination (40.26 g), followed by open pollination (38.44 g) and wind pollination (36.60 g).

Wadhwa and Sihag (2012) reported that cross-pollination between first day flower as pollen recipient (stigma) and second day flower as pollen donor (pollen available) produced seeds in 100% recipient flowers, indicating protogyny in Sarpagandha. However, fresh self-pollen (from second day flower) could not fertilize the ovary of second day flower confirming that stigma was not receptive on the second day after anthesis. These experiments revealed that in the two days' age of flower, its stigma was receptive only on the first day as anthers dehisced on the second day when stigma had become non-receptive.

Singhal *et al*. (2011) reported that fruit set initiation in open pollinated flowers was noticed to be high, with wild trees showing slightly higher percentage (70.58 ± 0.96%) compared to the cultivated trees where it varied between 60.00 ± 1.09 and 68.42 ± 1.18%. Percentage fruit set initiation with hand pollination was reduced in both the wild (37.50 ± 0.63%) and cultivated trees (25.00 ± 0.60–30.00 ± 0.89%). No fruits were set in the emasculated and non-emasculated flowers after bagging. However, bagging of whole panicles in cultivated and wild trees resulted into 12.21 ± 0.99–14.10 ± 0.57% and 14.12 ± 0.91% fruit set, respectively. Reciprocal crosses performed among wild and cultivated trees yielded no fruit.

Singhal *et al*. (2011) revealed that production of pollen in mass enabled the species for wind mode of pollination which was confirmed from the presence of air borne pollen grains on glass microscope slides hung around trees during peak blooming. Although flowers are dull coloured, insect visitors were attracted due to the presence of sweet fragrance, and pollen and stamens as food reward. As such the species possessed broad pollination spectrum, adapted to both insect and wind mode and the natural pollen transfer was quite efficient.

Wadhwa and Sihag (2012) reported that seed set on flowers of *R. serpentina* in insect pollination was 177.45g seeds/inflorescence. It was 87.33g seeds/inflorescence in open

pollination. However, seed set was found to be very low in wind and self-pollination. Same trend followed in yield per plant and per plot.

Balasubramaniam and Arulmozhiyan (2003) reported that 4 cultivars of aonla expressed poor fruit set and retention in bagging and improvement was observed with geitonogamy and sibbing. All cultivars resulted favourably for open pollination with respect to fruit set and retentivity (46.74 and 29.16%). The study confirmed the self incompatibility in aonla. The pollination stimulus from pollen of other cultivars was higher in open pollination. Among different cross combinations, the highest fruit set (58.42%) and retention (10.41%) were recorded in NA-7 x NA-6 combination closely followed by NA-6 x Krishna (46.86 and 9.83%, respectively). The poorest fruit set under bagging confirmed the problem of self-incompatibility in NA-7.

Singh *et al*. (1998 and 2001) reported that open pollination resulted in maximum fruit retention followed by sibbing and geitonogamy in amla, whereas bagging resulted in no fruit retention. Self-incompatibility caused poor fruit retention under sibbing and geitonogamy.

Bhattacharya and Mandal (2000) revealed that no fruit setting was observed in RedCotton Treein netted and bagged flowers, which strongly indicated that some external agents were required for successful pollination.

Sdraiati (1998) reported that fruit set on flowers of *Erythronium denscanis* (Liliaceae) that were open pollinated was 73.9 per cent. It was 21.3 per cent on flowers isolated from insects. The average number of seeds /fruit was 18.02 for open pollinated plants, 7.62 for isolated plants from insects.

Srivastava and Pathak (1993) observed maximum fruit set in amla under open pollination followed by hand pollination and bagging.

Kumar (1990) also reported that the average per cent fruit set in 'ber' in self and open pollinated flowers, irrespective of cultivars were 4.67 and 15.36, respectively. The per cent fruit set under open pollination was higher in all the cultivars than the self pollination.

Mohammad and Ram (1990) observed absolutely no fruit set under bagging in aonla. Significantly, the highest fruit set (61.43%) and retention (18.54%) were recorded under open pollination.

# CHAPTER - III

# MATERIALS AND METHODS

The present study entitled "Evaluation of some underutilized fruits and medicinal plants as bee forage" was carried out at Research Farm of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2014 and 2015. The following materials and methods were used for conducting the research.

## 3.1. Materials

**3. 1. 1. Bee forage**: The following seven underutilized and medicinal plants wereselected as plant material

*Phyllanthus emblica* L.(Aonla)

*Terminalia bellirica* Roxb.(Baheda)

*Cordia myxa* L. (Lasora)

*Carissa carandas*L.(Karonda)

*Aegle marmelos* L.(Bael)

*Syzygium cumini* L.(Jamun)

*Rauvolfia serpentina* L. (Sarpagandha)

### 3. 1. 2. Other Materials

#### 3. 1. 2. 1. Stopwatch

Stopwatch with an accuracy of 0.01 second was used to record the forging rate and speed of different insect visitors on flowers of different crops.

#### 3.1. 2. 2. Hand telly counter

Insect abundance was counted with the help of hand telly counter.

#### 3. 1. 2. 3. Insect box

To preserve the collected insect specimens for further identification.

#### 3. 1. 2. 4. Insect pins

Pins of No. 9 were used for pinning the insect visitors and pollinators for identification.

#### 3. 1. 2. 5. Hand net

To catch the insect visitors and pollinators.

#### 3. 1. 2. 6. Insect killing bottle

To kill the insect visitors and pollinators on flowers for their identification as dry specimens.

#### 3. 1. 2. 7. Forceps

Forceps was used for capturing the foraging bees required for the counting of loose pollen grains sticking to their body.

**3. 1. 2. 8. Ethyl Alcohol**

70 per cent ethyl alcohol was used to kill the major pollinators and to preserve them for the counting of loose pollen grains sticking to their body in glass vials.

**3. 1. 2. 9. Glass vials**

Glass vials of 25x50 mm were used to preserve the insect visitors for the counting of loose pollen grains sticking to their body and also for collecting the flower samples for dry nectar sugar estimation.

**3. 1. 2. 10. Digital camera**

To take the photographs of different insect pollinators on flowers.

**3. 1. 2. 11. Microscope**

To magnify and count the number of loose pollen grains sticking to bee body in an aliquot.

**3. 1. 2. 12. Haemocytometer**

To count the number of pollen grains sticking to bees body in an aliquot.

**3. 1. 2. 13. Spectrophotometer**

To estimate the dry nectar sugars in flowers.

**3. 1. 2. 14. Balance**

For the weighing of fruit and seed samples to estimate their weight.

**3. 1. 2. 15. Vernier caliper**

To measure the length and diameter of fruit and seed.

**3. 1. 2. 16. Miscellaneous**

The Other materials used during the studies were glass slides, cover slips, setting board, record book, tissue papers, muslin bags, butter paper bags, beakers, pipettes, distilled water, Conc. $H_2So_4$, phenol and glucose.

**3. 2. Methods**

**3. 2. 1. Diversity and abundance of insect visitors/pollinators**

To observe the variety of insects visiting the flowers during their flowering period, the insect visitors and pollinators were collected by hand net with 30 cm ring diameter. For this, sweeps were made throughout flowering period of the crop at two hourly intervals from the morning to the evening. Captured insects were killed by using ethyl alcohol and preserved as dry specimens and were got identified and a record of the flower visitors was prepared.

Abundance of different insect visitors/ pollinators, number of visitors/$m^2$branch of a tree/5minutes was recorded from five randomly selected branches. The abundance was recorded at two hourly intervals, starting from commencement to the cessation of insect activity and repeated at weekly intervals starting from commencement to the cessation of the flowering on the experimental trees. The recorded data were analyzed in Randomized Block Design (Snedecor and Cochran, 1989) and the results were compared.

**Plate 1: *Phyllanthus emblica* (Aonla) in bloom**

**Plate 2: *Terminalia bellirica* (Baheda) in bloom**

**Plate 3: *Cordia myxa* (Lasora) in bloom**

**Plate 4: *Carissa carandas* (Karonda) in bloom**

**Plate 5: *Aegle marmelos* (Bael) in bloom**

**Plate 6: *Syzygium cumini* (Jamun) in bloom**

**Plate 7: *Rauvlofia serpentina* (Sarpagandha) in bloom**

**Plate 8: Different modes of pollination (Open and WIP) of flowers in Aonla**

**Plate 9: Different modes of pollination (Open and WIP) of flowers in Baheda**

**Plate 10: Different modes of pollination (Open and WIP) of flowers in Lasora**

**Plate 11: Different modes of pollination (Open and WIP) of flowers in Karonda**

**3. 2. 2. Foraging behaviour and pollination efficiency of major insect pollinators**

Diverse aspects of foraging behaviour of the most frequent insect visitors associated as the pollinators of above mentioned trees were recorded as follows:foraging speed and foraging rate of each pollinator were recorded at peak flowering period.

**3. 2. 2. 1. Foraging speed**

It was recorded in terms of time spent/flower (seconds).

**3. 2. 2. 2. Foraging rate**

Foraging rate of major pollinators was also recorded in term of number of flowers visited/minute. Ten observations were taken for each pollinator species. Accordingly, the average number of flowers visited /minute was calculated for each species. The number of flowers visited per minute included the flight time of insect from one flower to another. For this, observations were recorded at 2 hours interval on a day and were repeated once a week. The data was analyzed in Randomized Block Design (Snedecor and Cochran, 1989) and foraging rates of different visitor species were compared.

**3. 2. 2. 3. Foraging mode**

Initiation and cessation of activity and working behaviour (whether working from top or side) of flower visitors was noted after 10 days of initiation of flowering. Ten individuals of each flower visitors were observed for this purpose. The visitors collecting nectar and/or pollen through legitimate route were characterized as pollinators whereas, those through illegitimate route as non-pollinators.

**3. 2. 2. 4. Loose pollen grains sticking on the body of insects visitors**

For estimating the number of loose pollen grains sticking to the body of major insect pollinating species, the insects were collected gently by forceps from the flowers to avoid shaking of body, and the hind legs of those pollinators which collected the pollen were amputated. Insects were captured at the time of their peak activity and were kept in 70% alcohol in vials. They were shaken vigorously to wash out pollen grains from its body. The numbers of pollen grains were counted with the help of a haemocytometer under the microscope (15 x 10 magnification). Ten samples were taken for each pollinator species and loose pollen grains present on each species were calculated and compared using Completely Randomized Design (Snedecor and Cochran, 1989).

Number of pollen grains = pollen grain count x dilution/number of squares ($1mm^2$) counted

**3. 2. 2. 5. Pollination efficiency of major insect pollinators**

Comparative pollination efficiency of different insect pollinators was calculated on the basis of their relative abundance and foraging behaviour parameters such as foraging speed, foraging rate and the number of loose pollen grains sticking to their bodies by using the following formula:

Pollination efficiency = Abundance X foraging Rate X number of loose pollen grains sticking on the body of the bee

**3. 2. 3. Estimation of the dry nectar sugars in flowers of different plants**

For estimating the dry nectar sugars, floral buds about to open next day morning were selected and bagged with butter paper bags. On the next day, the flowers were plucked in a plastic tube (15 ml) and washed with 5 ml distilled water. Each tube will be securely capped, shake vigorously to get the rinsate of the nectaries and the rinsate were stored in refrigerator till further analysis and to prevent the growth of micro-organisms. Total 10 replications (one flower/replicate) from each treatment and the blank were maintained for analysis of dry nectar sugars.

For quantitative estimation of total sugars, method of Roberts (1979) was followed. From the rinsate of aliquotes of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0 ml were taken so as to get the absorbance in the range of 0.1 to 0..9 , which is considered best for accurate measurements. The required amount of rinsate transferred to test tube and the volume was made to 1 ml by adding distilled water (wherever necessary). To this solution 1ml of 5 per cent phenol solution was added followed by 5 ml of concentrated sulphuric acid. The final solution was mixed with the help of test tube shaker for 5 minutes. After that the solution was measured at 490 nm with UV spectrophotometer against blank.

The amount of sugar corresponding to observed absorbance value was estimated from the standard glucose curve to obtain the amount of sugars per flower expressed as (milligram of glucose equivalent).

**3. 2. 4. Effect of different modes of pollination on fruit set/yield**

The role of insects in the pollination and fruit production were determined by conducting experiments in the field. Some newly opened flowers of each variety were randomly selected and covered with muslin bags to exclude insect pollination (WIP). The remaining flowers were kept open for open pollination (OP). Muslin bags were removed immediately after the flowering in the crop was over. Following parameters were compared in muslin bags (without insect pollination) and open pollinated conditions

**3. 2. 4. 1. Number of fruits/branch:** Total number of fruits per branch were calculated by counting the fruits of 10 randomly selected branches under muslin bagged and open conditions. Fruits were selected from all the branches under open pollinated and without insect pollinated area. Fruit length and fruit weight were also measured.

**3.3. Statistical Analysis**

All the data pertaining to foraging speed, foraging rate, abundance, diversity, yield parameters like seed weight, number fruits/plant, number of seeds/fruit were analysed by

**Plate 12: Different modes of pollination (Open and WIP) of flowers in Bael**

**Plate 13: Different modes of pollination (Open and WIP) of flowers in Jamun**

**Plate 14: Different modes of pollination (Open and WIP) of flowers in Sarpagandha**

Randomized Block Design. The data on number of loose pollen grains sticking to the insect body and dry nectar sugars were analysed by Completely Randomized Design.

## CHAPTER - IV

## RESULTS

The results of present investigation entitled "Evaluation of some underutilized fruit and medicinal plants as bee forage are presented here in this chapter under following heading includes

4.1. Diversity and Abundance of insect visitors/pollinators

4. 2.Foraging behaviour

4. 2. 1. Foraging rate

4. 2. 2. Foragiing speed

4. 2. 3. Number of loose pollen grains sticking on the body of insect visitors

4. 2. 4. Pollination efficiency of major insect pollinators

4. 3. Dry nectar sugars in flowers of different plants

4. 4. Effect of different modes of pollination on fruit set/yield

### 4.1. Diversity and Abundance of insect visitors/pollinators

#### 4.1.1. Diversity of insect visitors/ pollinators on Aonla flowers

Diversity of insect visitors/pollinators on Aonla flowers have been presented in Table 1 and Plate 15. Aonla flowers attracted wide varieties of insects belonging to 5 orders, 7 families, 9 genera and 12 species. Among them four belongs to order Hymenoptera, two to Coleoptera, four to Diptera, one to Hemiptera and one to Lepidoptera. The Dipterans were the major floral visitors comprising of three families *viz*., Syrphidae (*Sphaerophoria* sp. and *Episyrphus* sp.), Sarcophagidae (*Sarcophaga* sp.) and Muscidae (*Musca domestica*). They were followed in order of diversity by hymenopterans from one family *viz*., Apidae (*Apis florea, A. dorsata, A. cerana* and *A. mellifera*). Coleopterans belongs to family, Coccinellidae (*Coccinella septempunctata* and *Cheilomenes sexmaculata*), Hemipteran to Scutellaridae (*Chrysocoris stolli*) and one Lepidopteran to Arctiidae (*Amata*sp.). Out of 12 insects,all were top foragers except *Amata* sp. which was side forager also.

**Table 1: Diversity of Insect visitors/pollinators of *Phyllanthus emblica* (aonla)**

| Order | Family | Insect Species | IP/IV* | Working Behaviour |
|---|---|---|---|---|
| Hymenoptera | Apidae | *Apis florea* Fabricius | IP | T |
| | | *Apis dorsata* Fabricius | IP | T |
| | | *Apis cerana* Fabricius | IP | T |
| | | *Apis mellifera* Linnaeus | IP | T |
| Coleoptera | Coccinellidae | *Coccinella septempunctata* Linnaeus | IV | T |
| | | *Cheilomenes sexmaculata Fabricius* | IV | T |
| Diptera | Syrphidae | *Sphaerophoria* sp. | IP | T |
| | | *Episyrphus* sp. | IP | T |
| | Sarcophagidae | *Sarcophaga* sp. | IV | T |

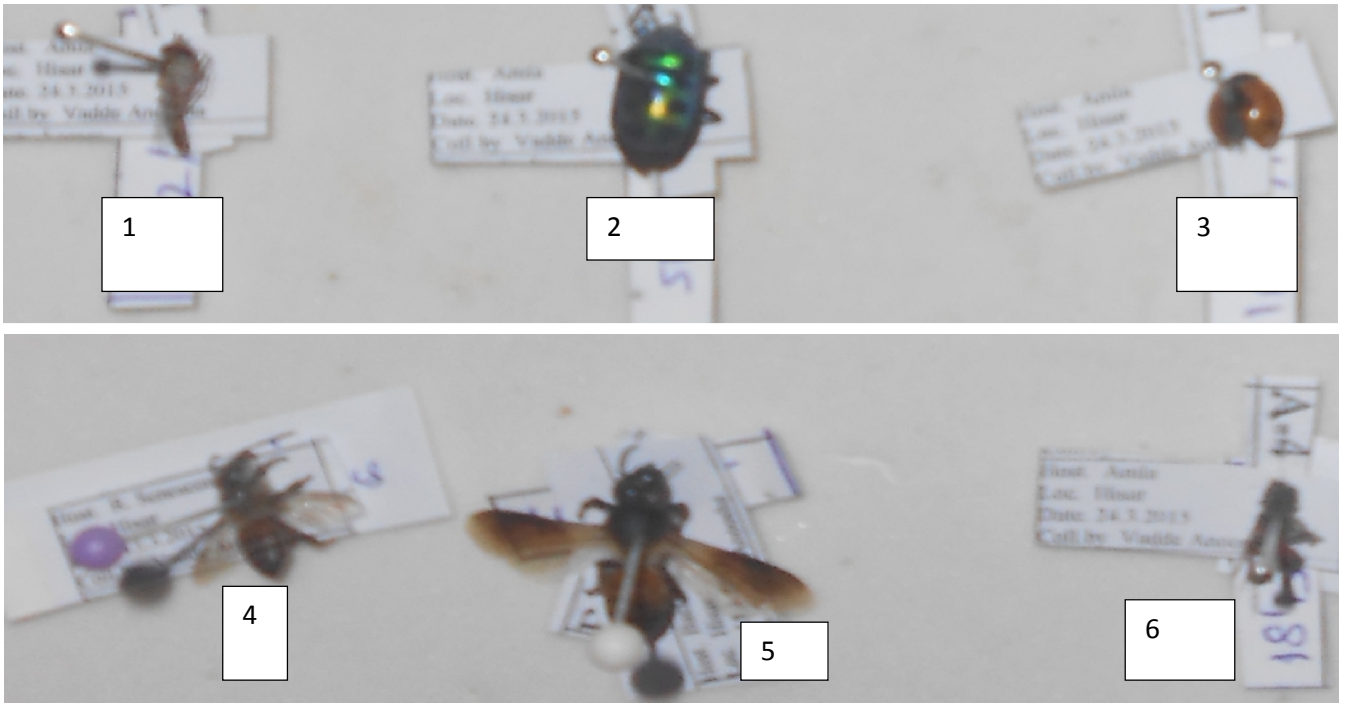


**Plate 15: Insect visitors/pollinators of Aonla flowers**


**Plate 16: Insect visitors/pollinators of Baheda flowers**

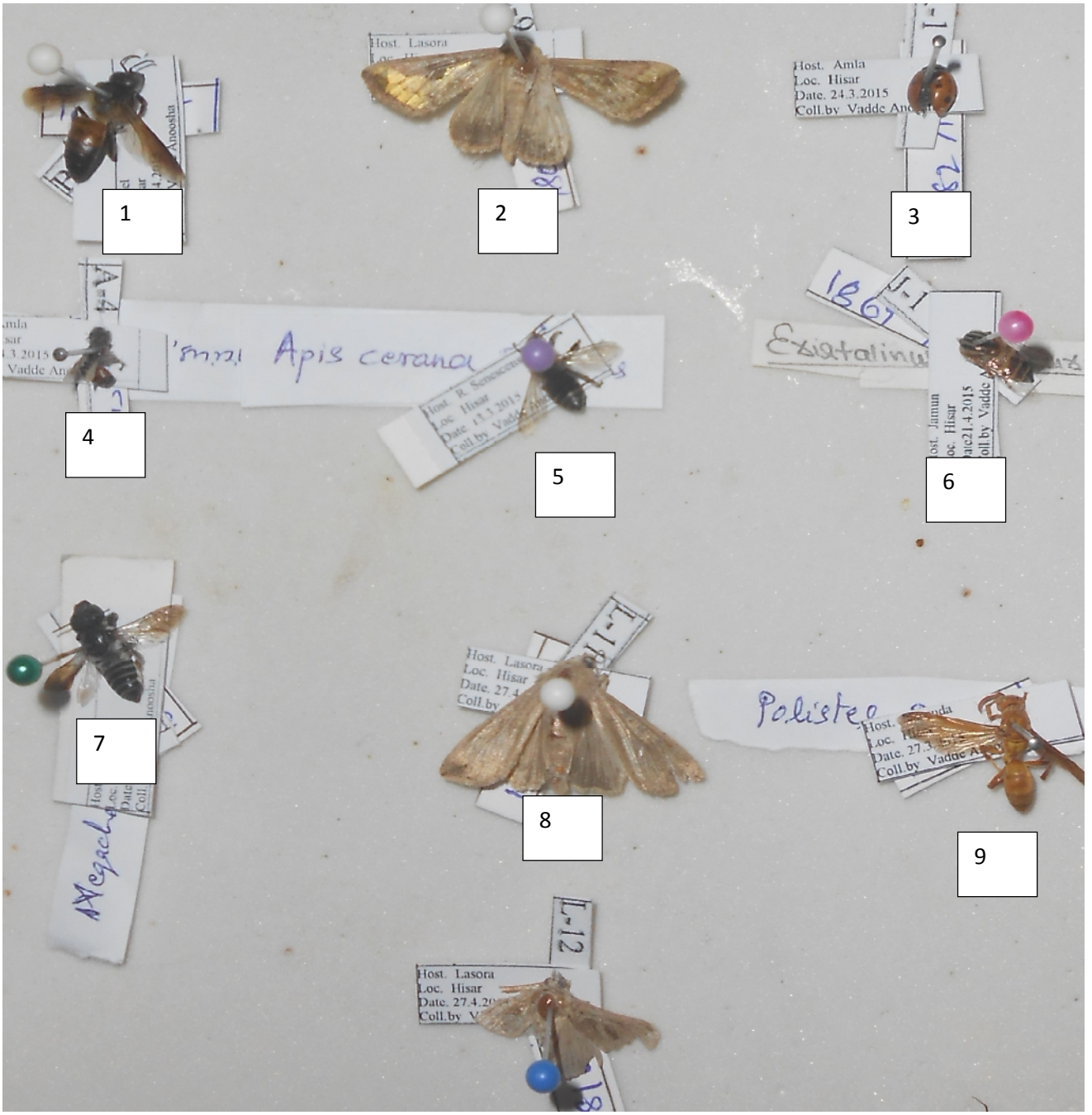


**Plate 17: Insect visitors/pollinators of Lasora flowers**

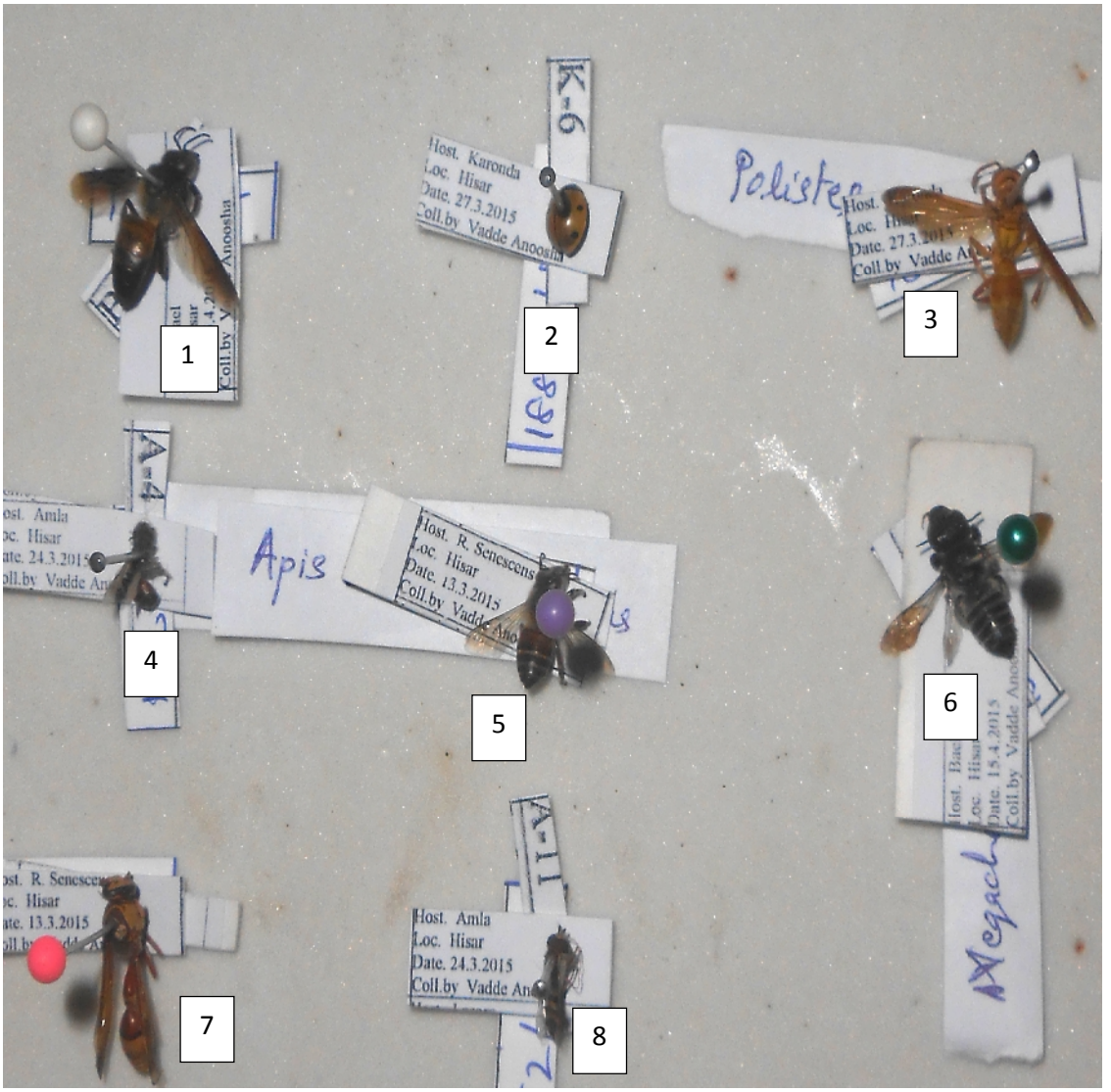


**Plate 18: Insect visitors/pollinators of Karonda flowers**

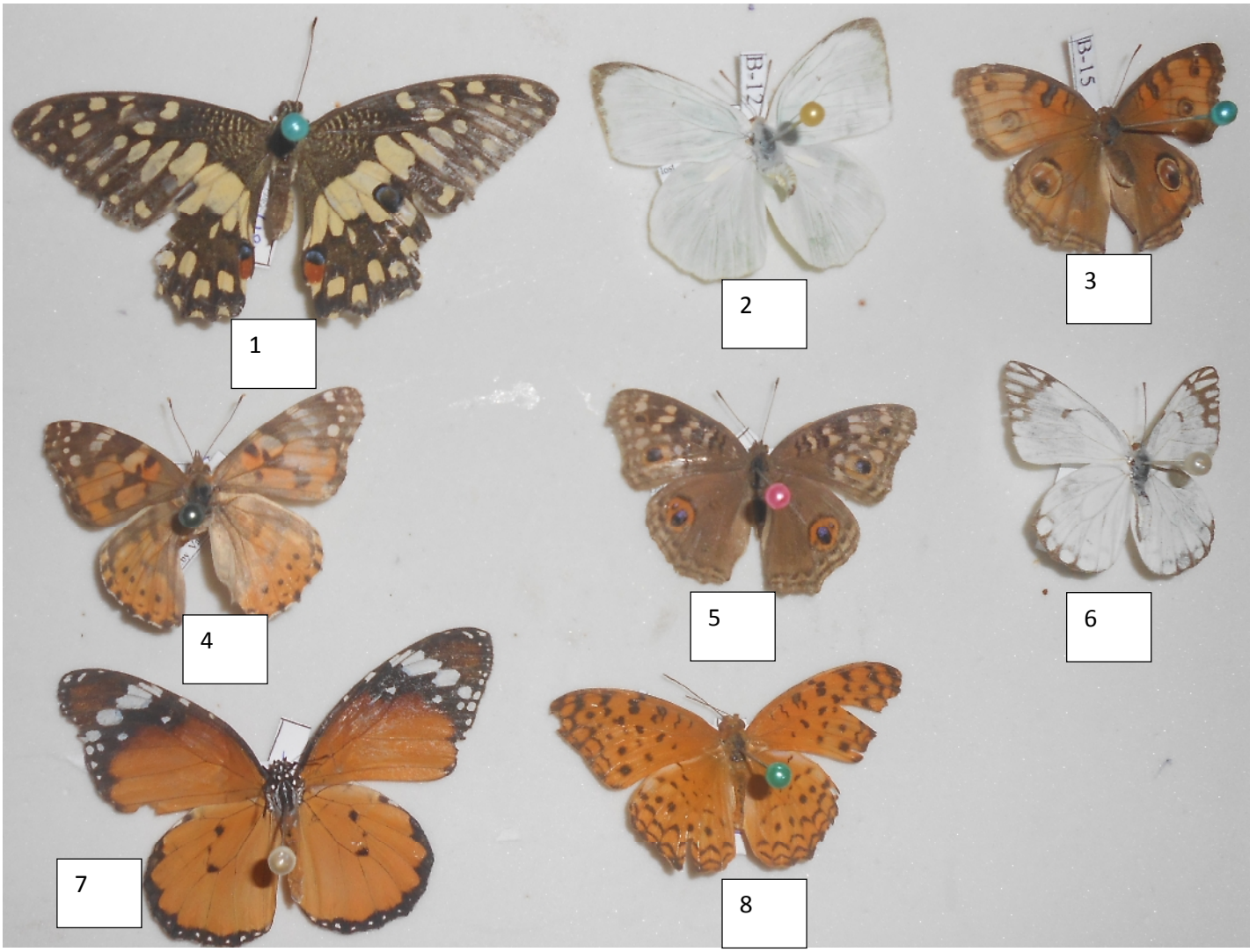


**Plate 19: Plate Insect visitors/pollinators of Bael flowers**

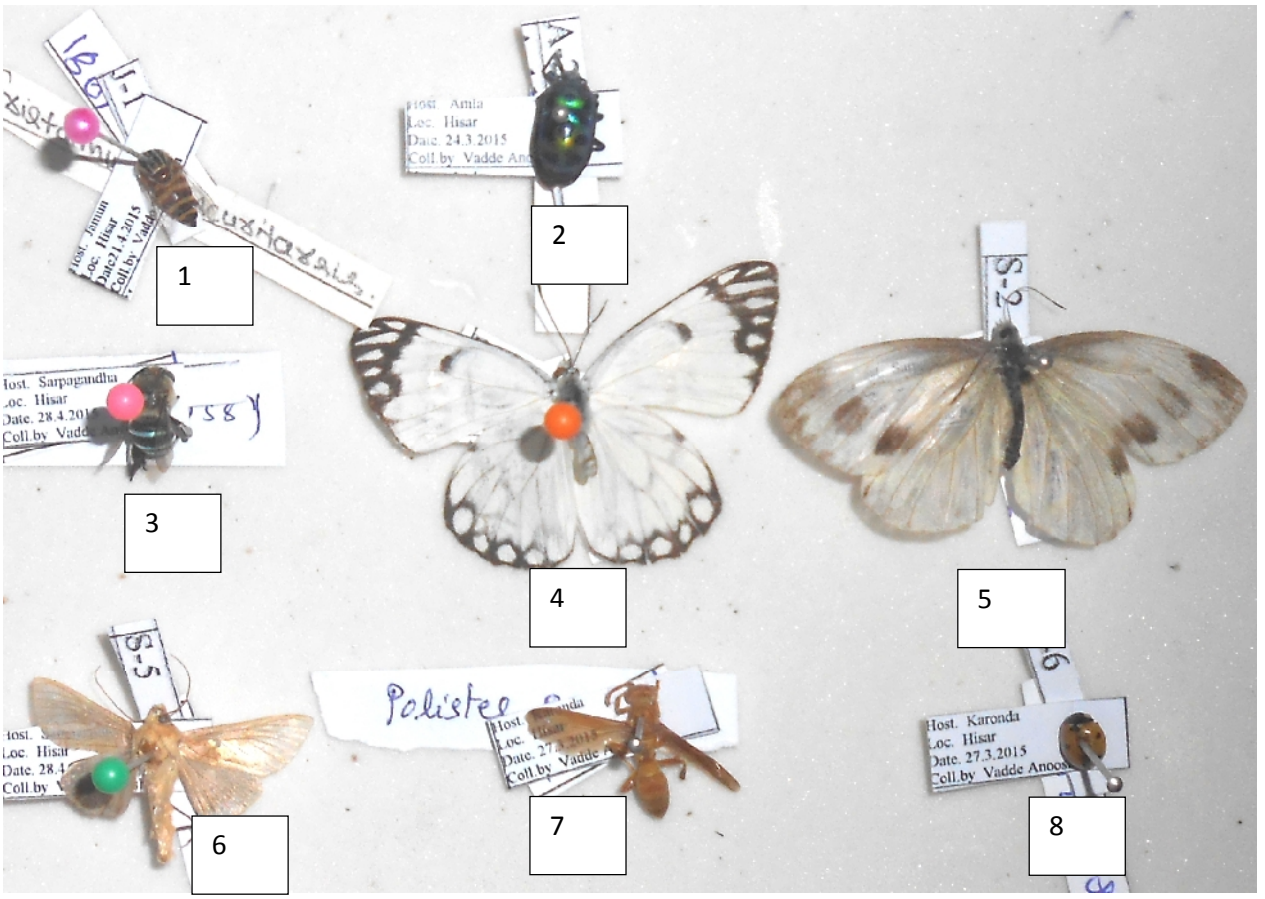


**Plate 20: Insect visitors/pollinators of Sarpagandha flowers**

| | | | | |
|---|---|---|---|---|
| | Muscidae | *Muscadomestica* Linnaeus | IV | T |
| Hemiptera | Scutellaridae | *Chrysocoris stolli* Wolff | IV | T |
| Lepidoptera | Arctiidae | *Amata* sp. | IV | T and S |

*IP –Insect Pollinator and IV – Insect Visitor

*T – Top worker and S- Side worker

**Plate 15**

| | | | |
|---|---|---|---|
| 1. | *Sphaerophoria* sp. | 4. | *Apis cerana* |
| 2. | *Chrysocoris stolli* | 5. | *Apis dorsata* |
| 3. | *Coccinella septempunctata* | 6. | *Apis florea* |

**4.1.2. Abundance of insect visitors/pollinators of Aonla**

During 2014, three species of flower visiting insects belonging to two orders, namely Hymenoptera (1), and Diptera (2) were collected from the aonla flowers. The majority belonged to Diptera comprising syrphid flies (*Episyrphus* sp.*and Sphaerophoria*sp.). Among Dipterans, maximum mean population of *Episyrphus* sp. (8.57 flies/$m^2$ branch/5min) followed by that of *Sphaerophoria* sp. (4.47 flies/$m^2$ branch/5 min) (Table 2). In Hymenoptera, *Apis florea* was recorded with mean population of 3.53 bees/$m^2$ branch/5min.

Time and week wise, the highest population of *Episyrphus* sp.(14.00 flies/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week of flowering during 2014 which was significantly different with 1$^{st}$ week (12.40 flies/$m^2$ branch/5min) and 3$^{rd}$ week (7.80 flies/$m^2$ branch/5min). In case of *Sphaerophoria* sp. maximum population (7.60 flies/$m^2$ branch/5min) was recorded at 0600h -08000h during 1$^{st}$ week which was significantly different with 2$^{nd}$ week (4.20 flies/$m^2$ branch/5min) and 3$^{rd}$ week (1.80 flies/$m^2$ branch/5min) (Table 2). Minimum activity of both syrphid flies (*Episyrphus* sp. and *Sphaerophoria* sp.) was recorded between 1600h - 1800h. Peak activity was recorded at 1000h – 1200h irrespective of weeks. In case of Hymenoptera, highest population of *A. florea* (13.80 bees/$m^2$ branch/5min) was recorded at 1000h-1200h during 3$^{rd}$ week of flowering which was significantly different with 1$^{st}$ week (8.80 bees/$m^2$ branch/5min) and 2$^{nd}$ week (12.80 bees/$m^2$ branch/5min).

During 2014, highest pooled mean of abundance (8.79 flies/$m^2$ branch/5min) was recorded in *Episyrphus* sp. followed by *A. florea* (5.40 bees/$m^2$ branch/5min). Lowest pooled mean of abundance was recorded in *Sphaerophoria* sp.(3.62 flies/$m^2$ branch/5min).

During 2015, three species of flower visiting insects belonging to two orders, namely Hymenoptera (1) and Diptera (2) were collected from the aonla flowers. The majority belonged to Diptera comprising syrphid flies (*Episyrphus*sp. *and Sphaerophoria*sp.). Among Dipterans, maximum mean population of *Episyrphus* sp. (8.56 flies/$m^2$ branch/5min) followed by that of *Sphaerophoria* sp. (3.54 flies/$m^2$ branch/5 min) (Table 3). In Hymenoptera, mean population of *Apis florea* was 5.70 bees/$m^2$ branch/5min.

Time and week wise, the highest population of *Episyrphus* sp.(14.80 flies/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week of flowering during 2015 which

was significantly different with 1st week (12.40 flies/$m^2$ branch/5min) and 3rd week (9.00 flies/$m^2$ branch/5min). In case of *Sphaerophoria* sp. maximum population 9.80 flies/$m^2$ branch/5min) was recorded at 0600h - 0800h during 1st week which was significantly different with 2nd week (1.40 flies/$m^2$ branch/5min) and 3rd week (1.40 bees/$m^2$ branch/5min) (Table 3). Minimum activity of both syrphid flies (*Episyrphus* sp. and *Sphaerophoria* sp.) was recorded between 1600h - 1800h. Peak activity was recorded at 1000h – 1200h irrespective of weeks.In case of Hymenoptera, highest population of *A. florea* (14.80 bees/$m^2$ branch/5min) was recorded at 1000h-1200h during 3rd week of flowering which was significantly different with 1st week (6.80 bees/$m^2$ branch/5min) and 2nd week (12.80 bees/$m^2$ branch/5min).

From the present pollination study, it is evident that Dipteran insect species were most abundant insect pollinators on aonla flowers. Irrespective of different day hours, significantly maximum number of *Episyrphus* sp. was recorded from aonla flowers followed by *Sphaerophora sp.* and *A. florea.* Peakabundance of *Episyrphus* sp. wasrecorded between 1000h -1200h during full bloom of crop. Maximum abundance of *A. florea* was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h irrespective of weeks.

**Plate 21: *Apis mellifera* foraging on Aonla flower**

**Plate 22: *Apis florea* foraging on Aonla flower**

**Plate 23: *Episyrphus* sp. foraging on Aonla flower**

**Plate 24: *Sphaerophoria* sp. foraging on Aonla flower**

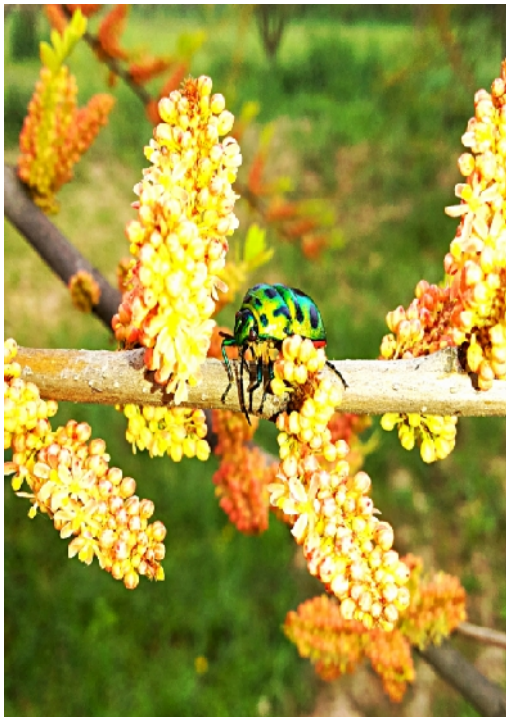

**Plate 25:** ***Chrysocoris stolli*** **foraging onAonla flower**

**Plate 26:** ***Musca*** **sp. foraging on Aonla flower**

**Plate 27:** ***Coccinella septempunctata*** **foraging on Aonla flower**

**Table 2: Abundance of insect visitors/pollinators on Aonla flowers during 2014**

| S.No. | Insect visitors | 25/3/14 | | | | | | Mean | 1/4/14 | | | | | | Over all mean | 8/4/14 | | | | | | Over all mean | Pooled mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Episyrphus*sp. | 9.40 (3.22) | 9.40 (3.21) | 12.40 (3.65) | 9.20 (3.19) | 7.40 (2.89) | 3.60 (2.14) | 8.57 (3.05) | 13.00 (3.74) | 12.40 (3.65) | 14.00 (3.87) | 7.40 (2.89) | 10.40 (3.37) | 5.00 (2.44) | 10.37 (3.33) | 12.40 (3.65) | 7.80 (2..96) | 7.80 (2.96) | 5.80 (2.60) | 8.40 (3.06) | 2.40 (1.83) | 7.43 (2.84) | 8.79 (3.07) |
| 2 | *Apis florea* | 0.00 (1.00) | 5.00 (2.44) | 8.80 (3.12) | 4.20 (2.27) | 3.20 (2.04) | 0.00 (1.00) | 3.53 (1.98) | 0.40 (1.16) | 5.20 (2.47) | 12.80 (3.71) | 10.20 (3.34) | 4.60 (2.36) | 0.40 (1.14) | 5.60 (2.36) | 0.00 (1.00) | 9.20 (3.18) | 13.80 (3.84) | 12.00 (3.60) | 7.20 (2.86) | 0.20 (1.08) | 7.07 (2.59) | 5.40 (2.31) |
| 3 | *Sphaerophoria*sp. | 7.60 (2.93) | 3.80 (2.18) | 5.80 (2.60) | 3.20 (2.04) | 4.20 (2.27) | 2.20 (1.77) | 4.47 (2.30) | 4.20 (2.27) | 4.80 (2.40) | 7.00 (2.82) | 5.00 (2.43) | 3.20 (2.04) | 1.80 (1.65) | 4.33 (2.27) | 1.80 (1.65) | 4.40 (2.31) | 3.00 (1.99) | 1.60 (1.59) | 1.00 (1.39) | 0.60 (1.24) | 2.07 (1.70) | 3.62 (2.09) |
| | Mean | 5.67 (2.38) | 6.07 (2.61) | 9.00 (3.12) | 5.53 (2.50) | 4.93 (2.40) | 1.93 (1.63) | 5.52 (2.44) | 5.87 (2.39) | 7.47 (2.84) | 11.27 (3.46) | 7.53 (2.89) | 6.07 (2.59) | 2.40 (1.74) | 6.77 (2.65) | 4.73 (2.10) | 7.13 (2.82) | 8.20 (2.93) | 6.47 (2.60) | 5.53 (2.44) | 1.07 (1.39) | 5.52 (2.38) | 5.94 (2.49) |

**Each value represents mean of 5 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.05 |
| Week | 0.02 | 0.05 |
| Time | 0.02 | 0.07 |
| Insect X Week | 0.03 | 0.09 |
| Insect visitors X Time | 0.04 | 0.13 |
| Week X Time | 0.04 | 0.13 |
| Insect visitors x Week Time | 0.08 | 0.23 |

**Table 3 : Abundance of insect visitors/pollinators on Aonla flowers during 2015**

| S.No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 27/3/15 | | | | | | Overall Mean | 3/4/15 | | | | | | Overall mean | 11/4/15 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Episyrphus* sp. | 10.80 (3.43) | 4.40 (2.31) | 12.40 (3.65) | 7.00 (2.82) | 8.00 (2.99) | 3.80 (2.18) | 7.73 (2.90) | 8.00 (2.99) | 13.40 (3.79) | 14.80 (3.97) | 7.80 (2.96) | 9.00 (3.16) | 4.80 (2.40) | 9.63 (3.21) | 13.00 (3.73) | 9.20 (3.19) | 9.00 (3.15) | 6.00 (2.64) | 9.60 (3.25) | 3.20 (2.04) | 8.33 (3.00) | 8.56 (3.03) |
| 2 | *Apis florea* | 0.00 (1.00) | 8.00 (2.99) | 6.80 (2.79) | 2.00 (1.71) | 2.60 (1.89) | 0.20 (1.08) | 3.26 (1.91) | 0.40 (1.16) | 6.20 (2.68) | 12.80 (3.71) | 11.20 (3.48) | 4.00 (2.22) | 0.40 (1.16) | 5.83 (2.40) | 0.20 (1.08) | 11.80 (3.57) | 14.80 (3.97) | 13.20 (3.76) | 8.00 (2.99) | 0.20 (1.08) | 8.03 (2.74) | 5.70 (2.35) |
| 3 | *Sphaerophoria*sp. | 9.80 (3.28) | 4.60 (2.35) | 5.20 (2.48) | 2.60 (1.89) | 3.20 (2.04) | 1.60 (1.60) | 4.50 (2.27) | 1.40 (1.54) | 4.40 (2.31) | 7.20 (2.86) | 4.00 (2.23) | 4.20 (2.27) | 2.60 (1.89) | 3.96 (2.18) | 1.40 (1.54) | 4.20 (2.27) | 3.80 (2.18) | 2.20 (1.77) | 1.00 (1.39) | 0.40 (1.16) | 2.16 (1.72) | 3.54 (2.06) |
| | Mean | 6.86 (2.38) | 5.66 (2.61) | 8.13 (3.12) | 3.86 (2.50) | 4.60 (2.40) | 1.86 (1.63) | 5.16 (2.36) | 3.26 (2.39) | 8.00 (2.84) | 11.60 (3.46) | 7.66 (2.89) | 5.73 (2.59) | 2.60 (1.74) | 6.47 (2.60) | 4.86 (2.10) | 8.40 (2.82) | 9.20 (2.93) | 7.13 (2.60) | 6.20 (2.44) | 1.26 (1.39) | 6.17 (2.49) | 5.93 (2.48) |

Each value represents mean of 5 observations
Figures in parentheses are square root transformed values

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.05 |
| Week | 0.02 | 0.05 |
| Time | 0.02 | 0.07 |
| Insect X Week | 0.03 | 0.09 |
| Insect visitors X Time | 0.04 | 0.13 |
| Week X Time | 0.04 | 0.13 |
| Insect visitors x Week Time | 0.08 | 0.23 |

### 4.1.2. Diversity of insect visitors/ pollinators on Baheda

Diversity of insect visitors/pollinators on Baheda flowers during 2014 and 2015 have been presented in Table 4 and Plate 2. Baheda flowers attracted wide varieties of insects belonging to 5 orders, 7 families, 9 genera and 10 species. Out of them four belonging to order Diptera, two to Hymenoptera, two to Coleoptera, one to Lepidoptera and one to Hemiptera. The dipterans were the major floral visitors comprising from two families *viz*., Syrphidae (*Eristalinus obliquus,Eristalis* sp. and *Eristalinus obscuritarsus*) and Calliophoridae (*Chrysomya rufifacies).* They were followed in order of diversity by hymenopterans from two families*viz*., Apidae (*Apis florea*) and Vespidae (*Allorhynchium metallicum*),Coleopterans from one family *viz*., Coccinellidae (*Coccinella septempunctata* and *Chilomenes sexmaculata*) and oneHemipteran to Scutellaridae (*Chrysocoris stolli* Wolff) and one species from one family of Lepidoptera *viz*., Pieridae (*Pieris* sp.). Out of 10 insects all were top foragers except*Pieris* sp. which was side forager also.

**Table 4: Diversity of insect visitors/pollinators of *Terminalia bellirica* (Baheda)**

| Order | Family | Insect Species | IP/IV | Working Behaviour |
|---|---|---|---|---|
| Hymenoptera | Apidae | *Apis florea* Fabricius | IP | T |
| | Vespidae | *Allorhynchium metallicum* (Saussure) | IP | T |
| Diptera | Calliophoridae | *Chrysomya rufifacies* (Macquart) | IP | T |
| | Syrphidae | *Eristalinus obliquus* Wiedemann | IP | T |
| | | *Eristalis* sp. | IP | T |
| | | *Eristalinus obscuritarsus* (de Meijre) | IP | T |
| Lepidoptera | Pieridae | *Pieris* sp. | IV | T and S |
| Coleoptera | Coccinellidae | *Coccinella septempunctata* Linnaeus | IV | T |
| | | *Chilomenes sexmaculata* Fabricius | IV | T |
| Hemiptera | Scutellaridae | *Chrysocoris stolli* Wolff | IV | T |

*IP –Insect Pollinator and IV – Insect Visitor
*T – Top and S- Side

**Plate 16**

| | | | |
|---|---|---|---|
| 1. | *Chrysomya rufifacies* | 5. | *Apis florea* |
| 2. | *Coccinella septempunctata* | 6. | *Eristalinus obscuritarsus* |
| 3. | *Allorhynchium metallicum* | 7. | *Pieris* sp. |
| 4. | *Chrysocoris stolli* | 8. | |

### 4.2.2. Abundance of insect visitors/pollinators of Baheda

During 2014, four species of flower visiting insects belonging to two orders, namely Diptera (3) and Hymenoptera (1) were collected from the baheda flowers. The majority belonged to Diptera comprising syrphid flies (*Eristalinus obliquus andE. obscuritarsus*). Among Dipterans, maximum mean population was of *Chrysomya rufifacies* (3.82 flies/$m^2$ branch/5min) followed by that of *E. obliquus* (3.66flies/$m^2$ branch/5min) and *E. obscuritarsus*

(2.20 flies/$m^2$ branch/5min) (Table 5). In Hymenoptera, *A. florea* was recorded with the mean population of 2.57 bees/$m^2$branch/5 min.

Time and week wise, the highest population of *C. rufifacies* (7.80 flies/$m^2$ branch/5min) was recorded at 1000h -1200h in 2nd week of flowering during April, 2014 which was significantly different with 1st week (6.00 flies/$m^2$ branch/5min) and 3rd week (4.60 flies/$m^2$ branch/5min). Incase of *E. obliquus* maximum population (8.20 flies/$m^2$ branch/5min) was recorded at 1000h -12000h during 2nd week which was significantly different with 1st week (6.80 flies/$m^2$ branch/5min) and 3rd week (5.60 flies/$m^2$ branch/5min) (Table 5). Highest population of *E. obscuritarsus* (5.20 flies/$m^2$ branch/5min) was recorded at 1000h-1200h during 2nd week of flowering which was significantly different with 1st week (3.40 flies/$m^2$ branch/5min) and 3rd week (2.80 flies/ $m^2$ branch/5min ). Minimum activity of all dipterans (*E.obliquus, E. obscuritarsus* and *C. rufifacies*) was recorded between 0600h - 0800h and peak activity was recorded at 1000h – 1200h irrespective of weeks.

Incase of Hymenoptera, highest population of *A. florea* (7.60 bees/$m^2$ branch/5min) was recorded at 1000h-1200h during 2nd week of flowering which was significantly different with 1st week (4.60 bees/$m^2$ branch/5min) and 3rd week (5.20 bees/$m^2$ branch/5min).

During 2015, four species of flower visiting insects belonging to two orders, namely Diptera (3) and Hymenoptera (1) were collected from the baheda flowers. The majority belonged to Diptera comprising syrphid flies (*E. obliquus* and *E. obscuritarsus*). Among Dipterans maximum mean population was of *C. rufifacies* (4.08 flies/$m^2$ branch/5min) followed by that of *E. obliquus* (3.91 flies/$m^2$ branch/5min) and *E. obscuritarsus* (2.17 flies/$m^2$ branch/5min) (Table 6). In Hymenoptera, mean population of *A. florea* was 2.77 bees/$m^2$branch/5 min.

Time and week wise, the highest population of *C. rufifacies* (8.40 flies/$m^2$ branch/5min) was recorded at 1000h -1200h in 2nd week of flowering during 2014 which was significantly different with 1st week (7.20 flies/$m^2$ branch/5min) and 3rd week (6.00 flies/$m^2$ branch/5min). Incase of *E. obliquus* maximum population (8.00 flies/$m^2$ branch/5min) was recorded at 1000h -12000h during 2nd week which was significantly different with 1stweek (6.80 flies/$m^2$ branch/5min) and 3rd week (6.20 flies/$m^2$ branch/5min) (Table 6). Highest population of *E. obscuritarsus* (4.60 flies/$m^2$ branch/5min) was recorded at 1000h-1200h during 2nd week of flowering which was significantly different with 1st week (4.00 flies/$m^2$ branch/5min) and 3rd week (2.40 flies/ $m^2$ branch/5min ). Minimum activity of all dipterans (*E.obliquus, E. obscuritarsus* and *C. rufifacies*) was recorded between 0600h - 0800h and peak activity was recorded at 1000h – 1200h, irrespective of weeks.

Incase of Hymenoptera, highest population of *A. florea* (7.60 bees/$m^2$ branch/5min) was recorded at 1000h-1200h during 2nd week of flowering which was significantly different with 1st week (5.00 bees/$m^2$ branch/5min) and 3rd week (5.80 bees/$m^2$ branch/5min).

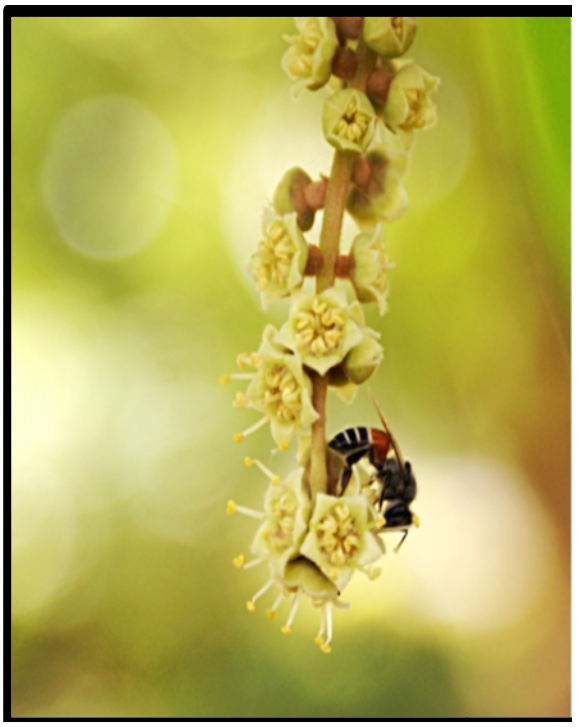

**Plate 28: *Apis florea* foraging on Baheda flower**

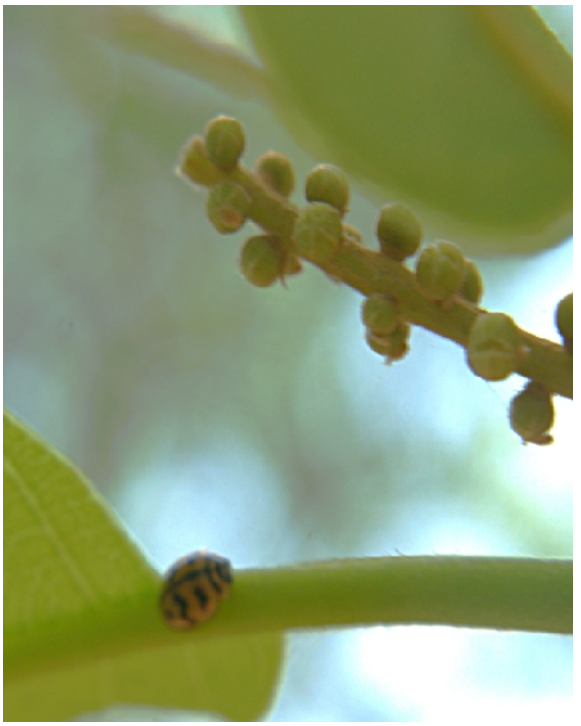

**Plate 29: *Chilomenes sexmaculata* foraging on Baheda flower**

**Plate 30: *Eristalinus obscuritarsus* foraging on Baheda flower**

**Plate 31: *Eristalinus obliquus* foraging on Baheda flower**

**Plate 32: *Chrysomya rufifacies* foraging on Baheda flower**

**Plate 33: *Allorhynchium metallicum* foraging on Baheda flower**

**Plate 34: *Chrysocoris stolli* foraging on Baheda flower**

From the present pollination study, it is evident that Dipteranswere most abundant insect pollinators on baheda flowers. Irrespective of different day hours, significantly maximum number of *C. rufifacies* was recorded from baheda flowers followed by *E.obliquus, A. florea* and *E.obscuritarsus*. Peakactivity of *C. rufifacies* wasrecorded between 1000h - 1200h during full bloom of crop. Peak abundance of *A. florea* was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h irrespective of weeks.

**Table 5: Abundance of insect visitors/pollinators on Baheda flowers during 2014**

| S.No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 25/4/14 | | | | | | Overall mean | 2/5/14 | | | | | | Overall mean | 9/5/14 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Eristalinus obliquus* | 1.80 (1.66) | 3.60 (3.76) | 6.80 (3.46) | 4.60 (3.28) | 1.80 (3.03) | 0.60 (2.64) | 3.20 (2.97) | 3.20 (1.94) | 6.60 (3.94) | 8.20 (3.51) | 4.60 (3.49) | 4.00 (3.06) | 2.60 (2.79) | 4.86 (3.12) | 1.60 (1.54) | 2.80 (3.54) | 5.60 (3.25) | 3.40 (2.99) | 2.20 (2.75) | 2.00 (2.44) | 2.93 (2.75) | 3.66 (2.95) |
| 2 | *Chrysomya rufifacies* | 0.60 (1.08) | 3.00 (1.65) | 6.00 (2.04) | 3.20 (1.77) | 4.00 (3.03) | 3.40 (2.64) | 3.36 (2.03) | 2.40 (1.22) | 6.60 (1.94) | 7.80 (2.14) | 4.40 (1.83) | 4.20 (1.60) | 4.20 (1.08) | 4.93 (1.64) | 0.80 (1.16) | 3.40 (1.54) | 4.60 (1.89) | 4.00 (1.60) | 2.80 (1.65) | 3.40 (1.08) | 3.16 (1.49) | 3.82 (1.72) |
| 3 | *Apis florea* | 0.60 (1.16) | 2.40 (1.33) | 4.60 (1.72) | 3.40 (1.24) | 1.60 (1.24) | 0.20 (1.00) | 2.13 (1.28) | 1.60 (1.31) | 0.20 (1.31) | 7.60 (1.83) | 3.60 (1.45) | 4.20 (1.47) | 4.20 (1.16) | 3.56 (1.42) | 0.00 (1.22) | 1.80 (1.31) | 5.20 (1.71) | 3.20 (1.39) | 1.80 (1.47) | 0.20 (1.16) | 2.03 (1.38) | 2.57 (1.36) |
| 4 | *Eristalinus obscuritarsus* | 1.20 (1.00) | 2.80 (1.37) | 3.40 (2.44) | 2.20 (2.14) | 1.20 (2.18) | 1.20 (1.77) | 2.00 (1.82) | 1.80 (1.16) | 3.60 (1.98) | 5.20 (2.52) | 2.60 (2.23) | 1.60 (2.36) | 2.40 (2.27) | 2.86 (2.09) | 0.80 (1.31) | 1.60 (1.77) | 2.80 (2.31) | 2.80 (1.89) | 1.40 (2.36) | 1.00 (2.04) | 1.73 (1.95) | 2.20 (1.95) |
| | Mean | 1.05 (1.22) | 2.95 (2.03) | 5.20 (2.41) | 3.35 (2.11) | 2.15 (2.37) | 1.35 (2.01) | 2.67 (2.03) | 2.25 (1.41) | 4.25 (2.29) | 7.20 (2.50) | 3.80 (2.25) | 3.50 (2.12) | 3.35 (1.82) | 4.05 (2.07) | 0.80 (1.31) | 2.40 (2.04) | 4.55 (2.29) | 3.35 (1.97) | 2.05 (2.06) | 1.65 (1.68) | 2.46 (1.89) | 3.06 (1.99) |

**Each value represents mean of 5 observations**
***Figures in parentheses are square root transformed values**

| Factor | SE m (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.05 |
| Week | 0.02 | 0.05 |
| Time | 0.03 | 0.08 |
| Insect X Week | 0.03 | N.S. |
| Insect visitors X Time | 0.05 | 0.14 |
| Week X Time | 0.05 | 0.14 |
| Insect visitors x Week Time | 0.08 | 0.24 |

**Table 6 : Abundance of insect visitors/pollinators on Baheda flowers during 2015**

| S.No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 20/4/15 | | | | | | Overall mean | 28/4/15 | | | | | | Overall mean | 6/5/15 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Eristalinus obliquus* | 2.40 (1.83) | 4.00 (2.23) | 6.80 (2.79) | 4.60 (2.35) | 2.60 (1.89) | 1.40 (1.54) | 3.63 (2.10) | 2.80 (1.94) | 6.00 (2.64) | 8.00 (2.99) | 5.40 (2.52) | 3.60 (2.14) | 2.40 (1.83) | 4.70 (2.34) | 2.00 (1.72) | 3.80 (2.18) | 6.20 (2.68) | 4.40 (2.32) | 2.40 (1.82) | 1.60 (1.60) | 3.40 (2.05) | 3.91 (2.17) |
| 2 | *Chrysomya rufifacies* | 1.40 (1.54) | 3.40 (2.09) | 7.20 (2.86) | 3.80 (2.18) | 4.20 (2.27) | 2.60 (1.89) | 3.76 (2.14) | 2.40 (1.83) | 6.00 (2.64) | 8.40 (3.06) | 4.80 (2.40) | 5.20 (2.48) | 3.60 (2.14) | 5.06 (2.43) | 1.40 (1.54) | 2.80 (1.94) | 6.00 (2.64) | 4.00 (2.23) | 3.60 (2.13) | 2.80 (1.94) | 3.43 (2.07) | 4.08 (2.21) |
| 3 | *Apis florae* | 1.00 (1.39) | 2.00 (1.72) | 5.00 (2.44) | 3.60 (2.14) | 2.40 (1.83) | 0.40 (1.16) | 2.40 (1.78) | 0.60 (1.24) | 4.00 (2.23) | 7.60 (2.92) | 4.60 (2.36) | 3.60 (2.14) | 0.80 (1.31) | 3.53 (2.03) | 0.20 (1.08) | 2.40 (1.83) | 5.80 (2.60) | 3.20 (2.04) | 2.40 (1.83) | 0.40 (1.16) | 2.40 (1.76) | 2.77 (1.86) |
| 4 | *Eristalinus obscuritarsus* | 0.80 (1.33) | 2.40 (1.83) | 4.00 (2.23) | 3.00 (1.99) | 1.40 (1.54) | 1.20 (1.47) | 2.13 (1.73) | 1.40 (1.54) | 3.20 (2.04) | 4.60 (2.36) | 3.40 (2.09) | 2.20 (1.78) | 1.60 (1.60) | 2.73 (1.90) | 0.60 (1.24) | 2.00 (1.71) | 2.40 (1.83) | 2.20 (1.77) | 1.60 (1.60) | 1.20 (1.47) | 1.66 (1.61) | 2.17 (1.75) |
| | Mean | 1.40 (1.52) | 2.95 (1.97) | 5.75 (2.58) | 3.75 (2.16) | 2.65 (1.88) | 1.40 (1.51) | 2.98 (1.94) | 1.80 (1.64) | 4.80 (2.39) | 7.15 (2.83) | 4.55 (2.34) | 3.65 (2.13) | 2.10 (1.72) | 4.00 (2.18) | 1.05 (1.39) | 2.75 (1.91) | 5.10 (2.44) | 3.45 (2.09) | 2.50 (1.85) | 1.50 (1.54) | 2.72 (1.87) | 3.23 (1.99) |

**Each value represents mean of 5 observations**

**[t]Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.01 | 0.05 |
| Week | 0.01 | 0.05 |
| Time | 0.02 | 0.07 |
| Insect X Week | 0.03 | N.S. |
| Insect visitors X Time | 0.04 | 0.12 |
| Week X Time | 0.04 | 0.12 |
| Insect visitors x Week Time | 0.08 | N.S. |

### 4.1.3. Diversity of insect visitors/ pollinators on Lasora

The data on diversity of insect visitors/pollinators on Lasora flowers have been presented in Table 7 and Plate 17. Lasora flowers attracted wide varities of insect species belonging to 4 orders,8 families, 12 genera and 15 species. Among them six belongs to order Hymenoptera, two to Coleoptera, four to Diptera, and three to Lepidoptera. The hymenopterans were the major floral visitors comprising from three families *viz*., Apidae (*Apis florea, A. dorsata, A.cerana* and*A. mellifera*), Megachilidae (*Megachile* sp.) and Vespidae (*Polistes* sp.) They were followed in order of diversity by dipterans from three families*viz*., Syrphidae (*Eristalinus obliquus* and *Eristalis* sp.), Tephritidae (*Bactrocera nigrofemoralis*), Calliophoridae (*Chrysomya rufifacies*). Coleopterans from one family *viz*., Coccinellidae (*Coccinella septempunctata* and *Chilomenes sexmaculata*) and Lepidopterans toNoctuidae (*Mythimna separata*, *Plusia*sp. and *Thysanoplusia orichalcea*). Out of 15 insects all were top foragers except Lepidopterans which were side foragers also.

**Table 7: Diversity of insect visitors/pollinators of *Cordia myxa* (Lasora)**

| Order | Family | Insect Species | IP/IV | Working Behaviour |
|---|---|---|---|---|
| Hymenoptera | Apidae | *Apis florea* Fabricius | IP | T |
| | | *Apis dorsata* Fabricius | IP | T |
| | | *Apis cerana* Fabricius | IP | T |
| | | *Apis mellifera* Linnaeus | IP | T |
| | Megachilidae | *Megachile* sp. | IP | T |
| | Vespidae | *Polistes* sp. | IV | T |
| Coleoptera | Coccinellidae | *Coccinella septempunctata* Linnaeus | IV | T |
| | | *Chilomenes sexmaculata* Fabricius | IV | T |
| Diptera | Syrphidae | *Eristalinus obliquus* Wiedemann | IP | T |
| | | *Eristalis* sp. | IP | T |
| | Tephritidae | *Bactrocera nigrofemoralis* Tsuruta&White | IV | T |
| | Calliophoridae | *Chrysomya rufifacies* (Macquart) | IP | T |
| Lepidoptera | Noctuidae | *Mythimna separata* Walker | IV | T and S |
| | | *Plusia* sp. | IV | T and S |
| | | *Thysanoplusia orichalcea* Fabricius | IV | T and S |

*IP –Insect Pollinator and IV – Insect Visitor
*T – Top worker and S –Side worker

**Plate 17**

| | | | |
|---|---|---|---|
| 1. | *Apis dorsata* | 6. | *Eristalinus obscuritarsus* |
| 2. | *Thysanoplusia orichalcea* | 7. | *Megachile* sp. |
| 3. | *Coccinella septempunctata* | 8. | *Mythimna separate* |
| 4. | *Apis florea* | 9. | *Polistes olivaceus* |
| 5. | *Apis cerana* | 10. | *Plusia* sp. |

### 4.2.3. Abundance of insect visitors/pollinators of Lasora

During 2014, seven species of flower visiting insects belonging to two orders, namely Hymenoptera (5), and Diptera (2) were collected from the lasora flowers. The majority

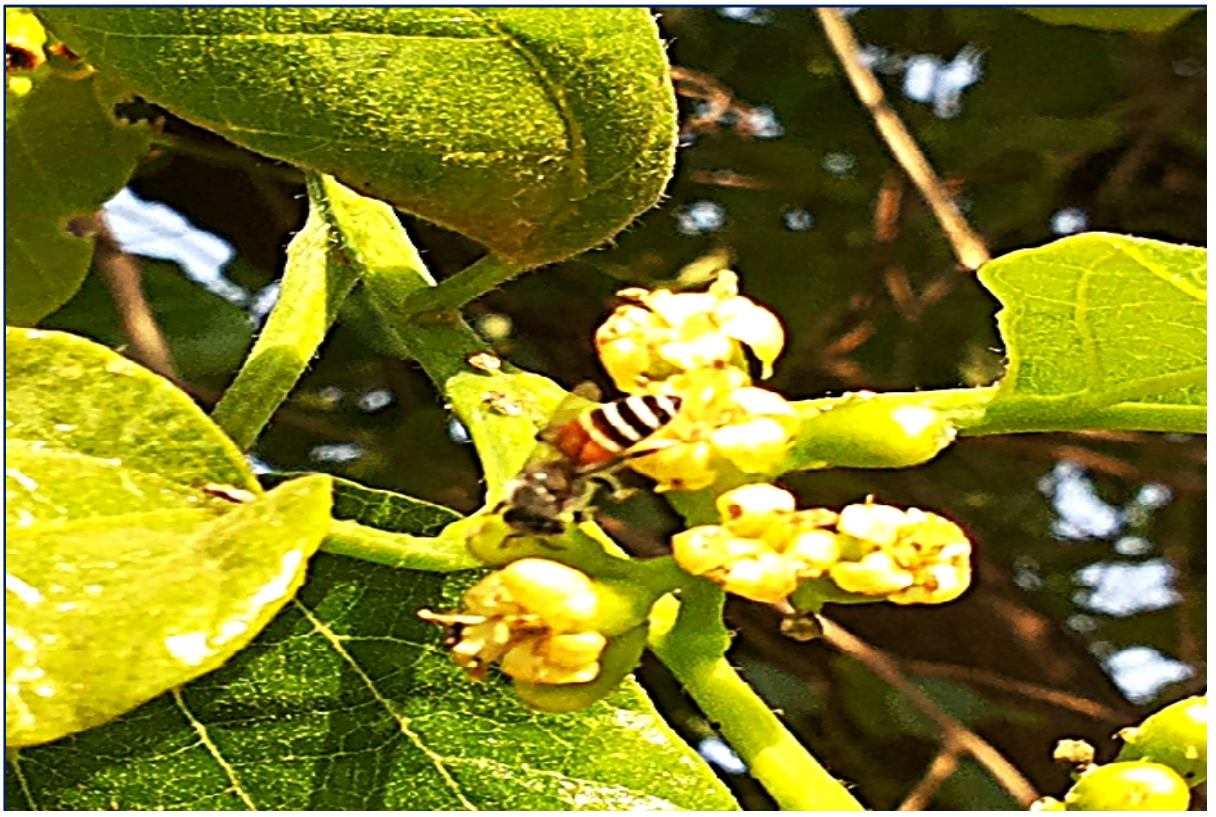

**Plate 35: *Apis florea* foraging on Lasora flower**

**Plate 36: *Apis cerana* foraging on Lasora flower**

**Plate 37: *Apis dorsata* foraging on Lasora flower**

**Plate 38: *Coccinella septempunctata* foraging on Lasora flower**

**Plate 39: *Eristalinus obliquus* foraging on Lasora flower**

**Plate 40: *Chilomenes sexmaculata* foraging on Lasora flower**

**Plate 41: *Chrysomya rufifacies* foraging on Lasora flower**

**Plate 42: *Mythimna separata* foraging on Lasora flower**

**Plate 43: *Thysanoplusia orichalcea* foraging on Lasora flower**

**Plate 44: *Eristalis* sp. foraging on Lasora flower**

belonged to Hymenoptera comprising honey bees (*A. dorsata, A. mellifera, A. florea* and *A. cerana*). Among honey bees, maximum mean population was of *A. dorsata* (4.18 bees/$m^2$ branch/5min) followed by that of *A. florea* (2.78bees/$m^2$ branch/5min) and *A. mellifera* (1.67 bees/$m^2$ branch/5min). *A. cerana* (0.46 bees/$m^2$ branch/5min) was significantly lowest among *Apis* bees (Table 8).

Time and week wise, the highest population of *A. dorsata* (13.80 bees/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week of flowering during April which was significantly different with 1$^{st}$ week (9.40 bees/$m^2$ branch/5min) and 3$^{rd}$ week (7.60 bees/$m^2$ branch/5min). Similarly, maximum population of *A. florea* (9.40 bees/$m^2$ branch/5min) was recorded at 1000 h -1200h during 1$^{st}$ week which was significantly different with 2$^{nd}$week (9.00 bees/$m^2$ branch/5min) and 3$^{rd}$ week (5.20 bees/$m^2$ branch/5min). The highest population of *A. mellifera* (6.60 bees/$m^2$ branch/5min) on flowers was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (3.20bees/$m^2$ branch/5min) and 3$^{rd}$ week (3.00 bee/$m^2$ branch/5min) (Table 8).The highest population of *A. cerana* (1.40 bees/$m^2$ branch/5min) on flowers was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (1.20bees/$m^2$ branch/5min) and 3$^{rd}$ week (0.60 bees/$m^2$ branch/5min) (Table 8).Minimum activity of all honey bee species was recorded between 0600h - 0800h and 1600 - 1800h. Peak activity was recorded at 1000h -1200h and 1200h – 1400h irrespective of weeks.Among other Hymenopterans, in addition to *Apis* spp. the next most abundant species was *Polistes* sp. Mean population of *Polistes* sp.recorded was (0.90 wasps/$m^2$ branch/5min).Time and week wise, the highest population of *Polistes* sp.(2.60 wasps/$m^2$ branch/5min) was recorded at 1200h -1400h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (0.80 wasps/$m^2$ branch/5min) and 3$^{rd}$ week (0.60 wasps/$m^2$ branch/5min).Minimum activity of *Polistes* sp.was recorded between 0600h to0800h. Peak activity was observed at 1000h -1200h and 1200h -1400h irrespective of weeks (Table 8).

Among Dipterans, mean population of *C. rufifacies* (3.48 flies/$m^2$ branch/5min) was recorded, followed by *E. obliquus* (0.96 flies.$m^2$ branch /5min). Time and week wise, the highest population of *C. rufifacies* (8.80 flies/$m^2$ branch/5min) was recorded at 0800h -1000h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (3.60 flies/$m^2$ branch/5min) and 3$^{rd}$ week (2.60 flies/$m^2$ branch/5min). Incase of *E. obliquus* highest population (2.80 flies/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (1.80 flies/$m^2$ branch/5min) and 3$^{rd}$ week (1.00 flies/$m^2$ branch/5min). Low abundance of both dipterans (*C. rufifacies* and *E. obliquus*) wasrecordedat 0600h-0800h and 1600h - 1800h. Peak abundance was recorded at 0800h -1200h irrespective of weeks (Table 8).

During 2015, seven species of flower visiting insects belonging to two orders, namely Hymenoptera (5), and Diptera (2) were collected from the lasora flowers. The majority belonged to Hymenoptera comprising honey bees (*A. dorsata, A. mellifera* and *A. florea* and *A. cerana*). Among honey bees maximum mean population was of *A. dorsata* (4.81 bees/$m^2$ branch/5min) followed by that of *A. florea* (3.13 bees/$m^2$ branch/5min) and *A. mellifera* (2.54 bees/$m^2$ branch/5min). *A. cerana* (0.53 bees/$m^2$ branch/5min) was significantly lowest among *Apis* bees (Table 9).

Time and week wise, the highest population of *A. dorsata* (15.00 bees/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week of flowering during April month which was significantly different with 1$^{st}$ week (10.60 bees/$m^2$ branch/5min) and 3$^{rd}$ week (8.60 bees/$m^2$ branch/5min). Similarly, maximum population of *A. florea* (9.80 bees/$m^2$ branch/5min) was recorded at 1000 h -1200h during 1$^{st}$ week which was significantly different with 1$^{st}$ week (8.40 bees/$m^2$ branch/5min) and 3$^{rd}$ week (6.20 bees/$m^2$ branch/5min).The highest population of *A. mellifera* (8.40 bees/$m^2$ branch/5min) on flowers was recorded at 1000h -1200h during 1$^{st}$ week which was significantly different with 2$^{nd}$ week (7.60bees/$m^2$ branch/5min) and 3$^{rd}$ week (4.60 bee/$m^2$ branch/5min) (Table 9).The highest population of *A. cerana* (2.20 bees/$m^2$ branch/5min) on flowers was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (1.40bees/$m^2$ branch/5min) and 3$^{rd}$ week (0.00 bees/$m^2$ branch/5min) (Table 9). Minimum activity of all honey bee species was recorded between 0600h - 0800h and 1600 - 1800h. Peak activity was recorded at 1000h -1200h and 1200h – 1400h irrespective of weeks.

Among other Hymenopterans, in addition to *Apis* spp., the next most abundant species was *Polistes* sp.. Mean population of *Polistes* sp.recorded was (1.07 wasps/$m^2$ branch/5min).

Time and week wise, the highest population of *Polistes* sp.(3.00 wasps/$m^2$ branch/5min) was recorded at 1200h -1400h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (1.00 wasps/$m^2$ branch/5min) and 3$^{rd}$ week (0.60 wasps/$m^2$ branch/5min).Minimum activity of *Polistes* sp.was recorded between 0600h to0800h. Peak activity was observed at 1000h -1200h and 1200h -1400h irrespective of weeks (Table 9).

Among Dipterans, mean population *C. rufifacies* recorded was (3.82 flies/$m^2$ branch/5min), followed by *E. obliquus* (0.98 flies.$m^2$ branch /5min). Time and week wise, the highest population of *C. rufifacies* (8.80 flies/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (5.40 flies/$m^2$ branch/5min) and 3$^{rd}$ week (4.40 flies/$m^2$ branch/5min). Incase of *E. obliquus* highest population (2.20 flies/$m^2$ branch/5min) was recorded at 1000h -1200h during 3$^{rd}$ week which was significantly different with 1$^{st}$ week (2.00 flies/$m^2$ branch/5min) and 2$^{nd}$ week (2.00 flies/$m^2$ branch/5min). Low abundance of both dipterans (*C. rufifacies* and *E. obliquus*) wasrecordedat 0600h-0800h

and 1600h - 1800h. Peak abundance was recorded at 0800h -1200h irrespective of weeks (Table 9).

From the present pollination study, it is evident that Hymenopterans were most abundant insect pollinators on lasora flowers. Irrespective of different day hours, significantly maximum number of *Apis dorsata* was recorded from lasora flowers followed by*C. rufifacies, A. florea*, *A. mellifera, E. obliquus, Polistes sp.* and *A. cerana.* Peakactivity of *A. dorsata* wasrecorded between 1000h -1200h during full bloom of crop. Peak abundance of all honey bee species was recorded at 1000-1200h. Minimum abundance was recorded at 0600h -0800h and 1600h-1800h irrespective of weeks.

**Table 8 : Abundance of insect visitors/pollinators on Lasora flowers during 2014**

| S.No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 19/4/14 | | | | | | Overall mean | 26/4/14 | | | | | | Overall mean | 3/5/14 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Apis dorasta* | 0.60 (1.24) | 4.00 (2.22) | 9.40 (3.22) | 4.20 (2.27) | 1.00 (1.39) | 0.80 (1.31) | 3.33 (1.94) | 1.60 (1.59) | 10.60 (3.40) | 13.80 (3.84) | 8.20 3.03) | 2.60 (1.88) | 1.60 (1.57) | 6.40 (2.55) | 1.20 (1.44) | 3.00 (1.99) | 7.60 (2.93) | 3.00 (1.99) | 1.40 (1.51) | 0.80 (1.31) | 2.83 (1.86) | 4.18 (2.12) |
| 2 | *Apis florae* | 0.40 (1.16) | 2.00 (1.72) | 9.40 (3.22) | 4.20 (2.27) | 1.00 (1.39) | 0.80 (1.31) | 2.96 (1.84) | 0.40 (1.16) | 6.80 (2.79) | 9.00 (3.16) | 3.60 (2.14) | 2.20 (1.77) | 0.60 1.22) | 3.76 (2.04) | 0.60 (1.24) | 1.00 (1.39) | 5.20 (2.48) | 1.80 (1.65) | 1.00 (1.39) | 0.20 (1.08) | 1.63 (1.54) | 2.78 (1.81) |
| 3 | *Apis mellifera* | 0.00 (1.00) | 2.00 (1.71) | 3.20 (2.04) | 0.80 (1.31) | 0.80 (1.31) | 0.40 (1.16) | 1.20 (1.42) | 0.40 (1.16) | 3.60 (2.13) | 6.60 (2.75) | 1.80 (1.65) | 1.80 (1.65) | 0.80 (1.31) | 2.50 (1.78) | 0.80 (1.31) | 1.60 (1.60) | 3.00 (1.98) | 1.60 (1.60) | 1.00 (1.39) | 0.00 (1.00) | 1.33 (1.48) | 1.67 (1.56) |
| 4 | *Apis cerana* | 0.20 (1.08) | 0.40 (1.16) | 1.20 (1.45) | 0.80 (1.31) | 0.20 (1.08) | 0.00 (1.00) | 0.46 (1.18) | 0.00 (1.00) | 1.00 (1.39) | 1.40 (1.54) | 1.00 (1.37) | 0.40 (1.16) | 0.00 (1.00) | 0.63 (1.24) | 0.00 (1.00) | 0.20 (1.08) | 0.60 (1.24) | 0.60 (1.22) | 0.40 (1.16) | 0.00 (1.00) | 0.30 (1.12) | 0.46 (1.18) |
| 5 | *Polistes* sp. | 0.20 (1.08) | 0.60 (1.24) | 0.80 (1.31) | 0.80 (1.31) | 1.00 (1.37) | 1.00 (1.37) | 0.73 (1.28) | 0.00 (1.00) | 1.00 (1.37) | 0.80 (1.31) | 2.60 (1.87) | 2.60 (1.89) | 1.00 (1.37) | 1.33 (1.47) | 0.00 (1.00) | 0.40 (1.16) | 0.60 (1.24) | 0.80 (1.31) | 1.20 (1.45) | 0.80 (1.31) | 0.63 (1.24) | 0.90 (1.33) |
| 6 | *Chrysomya rufifacies* | 1.20 (1.45) | 3.60 (2.13) | 5.20 (2.48) | 3.00 (1.98) | 2.00 (1.71) | 2.40 (1.82) | 2.90 (1.93) | 3.20 (2.04) | 8.80 (3.12) | 8.20 (3.03) | 5.20 (2.48) | 3.00 (1.98) | 3.00 (1.98) | 5.23 (2.44) | 1.60 (1.59) | 2.60 (1.87) | 3.40 (2.08) | 2.20 (1.75) | 2.40 (1.83) | 1.80 (1.65) | 2.33 (1.80) | 3.48 (2.06) |
| 7 | *Eristalinnus obliquus* | 0.40 (1.16) | 2.20 (1.77) | 1.80 (1.65) | 0.60 (1.22) | 0.60 (1.24) | 0.40 (1.16) | 1.00 (1.37) | 0.40 (1.16) | 1.40 (1.54) | 2.80 (1.92) | 1.00 (1.39) | 1.00 (1.39) | 0.20 (1.08) | 1.13 (1.41) | 0.80 (1.31) | 1.40 (1.51) | 1.00 (1.37) | 0.40 (1.16) | 0.80 (1.31) | 0.20 (1.08) | 0.76 (1.29) | 0.96 (1.36) |
| | Mean | 0.42 (1.17) | 2.11 (1.71) | 4.42 (2.20) | 2.05 (1.67) | 0.94 (1.36) | 0.82 (1.30) | 1.80 (1.57) | 0.85 (1.30) | 4.74 (2.25) | 6.08 (2.51) | 3.34 (1.99) | 1.94 (1.68) | 1.02 (1.36) | 3.00 (1.85) | 0.71 (1.27) | 1.45 (1.51) | 3.05 (1.90) | 1.48 (1.53) | 1.17 (1.44) | 0.54 (1.20) | 1.40 (1.48) | 2.06 (1.63) |

**Each value represents mean of 5 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.07 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Insect X Week | 0.04 | 0.12 |
| Insect visitors X Time | 0.06 | 0.17 |
| Week X Time | 0.04 | 0.11 |
| Insect visitors x Week Time | 0.11 | 0.30 |

**Table 9 : Abundance of insect visitors/pollinators on Lasora flowers during 2015**

| S.No. | Insect visitors | Number of insect visitors/$m^2$ branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 23/4/15 | | | | | | Overall mean | 30/4/15 | | | | | | Overall mean | 7/5/15 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Apis dorasta* | 0.40 (1.16) | 3.80 (2.18) | 10.60 (3.39) | 5.20 (2.48) | 1.60 (1.60) | 5.20 (2.48) | 4.46 (2.22) | 1.60 (1.60) | 10.20 (3.34) | 15.00 (3.99) | 7.80 (2.96) | 3.20 (2.04) | 1.60 (1.57) | 6.56 (2.58) | 1.20 (1.45) | 4.20 (2.27) | 8.60 (3.09) | 4.00 (2.23) | 1.20 (1.47) | 1.20 (1.47) | 3.40 (2.00) | 4.81 (2.27) |
| 2 | *Apis florea* | 0.60 (1.24) | 2.60 (1.88) | 8.40 (3.06) | 3.60 (2.14) | 2.40 (1.83) | 0.20 (1.08) | 2.96 (1.87) | 0.80 (1.31) | 6.80 (2.79) | 9.80 (3.28) | 4.40 (2.32) | 3.20 (2.04) | 0.60 1.22) | 4.26 (2.16) | 0.20 (1.08) | 2.00 (1.72) | 6.20 (2.68) | 2.60 (1.89) | 1.60 (1.60) | 0.40 (1.16) | 2.16 (1.69) | 3.13 (1.91) |
| 3 | *Apis mellifera* | 0.20 (1.08) | 2.60 (1.89) | 8.40 (3.06) | 3.60 (2.14) | 1.60 (1.60) | 0.60 (1.24) | 2.83 (1.83) | 0.60 (1.24) | 3.80 (2.18) | 7.60 (2.93) | 2.60 (1.88) | 2.40 (1.83) | 0.80 (1.31) | 2.96 (1.90) | 0.60 (1.24) | 2.00 (1.72) | 4.60 (2.36) | 2.40 (1.83) | 1.20 (1.47) | 0.20 (1.08) | 1.83 (1.62) | 2.54 (1.78) |
| 4 | *Apis cerana* | 0.00 (1.00) | 0.20 (1.08) | 1.40 (1.54) | 0.60 (1.24) | 0.40 (1.16) | 0.00 (1.00) | 0.43 (1.17) | 0.00 (1.00) | 1.20 (1.45) | 2.20 (1.77) | 2.00 (1.72) | 0.60 (1.24) | 0.00 (1.00) | 1.00 (1.36) | 0.00 (1.00) | 0.40 (1.16) | 0.00 (1.00) | 0.40 (1.16) | 0.20 (1.08) | 0.00 (1.00) | 0.16 (1.06) | 0.53 (1.20) |
| 5 | *Polistes*sp. | 0.00 (1.00) | 0.40 (1.16) | 1.00 (1.39) | 1.00 (1.39) | 1.00 (1.39) | 0.80 (1.31) | 0.70 (1.27) | 0.20 (1.08) | 0.80 (1.31) | 1.40 (1.54) | 3.00 (1.99) | 3.00 (1.98) | 1.00 (1.37) | 1.56 (1.54) | 0.00 (1.00) | 0.60 (1.22) | 1.40 (1.54) | 0.60 (1.24) | 1.60 (1.59) | 1.60 (1.54) | 0.96 (1.36) | 1.07 (1.39) |
| 6 | *Chrysomya rufifacies* | 1.40 (1.54) | 3.40 (2.08) | 5.40 (2.52) | 3.60 (2.14) | 2.40 (1.83) | 1.80 (1.65) | 3.00 (1.96) | 2.40 (1.83) | 8.00 (2.99) | 8.80 (3.12) | 5.80 (2.60) | 4.00 (2.23) | 3.00 (1.98) | 5.33 (2.46) | 1.60 (1.59) | 2.60 (1.89) | 4.40 (2.32) | 4.20 (2.27) | 3.40 (2.09) | 2.60 (1.88) | 3.13 (2.01) | 3.82 (2.14) |
| 7 | *Eristalinnus obliquus* | 0.20 (1.08) | 1.40 (1.51) | 2.00 (1.72) | 1..00 (1.39) | 1.00 (1.37) | 0.20 (1.08) | 0.96 (1.36) | 0.80 (1.31) | 1.20 (1.45) | 2.00 (1.71) | 0.40 (1.16) | 0.80 (1.31) | 0.20 (1.08) | 0.90 (1.34) | 0.80 (1.31) | 1.80 (1.65) | 2.20 (1.75) | 1.00 (1.39) | 0.60 (1.24) | 0.20 (1.08) | 1.10 (1.40) | 0.98 (1.37) |
| | Mean | 0.40 (1.16) | 2.05 (1.68) | 5.31 (2.38) | 2.65 (1.85) | 1.48 (1.54) | 1.25 (1.41) | 2.19 (1.67) | 0.91 (1.34) | 4.57 (2.22) | 6.68 (2.62) | 3.71 (2.09) | 2.45 (1.81) | 1.02 (1.36) | 3.22 (1.91) | 0.62 (1.24) | 1.94 (1.66) | 3.91 (2.10) | 2.17 (1.72) | 1.40 (1.51) | 0.88 (1.32) | 1.82 (1.59) | 2.41 (1.72) |

**Each value represents mean of 5 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.06 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.05 |
| Insect X Week | 0.03 | 0.10 |
| Insect visitors X Time | 0.05 | 0.15 |
| Week X Time | 0.03 | 0.09 |
| Insect visitors x Week Time | 0.09 | 0.26 |

### 4.1.4. Diversity of insect visitors/ pollinators on Karonda

The data on diversity of insect visitors/pollinators on Karonda flowers have been presented in Table 10 and Plate 4. Karonda flowers attracted wide variety of insect species belonging to 4 orders,8 families, 12 genera and 15 species. Among them eight belonging to order Hymenoptera, four to Lepidoptera, one to Coleoptera and one to Diptera. The Lepidopterans were the major floral visitors comprising from three families *viz*., Papilionidae (*Papilio demoleus*), Noctuidae (*Helicoverpa armigera*), Pieridae (*Eurema hecabe*) and Hesperiidae (*Pelopidas* sp.). They were followed in order of diversity by Hymenopterans from two families*viz*., Apidae (*Apis florea, Apis dorsata, Apis cerana*, *Apis mellifera and Xylocopa fenestrata*) and Vespidae (*Allorhynchium metallicum*, *Polistes* olivaceus and *Delta esuriens*).Coleopteran to Coccinellidae (*Coccinella septempunctata*) and two Dipteranto Syrphidae (*Sphaerophoria* sp. and *Episyrphus* sp.) were also observed.Only Lepidopterans and *P. olivaceus* were side foragers.

**Table 10:Diversity of insect visitors/pollinators of *Carissa carandas* (Karonda)**

| Order | Family | Insect Species | IP/IV | Working Behaviour |
|---|---|---|---|---|
| Hymenoptera | Apidae | *Apis florea* Fabricius | IP | T |
| | | *Apis dorsata* Fabricius | IP | T |
| | | *Apis cerana* Fabricius | IP | T |
| | | *Apis mellifera* Linnaeus | IP | T |
| | | *Xylocopa fenestrata* Fabricius | IV | T |
| | Vespidae | *Allorhynchium metallicum* (Saussure) | IP | T |
| | | *Polistes* olivaceus De Geer | IP | T and S |
| | | *Delta esuriens* (Fabricius) | IV | S |
| Lepidoptera | Papilionidae | *Papilio demoleus* Linnaeus | IP | T and S |
| | Noctuidae | *Helicoverpa armigera* Hubner | IV | T and S |
| | Pieridae | *Eurema hecabe* Linnaeus | IP | T and S |
| | Hesperiidae | *Pelopidas* sp. | IV | T and S |
| Coleoptera | Coccinellidae | *Coccinella septempunctata* Linnaeus | IV | T |
| Diptera | Syrphidae | *Sphaerophoria* sp. | IV | S |
| | | *Episyrphus* sp. | IV | S |

*IP –Insect Pollinator and IV – Insect Visitor
T – Top Worker and S – Side Worker

**Plate 18**

| | | | |
|---|---|---|---|
| 1. | *Apis dorsata* | 5. | *Apis cerana* |
| 2. | *Coccinella septempunctata* | 6. | *Megachile sp.* |
| 3. | *Polistes olivaceus* | 7. | *Delta esuriens* |
| 4. | *Apis florea* | 8. | *Sphaerophoria* sp. |

### 4.2.4. Abundance of insect visitors/pollinators of Karonda

During 2014, six species of flower visiting insects belonging to two orders, namely Hymenoptera (3) and Lepidoptera (3) were collected from the karonda flowers. Hymenopterans mainly comprising of honey bees (*Apis florea*) and wasps (*Polistesolivaceus* and *Delta esuriens*). Among Hymenopterans maximum mean population was of *A. florea*

**Plate 45: *Apis florea* foraging on Karonda flower**

**Plate 46: *Delta esuriens* foraging on Karonda flower**

**Plate 47:*Apis dorsata* foraging on Karonda flower**

**Plate 48:*Allorhynchium metallicum* foraging on Karonda flower**

**Plate 49: *Coccinella septempunctata* foraging on Karonda flower**

**Plate 50: *Papilio demoleus* foraging on Karonda flower**

**Plate 51: *Danaus chrysippus* foraging on Karonda flower**

**Plate 52: *Helicoverpa armigera* foraging on Karonda flower**

(1.45 bees/$m^2$ branch/5min) followed by that of *P. olivaceus* (1.40 wasps/$m^2$ branch/5min). *D.esuriens* (0.87 wasps/$m^2$ branch/5min) was significantly lowest among Hymenopterans(Table 11).

Time and week wise, the highest population of *A. florea* (3.40 bees/$m^2$ branch/5min) was recorded at 1000h -1200h during 1st week of flowering during April which was significantly different with 2nd week (3.00 bees/$m^2$ branch/5min) and 3rd week (2.20 bees/$m^2$ branch/5min). Similarly, maximum population of*P.olivaeus* (3.20 wasps/$m^2$ branch/5min) was recorded at 1400 h -1600h during 2ndweek which was significantly different with 3rd week (2.60 wasps/$m^2$ branch/5min) and 1st week (2.40 wasps/$m^2$ branch/5min). The highest population of *D. esuriens* (3.00 wasps/$m^2$ branch/5min) was recorded at 1200h -1400h during 2nd week which was significantly different with 1st week (1.60 wasps/$m^2$ branch/5min) and 3rdweek (0.60 wasps/$m^2$ branch/5min) (Table 11). Minimum activity of all Hymenopteran species was recorded between 0600h - 0800h and 1600 - 1800h. Peak activity was recorded at 1000h -1200h and 1400h – 1600h irrespective of weeks.

Among Lepidopterans, maximum mean population was of*Papilio demoleus* (3.35 insects/$m^2$ branch/5min) followed by that of *Helicoverpa armigera* (2.23 insects/$m^2$ branch/5min) and *Eurema hecabe* (0.92 insects/$m^2$ branch/5min). Time and week wise, the highest population of *P. demoleus* (9.20 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 2nd week of April which was significantly different with 1st week (6.00 insects/$m^2$ branch/5min) and 3rd week (4.00 insects/$m^2$ branch/5min). Similarly, maximum population of *H. armigera* (6.20 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 2nd week which was significantly different with 1st week (3.80 insects/$m^2$ branch/5min) and 3rd week (2.40 insects/$m^2$ branch/5min). Maximum population of *E. hecabe* (2.60 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 1st week which was significantly different with 2nd week (2.20 insects/$m^2$ branch/5min) and 3rd week (1.20 insects/$m^2$ branch/5min). Minimum abundance of all Lepidopteran species was recorded at 0600h -0800h and 1600h - 1800h. Peak abundance was recorded at 1000h -1400h irrespective of weeks (Table 11).

During 2014, highest pooled mean abundance (3.35 insects/$m^2$ branch/5min) was recorded in *P.demoleus* followed by *H. armigera* (2.23 insects/$m^2$ branch/5min), *A. florea* (1.45 bees/$m^2$ branch/5min), *P. olivaceus* (1.40 insects/$m^2$ branch/5min) and *E. hecabe* (0.92 insects/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *D. esuriens* (0.87 insects/$m^2$ branch/5min) (Table 11).

During 2015, six species of flower visiting insects belonging to two orders, namely Hymenoptera (3) and Lepidoptera (3) were collected from the karonda flowers. Hymenopteran order mainly comprises honey bee (*A. florea*) and wasps (*P.olivaceus* and *D. esuriens*). Among Hymenopterans maximum mean population was of *P. olivaceus* (1.61

wasps/$m^2$ branch/5min) followed by that of *A. florea* (1.45 bees/$m^2$ branch/5min). *D.esuriens* (1.10 wasps/$m^2$branch/5min) was significantly lowest among Hymenopterans(Table 12).

Time and week wise, the highest population of *A. florea* (3.60 bees/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week of flowering which was significantly different with 1$^{st}$ week (3.00 bees/$m^2$ branch/5min) and 3$^{rd}$ week (2.40 bees/$m^2$ branch/5min). Similarly, maximum population of *P.olivaeus* (3.60 wasps/$m^2$ branch/5min) was recorded at 1400 h -1600h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (3.00 wasps/$m^2$ branch/5min) and 3$^{rd}$ week (2.00 wasps/$m^2$ branch/5min).

The highest population of *D. esuriens* (3.40 wasps/$m^2$ branch/5min) was recorded at 1200h -1400h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (2.80 wasps/$m^2$ branch/5min) and 3$^{rd}$week (0.80 wasps/$m^2$ branch/5min) (Table 12). Minimum activity of all Hymenopterana species was recorded between 0600h - 0800h and 1600 - 1800h. Peak activity was recorded at 1000h -1200h and 1400h – 1600h irrespective of weeks.

Among Lepidopterans, maximum mean population was of *P. demoleus* (3.60 insects/$m^2$ branch/5min) followed by that of *H. armigera* (2.41 insects/$m^2$ branch/5min) and *E. hecabe* (1.08 insects/$m^2$ branch/5min). Time and week wise, the highest population of *P. demoleus* (8.60 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (6.60 insects/$m^2$ branch/5min) and 3$^{rd}$ week (4.60 insects/$m^2$ branch/5min). Similarly, maximum population of *H. armigera* (6.00 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (4.80 insects/$m^2$ branch/5min) and 3$^{rd}$ week (3.20 insects/$m^2$ branch/5min). Maximum population of *E. hecabe* (3.20 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 1$^{st}$ week which was significantly different with 2$^{nd}$ week (2.80 insects/$m^2$ branch/5min) and 3$^{rd}$ week (1.60 insects/$m^2$ branch/5min). Minimum abundance of all Lepidopteran species was recorded at 0600h -0800h and 1600h - 1800h. Peak abundance was recorded at 1000h -1400h irrespective of weeks (Table 12).

During 2015, highest pooled mean abundance (3.60 insects/$m^2$ branch/5min) was recorded in *P.demoleus* followed by *H. armigera* (2.41 insects/$m^2$ branch/5min),), *P. olivaceus* (1.61 insects/$m^2$ branch/5min), *A. florea* (1.45 bees/$m^2$ branch/5min and *D. esuriens* (1.10 insects/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *E. hecabe* (0.87 insects/$m^2$ branch/5min) (Table 12).

From the present pollination study, it is evident that Hymenopteran and Lepidopteran insects were more abundant insect pollinators on karonda flowers. Irrespective of different day hours, significantly maximum number of *P. demoleus* was recorded from karonda flowers followedby *H. armigera*, *A. florea, P. olivaceus, E. hecabe* and *D. esuriens*. Peakactivity of *P. demoleus* wasrecorded between 1000h -1200h during full bloom of crop. Peak abundance of

all Hymenopterans was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h and 1600h-1800h irrespective of weeks.

**Table 11: Abundance of insect visitors/pollinators on Karonda flowers during 2014**

| S.No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 21/4/14 | | | | | | Overall Mean | 28/4/14 | | | | | | Overall mean | 5/5/14 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Papilio demoleus* | 0.60 (1.24) | 3.20 (2.04) | 6.00 2.64) | 4.40 (2.32) | 2.20 (1.78) | 2.40 (1.83) | 3.13 (1.98) | 2.20 (1.77) | 5.40 (2.52) | 9.20 (3.19) | 5.40 (2.52) | 3.40 (2.09) | 2.60 (1.89) | 4.70 (2.33) | 1.00 (1.39) | 1.80 (1.65) | 4.00 (2.22) | 2.60 (1.89) | 2.60 (1.88) | 1.40 (1.54) | 2.23 (1.76) | 3.35 (2.02) |
| 2 | *Helicoverpa armigera* | 0.60 (1.24) | 2.40 (1.83) | 3.80 (2.18) | 3.60 (2.14) | 2.20 (1.77) | 1.00 (1.39) | 2.26 (1.76) | 2.20 (1.77) | 4.40 (2.31) | 6.20 (2.68) | 3.00 (1.99) | 1.80 (1.65) | 1.20 (1.45) | 3.13 (1.98) | 0.40 (1.16) | 1.40 (1.54) | 2.40 (1.82) | 1.60 (1.59) | 1.40 (1.54) | 0.60 (1.24) | 1.30 (1.48) | 2.23 (1.74) |
| 3 | *Apis florea* | 0.20 (1.08) | 1.40 (1.54) | 3.40 (2.09) | 2.00 (1.72) | 1.80 (1.65) | 0.20 (1.08) | 1.50 (1.53) | 0.40 (1.16) | 1.80 (1.66) | 3.00 (1.99) | 3.40 (2.09) | 2.00 (1.72) | 0.40 (1.16) | 1.83 (1.63) | 0.20 (1.08) | 0.60 (1.24) | 2.20 (1.77) | 1.20 (1.45) | 1.80 (1.65) | 0.20 (1.08) | 1.03 (1.38) | 1.45 (1.51) |
| 4 | *Polistes olivaceus* | 0.00 (1.00) | 0.80 (1.31) | 2.00 (1.72) | 1.40 (1.54) | 2.40 (1.83) | 1.60 (1.60) | 1.36 (1.50) | 0.20 (1.08) | 1.20 (1.47) | 1.80 (1.65) | 2.20 (1.76) | 3.20 (2.03) | 2.20 (1.77) | 1.80 (1.63) | 0.00 (1.00) | 0.80 (1.33) | 0.60 (1.24) | 1.00 (1.37) | 2.60 (1.88) | 1.20 (1.47) | 1.03 (1.38) | 1.40 (1.50) |
| 5 | *Delta esuriens* | 0.00 (1.00) | 0.20 (1.08) | 1.40 (1.54) | 1.60 (1.60) | 1.60 (1.60) | 0.40 (1.14) | 0.86 (1.33) | 0.20 (1.08) | 0.20 (1.08) | 0.80 (1.31) | 3.00 (1.98) | 2.00 (1.72) | 0.80 (1.31) | 1.16 (1.41) | 0.00 (1.00) | 0.40 (1.16) | 0.80 (1.31) | 0.60 (1.22) | 1.40 (1.54) | 0.40 (1.16) | 0.60 (1.23) | 0.87 (1.32) |
| 6 | *Eurema hecabe* | 0.40 (1.16) | 0.80 (1.33) | 2.60 (1.89) | 1.60 (1.59) | 1.20 (1.45) | 0.40 (1.16) | 1.16 (1.43) | 0.60 (1.24) | 1.00 (1.37) | 2.20 (1.77) | 0.80 (1.31) | 1.20 (1.45) | 0.60 (1.24) | 1.06 (1.40) | 0.40 (1.16) | 0.40 (1.16) | 1.20 (1.45) | 0.20 (1.08) | 0.60 (1.24) | 0.40 (1.16) | 0.53 (1.21) | 0.92 (1.35) |
| | Mean | 0.30 (1.12) | 1.46 (1.52) | 3.20 (2.01) | 2.43 (1.82) | 1.90 (1.68) | 1.00 (1.37) | 1.71 (1.59) | 0.96 (1.35) | 2.33 (1.74) | 3.86 (2.10) | 2.96 (1.94) | 2.26 (1.78) | 1.30 (1.47) | 2.28 (1.73) | 0.33 (1.13) | 0.90 (1.35) | 1.86 (1.64) | 1.20 (1.43) | 1.73 (1.62) | 0.70 (1.28) | 1.12 (1.41) | 1.70 (1.57) |

Each value represents mean of 5 observations

Figures in parentheses are square root transformed values

| Factor | SE m (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.06 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Insect X Week | 0.04 | 0.11 |
| Insect visitors X Time | 0.05 | 0.15 |
| Week X Time | 0.04 | 0.11 |
| Insect visitors x Week Time | 0.09 | 0.27 |

**Table 12 : Abundance of insect visitors/pollinators on Karonda flowers during 2015**

| S.No. | Insect visitors | Number of insect visitors/$m^2$ branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 17/4/15 | | | | | | Overall mean | 24/4/15 | | | | | | Overall mean | 1/5/15 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Papilio demoleus* | 1.00 (1.39) | 4.60 (2.36) | 6.60 2.75) | 5.00 (2.44) | 3.20 (2.04) | 2.00 (1.72) | 3.73 (2.11) | 1.80 (1.65) | 6.20 (2.68) | 8.60 (3.09) | 5.60 (2.56) | 4.00 (2.22) | 2.60 (1.88) | 4.80 (2.35) | 0.80 (1.33) | 2.40 (1.83) | 4.60 (2.36) | 3.40 (2.09) | 1.80 (1.65) | 0.60 (1.22) | 2.26 (1.75) | 3.60 (2.07) |
| 2 | *Helicoverpa armigera* | 0.60 (1.24) | 3.20 (2.04) | 4.80 (2.40) | 3.00 (1.99) | 1.80 (1.65) | 0.80 (1.33) | 2.36 (1.77) | 1.60 (1.57) | 5.00 (2.44) | 6.00 (2.64) | 3.60 (2.14) | 2.60 (1.89) | 1.40 (1.54) | 3.36 (2.04) | 0.20 (1.08) | 2.20 (1.77) | 3.20 (2.04) | 2.00 (1.72) | 1.00 (1.37) | 0.40 (1.16) | 1.50 (1.52) | 2.41 (1.78) |
| 3 | *Apis florea* | 0.00 (1.00) | 1.20 (1.47) | 3.00 (1.99) | 2.40 (1.83) | 2.00 (1.71) | 0.40 (1.16) | 1.50 (1.53) | 0.20 (1.08) | 2.20 (1.77) | 3.60 (2.14) | 3.40 (2.09) | 2.60 (1.89) | 0.20 (1.08) | 2.03 (1.67) | 0.00 (1.00) | 0.00 (1.00) | 2.40 (1.83) | 1.40 (1.54) | 1.00 (1.39) | 0.20 (1.08) | 0.83 (1.31) | 1.45 (1.50) |
| 4 | *Polistes olivaceus* | 0.00 (1.00) | 0.80 (1.33) | 2.00 (1.72) | 2.40 (1.82) | 3.00 (1.99) | 1.40 (1.54) | 1.60 (1.57) | 0.20 (1.08) | 1.20 (1.47) | 2.60 (1.89) | 2.60 (1.89) | 3.60 (2.14) | 2.40 (1.83) | 2.10 (1.72) | 0.00 (1.00) | 0.80 (1.33) | 1.00 (1.39) | 1.40 (1.54) | 2.00 (1.72) | 1.60 (1.59) | 1.13 (1.43) | 1.61 (1.57) |
| 5 | *Delta esuriens* | 0.00 (1.00) | 0.40 (1.16) | 1.80 (1.65) | 2.80 (1.94) | 2.00 (1.71) | 0.40 (1.16) | 1.23 (1.44) | 0.00 (1.00) | 0.40 (1.16) | 2.20 (1.77) | 3.40 (2.08) | 2.40 (1.83) | 0.60 (1.24) | 1.50 (1.52) | 0.00 (1.00) | 0.40 (1.16) | 0.60 (1.24) | 0.80 (1.31) | 0.80 (1.31) | 0.80 (1.31) | 0.56 (1.22) | 1.10 (1.39) |
| 6 | *Eurema hecabe* | 0.60 (1.24) | 0.80 (1.33) | 3.20 (2.04) | 1.60 (1.60) | 1.00 (1.39) | 0.20 (1.08) | 1.23 (1.45) | 1.20 (1.47) | 1.40 (1.54) | 2.80 (1.94) | 1.40 (1.54) | 1.40 (1.54) | 1.40 (1.16) | 1.43 (1.53) | 0.20 (1.08) | 0.40 (1.16) | 1.60 (1.60) | 0.40 (1.16) | 0.40 (1.16) | 0.60 (1.24) | 0.60 (1.23) | 1.08 (1.40) |
| | Mean | 0.36 (1.14) | 1.83 (1.61) | 3.56 (2.09) | 2.86 (1.94) | 2.16 (1.75) | 0.86 (1.33) | 1.94 (1.64) | 0.83 (1.31) | 2.73 (1.84) | 4.30 (2.24) | 3.33 (2.05) | 2.76 (1.92) | 1.26 (1.46) | 2.53 (1.80) | 0.20 (1.08) | 1.03 (1.38) | 2.23 (1.74) | 1.56 (1.56) | 1.16 (1.43) | 0.70 (1.27) | 1.15 (1.41) | 1.87 (1.61) |

Each value represents mean of 5 observations

tFigures in parentheses are square root transformed values

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.05 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.05 |
| Insect X Week | 0.03 | 0.10 |
| Insect visitors X Time | 0.05 | 0.14 |
| Week X Time | 0.03 | 0.10 |
| Insect visitors x Week Time | 0.09 | 0.25 |

### 4.1.5. Diversity of insect visitors/ pollinators on Bael

The data on diversity of insect visitors/pollinators on Bael flowers have been presented in Table 13 and Plate 5. Bael flowers attracted variety of insects belonging to 4 orders, 12 families, 19 genera and 24 species. Among them nine belonged to order Hymenoptera, eleven to Lepidoptera, two to Coleoptera and two to Diptera. The hymenopterans were the major floral visitors comprising of four families *viz*., Apidae (*Apis florea, A. dorsata, A. cerana*, *A. mellifera* and *Xylocopa pubescence*), Megachilidae (*Megachile* sp.), Vespidae (*Delta esuriens* and *Eumenes dimidatipennis*) and Formicidae (*Monomorium* sp.). They were followed in order of diversity by lepidopterans from five families*viz*., Papilionidae (*Papilio demoleus*), Nymphalidae (*Danaus chrysippus*, *Junonia alomana*, *Junonia lemonias*, *Venessa cardui*and *Phalanta phalantha*), Pieridae (*Catopsilia pyranthe* and *Pieris* sp.), Lycaenidae (*Lampides boeticus*) and Arctiidae (*Utetheisa pulchella* and *Amata* sp.). Coleopterans to Coccinellidae (*Coccinella septempunctata*) andMeloidae *(Mylabris pustulata*) and Dipterans to Syrphidae (*Eristalinus obscuritarsis* and *Eristalinus obliquus*). Out of 24 insects, all were top foragers except Lepidopterans which were side foragers also.

**Table 13: Diversity of insect visitors/pollinators of *Aegle marmelos* (Bael)**

| Order | Family | Insect Species | IP/IV | Working Behaviour |
|---|---|---|---|---|
| Hymenoptera | Apidae | *Apis dorsata* Fabricius | IP | T |
| | | *Apis florea* Fabricius | IP | T |
| | | *Apis mellifera* Linnaeus | IP | T |
| | | *Apis cerana* Fabricius | IP | T |
| | | *Xylocopa pubescence* (Spinola) | IV | T |
| | Vespidae | *Delta esuriens* (Fabricius) | IV | T |
| | | *Eumenes dimidatipennis* Sauss | IV | T |
| | Megachilidae | *Megachilecephalotes* Smith | IP | T |
| | Formicidae | *Monomorium* sp. | IV | T |
| Lepidoptera | Papilionidae | *Papilio demoleus* Linnaeus | IP | T and S |
| | Nymphalidae | *Danaus chrysippus* Linnaeus | IV | T and S |
| | | *Junonia alomana* Linnaeus | IP | T and S |
| | | *Junonia lemonias* Linnaeus | IP | T and S |
| | | *Venessa cardui* Linnaeus | IV | T and S |
| | | *Phalanta phalantha* Drury | IP | T and S |
| | Pieridae | *Catopsilia pyranthe* Linnaeus | IP | T and S |
| | | *Pieris* sp. | IP | T and S |
| | Lycaenidae | *Lampides boeticus* Linnaeus | IV | T and S |
| | Arctiidae | *Utetheisa pulchella* Moore | IV | T and S |
| | | *Amata* sp. | IV | T and S |
| Diptera | Syrphidae | *Eristalinus obscuritarsis* (de Meijere) | IP | T |
| | | *Eristalinus obliquus* Wiedemann | IP | T |
| Coleoptera | Coccinellidae | *Coccinella septempunctata* Linnaeus | IV | T |
| | Meloidae | *Mylabris pustulata* (Thunberg) | IV | T |

*IP –Insect Pollinator and IV – Insect Visitor *T – Top Worker and S – Side Worker

**Plate 54: *Danaus chrysippus* foraging on Bael flower**

**Plate 55: *Belenois aurota* foraging on Bael flower**

**Plate 56: *Papilio demoleus* foraging on Bael flower**

**Plate 57: *Junonia alomana* foraging on Bael flower**

**Plate 58: *Venessa cardui* foraging on Bael flower**

**Plate 59: *Utetheisa pulchella* foraging on Bael flower**

**Plate 19**

| | | | |
|---|---|---|---|
| 1. | *Papilio demoleus* | 5. | *Junonia lemonias* |
| 2. | *Catopsilia pyranthe* | 6. | *Belenois aurota* |
| 3. | *Junonia alomana* | 7. | *Danaus chrysippus* |
| 4. | *Venessa cardui* | 8. | *Phalanta phalantha* |

**4.2.5. Abundance of insect visitors/pollinators of Bael**

During 2014, seven species of flower visiting insects belonging to three orders, namely Hymenoptera (4), Lepidoptera (2) and Diptera (1) were collected from the bael flowers. The majority belonged to Hymenoptera comprising honey bees (*A. dorsata, A. mellifera and A. florea*) and *M. cephalotes*. Among honey bees maximum mean population was of *A. dorsata* (7.40 bees/$m^2$ branch/5min) followed by that of *A. florea* (1.17 bees/$m^2$ branch/5min). *A. mellifera* (0.84 bees/$m^2$ branch/5min) was significantly lowest among *Apis* bees (Table 14).

Time and week wise, the highest population of *A. dorsata* (13.00 bees/$m^2$ branch/5min) was recorded at 0800h -1000h during 2$^{nd}$ week of May, 2014 which was significantly different with 1$^{st}$ week (10.60 bees/$m^2$ branch/5min) and 3$^{rd}$ week (10.80 bees/$m^2$ branch/5min). Similarly, maximum population of *A. florea* (4.00 bees/$m^2$ branch/5min) was recorded at 1000 h -1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (2.40 bees/$m^2$ branch/5min) and 3$^{rd}$ week (1.60 bees/$m^2$ branch/5min). The highest population of *A. mellifera* (2.40 bees/$m^2$ branch/5min) on flowers was recorded at 1000h -1200h during 3$^{rd}$ week which was significantly different with 1$^{st}$ week (1.80 bees/$m^2$ branch/5min) and 2$^{nd}$ week (2.00 bees/$m^2$ branch/5min) (Table 14). Minimum activity of all honey bee species was recorded between 0600h - 0800h and 1400 - 1600h. Peak activity was recorded at 0800h -1000h and 1000h – 1200h, irrespective of weeks

Among other Hymenopterans, in addition to *Apis* spp., the next most abundant species was *M. cephalotes*. Mean population of *M. cephalotes* recorded was (3.01 bees/$m^2$ branch/5min).Time and week wise, the highest population of *M. cephalotes* (6.00 bees/$m^2$ branch/5min) was recorded at 1000h -1200h during 1$^{st}$ week which was significantly different with 2$^{nd}$ week (4.40 bees/$m^2$ branch/5min) and 3$^{rd}$ week (3.00 bees/$m^2$ branch/5min).Minimum activity of *M. cephalotes* was recorded between 0600h to1000h. Peak activity was observed at 1000h -1200h and 1400h -1600h irrespective of weeks (Table 14).

Among Lepidopterans, maximum mean population was of *B. aurota* (5.14 insects/$m^2$ branch/5min) followed by that of *C. pyranthe* (4.10 insects/$m^2$ branch/5min). Time and week wise, the highest population of *B. aurota* (12.80 insects/$m^2$ branch/5min) was recorded at 0800h -1000h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (7.20

insects/$m^2$ branch/5min) and 3rd week (4.80 insects/$m^2$ branch/5min). Similarly, maximum population of *C. pyranthe* (9.20 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 2nd week which was significantly different with 1st week (6.20 insects/$m^2$ branch/5min) and 3rd week (4.60 insects/$m^2$ branch/5min). Minimum abundance of both Lepidopteran species was recorded at 0600h -0800h and 1400h - 1600h. Peak abundance was recorded at 1000h -1400h irrespective of weeks (Table 14).

Among Diptera, mean population of *E. obscuritarsis* recorded was (1.55 insects/$m^2$ branch/5min). Time and week wise, the highest population of *E. obscuritarsis* (3.20 inseccts/$m^2$ branch/5min) was recorded at 1000h -1200h during 2nd week which was significantly different with 1st week (2.00 insects/$m^2$ branch/5min) and 3rd week (1.60 insects/$m^2$ branch/5min). Low abundance of *E.obscuritarsis* recordedat 0600h-0800h and 1400h - 1600h. Peak abundance was recorded at 0800h -1200h irrespective of weeks (Table 14).

During 2014, highest pooled mean abundance (7.40 bees/$m^2$ branch/5min) was recorded in *A. dorsata* followed by *B. aurota* (5.14 bees/$m^2$ branch/5min), *C. pyranthe* (4.10 insects/$m^2$ branch/5min), *M. cephalotes* (3.01 insects/$m^2$ branch/5min), *E. obscuritarsus* (1.55 insects/$m^2$ branch/5min) and *A. florea* (1.17 bees/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *A. mellifera* (0.84 bee/$m^2$ branch/5min). Thus it proves that *A. dorsata* and other wild pollinators are most abundant in bael. So there is need to conserve these pollinators to enhance the pollnation services (Table 14).

During 2015, seven species of flower visiting insects belonging to three orders, namely Hymenoptera (4), Lepidoptera (2) and Diptera (1) were collected from the bael flowers. The majority belonged to Hymenoptera comprising honey bees (*A. dorsata, A. mellifera* and *A. florea*) and *M. cephalotes*. Among honey bees maximum mean population was of *A. dorsata* (8.18 bees/$m^2$ branch/5min) followed by that of *A. florea* (2.26 bees/$m^2$ branch/5min). *A. mellifera* (0.95 bees/$m^2$ branch/5min) was significantly lowest among *Apis* bees (Table 15).

Time and week wise, the highest population of *A. dorsata* (14.60 bees/$m^2$ branch/5min) was recorded at 0800h -1000h during 2nd week, which was significantly different with 1st week (13.20 bees/$m^2$ branch/5min) and 3rd week (11.60 bees/$m^2$ branch/5min). Similarly, maximum population of *A. florea* (3.60 bees/$m^2$ branch/5min) was recorded at 1000 h -1200h during 2nd week which was significantly different with 1st week (3.20 bees/$m^2$ branch/5min) and 3rd week (2.60 bees/$m^2$ branch/5min). The highest population of *A. mellifera* (2.40 bees/$m^2$ branch/5min) on flowers was recorded at 1000h -1200h during 3rd week which was significantly different with 1st week (2.00 bees/$m^2$ branch/5min) and 2nd week (2.00 bees/$m^2$ branch/5min). Peak abundance of all honey bee species was recorded at

**Plate 60: *Catopsilia pyranthe* foraging on Bael flower**

**Plate 61: *Junonia lemonias* foraging on Bael flower**

**Plate 62: *Pedis* skipper foraging on Bael flower**

**Plate 63: *Phalanta phalantha* foraging on Bael flower**

**Plate 64: *Rhynchium oculatum* foraging on Bael flower**

**Plate 65: *Delta esuriens* foraging on Bael flower**

**Plate 66: *Mylabris pustulata* foraging on Bael flower**

**Plate 67: *Amata* sp. foraging on Bael flower**

**Plate 68: *Apis dorsata* foraging on Bael flower**

**Plate 69: *Apis florea* foraging on Bael flower**

**Plate 70: *Megachile cephalotes* foraging on Bael flower**

**Plate 71: *Monomorium* sp. foraging on Bael flower**

1000-1200h. Minimum abundance was recorded at 0600h -0800h, irrespective of weeks (Table 15).

Among other Hymenopterans, mean population of *M. cephalotes* recorded was (3.05 bees/$m^2$ branch/5min).Time and week wise, the highest population of *M. cephalotes* (5.40 bees/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week which was significantly different with 1st week (5.00 bees/$m^2$ branch/5min) and 3$^{rd}$ week (4.40 bees/$m^2$ branch/5min). Lowest abundance of *M. cephalotes* was recordedbetween 0600h -1000h. Highest abundance was recorded between 1000h to 1600h irrespective of weeks (Table 15).

Among Lepidopterans, maximum mean population was of *B. aurota* (5.55 insects/$m^2$ branch/5min) followed by that of *C. pyranthe* (4.43/$m^2$ branch/5min insects). Time and week wise, the highest population of *B. aurota* (11.80 insects/$m^2$ branch/5min) was recorded at 0800h -1000h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (8.00 insects/$m^2$ branch/5min) and 3$^{rd}$ week (6.20 insects/$m^2$ branch/5min). Similarly, maximum population of *C. pyranthe* (7.40 insects/$m^2$ branch/5min) was recorded at 0800 h -1000h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (5.00 insects/$m^2$ branch/5min) and 3$^{rd}$ week (4.00 insects/$m^2$ branch/5min). Minimum abundance of both Lepidopteran species was recorded at 0600h -0800h and 1400 - 1600h. Peak abundance was recorded at 1000h to 1400h, irrespective of weeks (Table 15).

Among Diptera, mean population of *E.obscuritarsis* was 0.87 insects/$m^2$ branch/5min. Time and week wise, the highest population of *E.obscuritarsis* (1.60 insects/$m^2$ branch/5min) was recorded between both 0800h - 1200h during 2$^{nd}$ week which was significantly different with 1$^{st}$ week (1.00 insects/$m^2$ branch/5min and 1.02 insects/$m^2$ branch/5min) and 3$^{rd}$ week (0.80 insects/$m^2$ branch/5min and 0.60 insects/$m^2$ branch/5min). Minimum abundance of *E.obscuritarsis* was recorded at 0600h-0800h and 1400h -1600h. Highest abundance was recorded at 0800h-1000h irrespective of weeks (Table 15).

During 2015, *A. dorsata* was recorded highest pooled mean abundance (8.18 bees/$m^2$ branch/5min) followed by *B. aurota* (5.55 bees/$m^2$ branch/5min), *C. pyranthe* (4.43 insects/$m^2$ branch/5min), *M. cephalotes* (3.05 insects/$m^2$ branch/5min), *A. florea* (2.26 bees/$m^2$ branch/5min) and *A. mellifera* (0.95 bees/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in*E. obscuritarsus* (0.87 insects/$m^2$ branch/5min) (Table 15).

From the present pollination study, it is evident that Hymenopteran insects were most abundant and Lepidopterans were more diversified insect pollinators on bael flowers. Irrespective of different day hours, significantly maximum number of *Apis dorsata* was recorded from bael flowers followed by *Belenois aurota*, *Catopsilia pyranthe, Megachile cephalotes*, *Apis florea, Eristalinusobscuritarsis* and *Apis mellifera.* Peakactivity of *A. dorsata* wasrecorded between 0800h -1000h during full bloom of crop. Peak abundance of all

honey bee species was recorded at 1000-1200h. Minimum abundance was recorded at 0600h - 0800h irrespective of weeks.

**Plate 72: *Eristalinus obscuritarsus* foraging on Bael flower**

**Plate 73: *Eristalinus obliquus* foraging on Bael flower**

**Plate 74: *Chrysomya* sp. foraging on Bael flower**

**Plate 75: *Coccinella septempunctata* foraging on Bael flower**

**Table 14 : Abundance of insect visitors/pollinators on Bael flowers during 2014**

| S.No. | Insect visitors | Number of insect visitors/$m^2$ branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4/5/14 | | | | | | Overall mean | 11/5/14 | | | | | | Overal l mean | 18/5/14 | | | | | | Overal l mean | Pooled mean |
| | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h - 1800h | | 0600h-0800h | 0800h-1000h | 1000h - 1200h | 1200h-1400h | 1400h-1600h | 1600h - 1800h | | |
| 1 | *A. dorasta* | 2.60 (1.88) | 10.60 (3.40) | 9.20 (3.19) | 9.60 (3.25) | 5.00 (2.44) | 5.60 2.56) | 7.10 (2.79) | 3.20 (2.04) | 13.00 (3.74) | 12.60 (3.68) | 10.40 3.37) | 7.60 (2.93) | 5.40 (2.52) | 8.70 (3.05) | 1.20 (1.47) | 10.80 (3.43) | 9.00 (3.16) | 7.20 (2.86) | 6.00 2.64) | 4.20 (2.27) | 6.40 (2.64) | 7.40 (2.82) |
| 2 | *A. florea* | 0.40 (1.16) | 2.40 (1.83) | 4.00 (2.22) | 1.60 (1.60) | 0.80 (1.33) | 0.00 (1.00) | 1.53 (1.52) | 0.80 (1.29) | 1.80 (1.66) | 2.40 (1.83) | 1.40 (1.54) | 0.60 (1.24) | 0.00 (1.00) | 1.16 (1.43) | 0.20 (1.08) | 0.80 (1.33) | 1.60 (1.60) | 1.20 (1.47) | 1.20 (1.45) | 0.00 (1.00) | 0.83 (1.32) | 1.17 (1.42) |
| 3 | *A. mellifera* | 0.20 (1.08) | 1.40 (1.54) | 1.80 (1.66) | 1.00 (1.39) | 0.40 (1.16) | 0.00 (1.00) | 0.80 (1.30) | 0.20 (1.08) | 1.00 (1.41) | 2.00 (1.71) | 1.20 (1.47) | 1.20 (1.45) | 0.00 (1.00) | 0.93 (1.35) | 0.40 (1.16) | 0.40 (1.16) | 2.40 (1.82) | 0.60 (1.24) | 0.80 (1.33) | 0.20 (1.08) | 0.80 (1.30) | 0.84 (1.32) |
| 4 | *Megachile cephalotes.* | 0.00 (1.00) | 2.20 (1.78) | 6.00 (2.64) | 3.20 (2.04) | 3.20 (2.04) | 1.80 (1.66) | 2.73 (1.86) | 0.60 (1.22) | 3.60 (2.14) | 4.40 (2.32) | 4.40 (2.32) | 3.80 (2.18) | 5.40 (2.52) | 3.70 (2.12) | 0.60 (1.22) | 2.20 (1.77) | 3.00 (1.99) | 2.00 (1.71) | 4.60 (2.36) | 3.20 2.04) | 2.60 (1.85) | 3.01 (1.94) |
| 5 | *Catopsilia pyranthe* | 1.80 (1.65) | 4.00 (2.23) | 6.20 (2.68) | 3.60 (2.14) | 4.00 (2.23) | 2.40 (1.83) | 3.66 (2.13) | 3.40 (2.09) | 6.60 (2.75) | 9.20 (3.19) | 4.00 (2.22) | 4.60 (2.36) | 3.60 (2.14) | 5.23 (2.46) | 1.60 (1.60) | 3.40 (2.09) | 4.60 (2.36) | 3.20 (2.03) | 3.60 (2.14) | 4.00 (2.22) | 3.40 (2.07) | 4.10 (2.22) |
| 6 | *Pieris*sp. | 2.40 (1.82) | 7.20 (2.86) | 6.40 (2.71) | 2.60 (1.89) | 5.40 (2.52) | 1.40 (1.54) | 4.23 (2.22) | 3.60 (2.14) | 12.80 (3.71) | 8.80 (3.12) | 6.60 (2.75) | 5.40 (2.52) | 5.80 (2.60) | 7.16 (2.81) | 3.00 (1.99) | 4.80 (2.40) | 4.60 (2.35) | 3.40 (2.09) | 5.60 (2.56) | 2.80 (1.94) | 4.03 (2.22) | 5.14 (2.42) |
| 7 | *Eristalinu obscuritarsus* | 0.60 (1.24) | 2.40 (1.83) | 2.00 (1.72) | 1.20 (1.47) | 1.60 (1.60) | 0.20 (1.08) | 1.33 (1.49) | 1.20 (1.47) | 2.40 (1.83) | 3.20 (2.04) | 2.00 (1.72) | 1.60 (1.60) | 0.60 (1.24) | 1.83 (1.65) | 0.60 (1.24) | 1.40 (1.54) | 1.60 (1.60) | 2.00 (1.72) | 2.80 (1.94) | 0.60 (1.24) | 1.50 (1.55) | 1.55 (1.56) |
| | Mean | 1.14 (1.40) | 4.31 (2.21) | 5.08 (2.40) | 3.25 (1.97) | 2.91 (1.90) | 1.62 (1.52) | 3.05 (1.90) | 1.85 (1.62) | 5.88 (2.46) | 6.08 (2.56) | 4.28 (2.20) | 3.54 (2.04) | 2.97 (1.86) | 4.10 (2.12) | 1.08 (1.40) | 3.40 (1.96) | 3.82 2.13) | 2.80 (1.87) | 3.51 (2.06) | 2.14 (1.68) | 2.79 (1.85) | 3.31 (1.95) |

Each value represents mean of 5 observations

[t]Figures in parentheses are square root transformed values

| Factor | SE m (±) | C.D. |
|---|---|---|
| Insect visitors | 0.01 | 0.05 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.04 |
| Insect X Week | 0.03 | 0.10 |
| Insect visitors X Time | 0.04 | 0.13 |
| Week X Time | 0.03 | 0.08 |
| Insect visitors x Week Time | 0.08 | 0.22 |

**Table 15 : Abundance of insect visitors/pollinators on Bael flowers during 2015**

| S.No. | Insect visitors | Number of insect visitors/$m^2$ branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2/5/15 | | | | | | Overallmean | 9/5/15 | | | | | | Overall mean | 16/5/15 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *A. dorasta* | 1.80 (1.66) | 13.20 (3.76) | 11.00 (3.46) | 9.80 (3.28) | 8.20 (3.03) | 6.00 (2.64) | 8.33 (2.97) | 2.80 (1.94) | 14.60 (3.94) | 11.40 (3.51) | 11.20 3.49) | 8.40 (3.06) | 6.80 (2.79) | 9.20 (3.12) | 1.40 (1.54) | 11.60 (3.54) | 9.60 3.25) | 8.00 (2.99) | 6.60 (2.75) | 5.00 (2.44) | 7.03 (2.75) | 8.18 (2.95) |
| 2 | *A. florea* | 0.20 (1.08) | 1.80 (1.65) | 3.20 (2.04) | 2.20 (1.77) | 0.80 (1.39) | 0.00 (1.31) | 3.60 (2.03) | 0.60 (1.22) | 2.80 (1.94) | 3.60 (2.14) | 2.40 (1.83) | 1.60 (1.60) | 0.20 (1.08) | 1.86 (1.64) | 0.40 (1.16) | 1.40 (1.54) | 2.60 (1.89) | 1.60 (1.60) | 1.80 (1.65) | 0.20 (1.08) | 1.33 (1.49) | 2.26 (1.72) |
| 3 | *A. mellifera* | 0.40 (1.16) | 0.80 (1.33) | 2.00 (1.72) | 0.60 (1.24) | 0.60 (1.24) | 0.00 (1.00) | 0.73 (1.28) | 0.80 (1.31) | 0.80 (1.31) | 2.40 (1.83) | 1.20 (1.45) | 1.20 (1.47) | 0.40 (1.16) | 1.13 (1.42) | 0.60 (1.22) | 0.80 (1.31) | 2.00 (1.71) | 1.00 (1.39) | 1.20 (1.47) | 0.40 (1.16) | 1.00 (1.38) | 0.95 (1.36) |
| 4 | *Megachile* sp. | 0.00 (1.00) | 1.00 (1.37) | 5.00 (2.44) | 3.60 (2.14) | 3.80 (2.18) | 2.20 (1.77) | 2.60 (1.82) | 0.40 (1.16) | 3.00 (1.98) | 5.40 (2.52) | 4.00 (2.23) | 4.60 (2.36) | 4.20 (2.27) | 3.60 (2.09) | 0.80 (1.31) | 2.20 (1.77) | 4.40 (2.31) | 2.60 (1.89) | 4.60 (2.36) | 3.20 (2.04) | 2.96 (1.95) | 3.05 (1.95) |
| 5 | *Catopsilia pyranthe* | 1.40 (1.54) | 5.00 (2.44) | 6.60 (2.75) | 4.20 (2.27) | 5.20 (2.48) | 2.80 (1.94) | 4.20 (2.23) | 2.40 (1.83) | 7.40 (2.89) | 7.20 (2.85) | 5.20 (2.48) | 5.40 (2.52) | 4.20 (2.27) | 5.30 (247) | 2.20 (1.77) | 4.00 (2.23) | 5.80 (2.60) | 3.40 (2.09) | 4.20 (2.27) | 3.20 (2.04) | 3.80 (2.17) | 4.43 (2.29) |
| 6 | *Pieris*sp. | 2.00 (1.72) | 8.00 (2.99) | 7.20 (2.85) | 3.60 (2.12) | 6.00 (2.64) | 2.60 (1.89) | 4.90 (2.37) | 3.60 (2.13) | 11.80 (3.57) | 8.20 (3.02) | 6.40 (2.70) | 6.40 (2.71) | 4.80 (2.39) | 6.86 (2.76) | 2.60 (1.89) | 6.20 (2.68) | 6.60 (275) | 3.40 (2.08) | 6.60 (2.75) | 4.00 (2.22) | 4.90 (2.39) | 5.55 (2.51) |
| 7 | *Eristalinu obscuritarsus* | 0.00 (1.00) | 1.00 (1.39) | 1.20 (1.45) | 1.00 (1.39) | 1.20 (1.45) | 0.60 (1.24) | 0.83 (1.32) | 0.00 (1.00) | 1.60 (1.59) | 1.60 (1.59) | 1.40 (1.54) | 1.40 (1.54) | 1.00 (1.39) | 1.16 (1.44) | 0.00 (1.00) | 0.80 (1.33) | 0.60 (1.24) | 0.60 (1.24) | 1.00 (1.39) | 0.80 (1.31) | 0.63 (1.25) | 0.87 (1.34) |
| | Mean | 0.82 (1.31) | 4.40 (2.13) | 5.17 (2.39) | 3.57 (2.03) | 4.74 (2.29) | 2.88 (1.87) | 3.60 (2.00) | 1.51 (1.51) | 6.00 (2.46) | 5.68 (2.50) | 4.54 (2.25) | 4.14 (2.18) | 3.08 (1.91) | 4.16 (2.13) | 1.14 (1.41) | 3.85 (2.06) | 4.51 (2.25) | 2.94 (1.90) | 3.71 (2.09) | 2.40 (1.75) | 3.09 (1.91) | 3.31 (2.01) |

Each value represents mean of 5 observations

Figures in parentheses are square root transformed values

| Factor | SE m (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.05 |
| Week | 0.01 | 0.03 |
| Time | 0.02 | 0.05 |
| Insect X Week | 0.03 | 0.10 |
| Insect visitors X Time | 0.05 | 0.14 |
| Week X Time | 0.03 | 0.09 |
| Insect visitors x Week Time | 0.09 | N.S. |

### 4.1.6. Diversity of insect visitors/ pollinators on Jamun

The data on diversity of insect visitors/pollinators on Jamun flowers have been presented in Table 16. Jamun flowers attracted insect species belonging to 3 orders, 5 families, 6 genera and 9 species. Among them seven belongs to order Diptera, one to Hymenoptera and one to Lepidoptera. The Dipterans were the major floral visitors comprising of three families *viz*., Syrphidae (*Eristalinus obliquus*, *Eristalis* sp., *Eristalinus obscuritarsis*, *Eristalinus aeneus*and *Eristalinus tabanoides*, Muscidae (*Musca* sp.) and Calliophoridae (*Chrysomya megacephala*). Lepidopteran to Arctiidae (*Amata* sp.) and Hymenoptera*n* to Apidae (*Apis dorsata*).

**Table 16: Diversity of insect visitors/pollinators of *Syzygium cumini* (Jamun)**

| Order | Family | Insect Species | IP/IV | Working Behaviour |
|---|---|---|---|---|
| **Order** Diptera | **Family** Syrphidae | *Eristalinus obliquus* Wiedemann | IP | T |
| | | *Eristalis* sp. | IP | T |
| | | *Eristalinus tabanoides* Jaennicke | IP | T |
| | | *Eristalinus obscuritarsis* (de Meijere) | IP | T |
| | | *Eristalinus aeneus* Scopoli | IP | T |
| | Calliphoridae | *Chrysomya megacephala* (Fabricius) | IP | T |
| | Muscidae | *Musca* sp. | IP | T |
| Hymenoptera | Apidae | *Apis dorsata* Fabricius | IP | T |
| Lepidoptera | Arctiidae | *Amata* sp. | IV | T and S |

*IP –Insect pollinator and IV – Insect visitor
* T – Top Worker and S – Side Worker

### 4.2.6. Abundance of insect visitors/pollinators of Jamun

During 2014, three species of flower visiting insects belonging to order, namely Diptera (3) were collected from the jamun flowers. Dipteran order comprises of *Eristaliinus obliquus*, *Chrysomya megacephala* and *Musca* sp. Among Dipterans maximum mean population was of *E. obliquus* (13.54 flies/$m^2$ branch/5min) followed by that of *C. megacephala*(10.97 flies/$m^2$ branch/5min) (Table). Lowest mean population was recorded incase of *Musca* sp. (3.62 flies/$m^2$branch/5 min).

Time and week wise, the highest population of *E. obliquus* (23.80 flies/$m^2$ branch/5min) was recorded at 1000h -1200h during 1$^{st}$ week of flowering which was significantly different with 2$^{nd}$ week (12.40 flies/$m^2$ branch/5min) and 3$^{rd}$ week (20.40 flies/$m^2$ branch/5min). Incase of *C. megacephala* maximum population (18.00 flies/$m^2$ branch/5min) was recorded at 1600h -18000h during 3$^{rd}$ week which was significantly different with 2$^{nd}$ week (14.60 flies/$m^2$ branch/5min) and 1$^{st}$ week (12.60 flies/$m^2$ branch/5min) (Table 17).

Incase of *Musca* sp., highest population (6.40 flies/$m^2$ branch/5min) was recorded at 1000h-1200h during 2$^{nd}$ week of flowering which was significantly different with 1$^{st}$ week (2.40 bees/$m^2$ branch/5min) and 3$^{rd}$ week (4.60 flies/$m^2$ branch/5min).

During 2014, highest pooled mean abundance (13.54 flies/$m^2$ branch/5min) was recorded in *E. obliquus,* followed by *C. megacephala* (10.97 flies/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *Musca* sp.(3.62 flies/$m^2$ branch/5min).

During 2015, three species of flower visiting insects belonging to order, namely Diptera (3) were collected from the jamun flowers. Dipterans comprising *Eristalinus obliquus*, *Chrysomya megacephala* and *Musca* sp.. Among Dipterans maximum mean population was of *E. obliquus* (14.07 flies/$m^2$ branch/5min) followed by that of *C. megacephala*(10.28 flies/$m^2$ branch/5min) (Table 18). Lowest mean population was recorded incase of *Musca* sp. (3.67 flies/$m^2$branch/5 min).

Time and week wise, the highest population of *E. obliquus* (24.60 flies/$m^2$ branch/5min) was recorded at 1000h -1200h during 2$^{nd}$ week of flowering which was significantly different with 1$^{st}$ week (21.40 flies/$m^2$ branch/5min) and 3$^{rd}$ week (21.60 flies/$m^2$ branch/5min). Incase of *C. megacephala* maximum population (16.80 flies/$m^2$ branch/5min) was recorded at 1600h -18000h during 3$^{rd}$ week which was significantly different with 2$^{nd}$ week (15.20 flies/$m^2$ branch/5min) and 1$^{st}$ week (11.60 flies/$m^2$ branch/5min) (Table 18).

Incase of *Musca* sp., highest population (6.00 flies/$m^2$ branch/5min) was recorded at 0800h-1000h during 2$^{nd}$ week of flowering which was significantly different with 1$^{st}$ week (4.60 bees/$m^2$ branch/5min) and 3$^{rd}$ week (3.80 flies/$m^2$ branch/5min).

From the present pollination study, it is evident that Dipteran insects were most abundant insect pollinators on jamun flowers. Irrespective of different day hours, significantly maximum number of *E. obliquus* was recorded from jamun flowers followed by *C. megacephala.* and*Musca sp.* Peakactivity of *E. obliquus* wasrecorded between 1000h -1200h during full bloom of crop. Peak abundance of *C. megacephala* was recorded at 1600-1800h and minimum abundance was recorded at 1200h -1400h irrespective of weeks.

**Plate 76: *Amata* sp. foraging on Jamun flower**

**Plate 77: *Chrysomya megacephala* foraging on Jamun flower**

**Plate 78: *Eristalinus obscuritarsus* foraging on Jamun flower**

**Plate 79: *Eristalinus obliquus* foraging on Jamun flower**

**Table 17 : Abundance of insect visitors/pollinators on Jamun flowers during 2014**

| S.No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 20/4/14 | | | | | | Overal lmean | 28/4/14 | | | | | | Overall mean | 5/5/14 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Eristalinus obliquus* | 8.40 (3.06) | 14.60 (3.94) | 23.80 (4.96) | 20.40 (4.61) | 14.40 (3.92) | 7.20 (2.86) | 14.80 (3.89) | 8.60 (3.09) | 16.80 (4.21) | 12.40 (3.65) | 17.60 (4.31) | 12.20 (3.63) | 13.60 (3.81) | 13.53 (3.78) | 6.40 (2.71) | 7.60 (2..93) | 20.40 (4.62) | 17.80 (4.33) | 12.80 (3.71) | 8.80 (3.12) | 12.30 (3.57) | 13.54 (3.75) |
| 2 | *Chrysomya megacephala* | 14.00 (3.87) | 11.80 (3.56) | 4.60 (2.35) | 2.40 (1.82) | 10.00 (3.31) | 12.60 (3.68) | 9.23 (3.10) | 10.80 (3.43) | 14.20 (3.89) | 13.60 (3.81) | 7.80 (2.96) | 12.20 (3.63) | 14.60 (3.94) | 12.20 (3.61) | 11.80 (3.57) | 13.80 (3.84) | 6.60 (2.75) | 4.60 (2.36) | 14.20 (3.89) | 18.00 (4.35) | 11.50 (3.46) | 10.97 (3.39) |
| 3 | *Musca* sp. | 3.00 (1.98) | 4.60 (2.36) | 2.40 (1.83) | 2.40 (1.82) | 1.60 (1.60) | 1.20 (1.47) | 2.53 (1.85) | 4.60 (2.26) | 6.40 (2.71) | 3.00 (1.98) | 5.40 (2.52) | 3.60 (2.14) | 5.20 (2.48) | 4.70 (2.35) | 1.60 (1.60) | 3.60 (2.14) | 4.60 (2.36) | 2.60 (1.89) | 6.40 (2.71) | 4.20 (2.27) | 3.83 (2.16) | 3.62 (2.12) |
| | Mean | 8.46 (2.97) | 10.33 (3.29) | 10.26 (3.05) | 8.40 (2.75) | 8.66 (2.94) | 7.00 (2.67) | 8.85 (2.94) | 8.00 (2.93) | 12.46 (3.61) | 9.66 (3.15) | 10.26 (3.26) | 9.33 (3.13) | 11.13 (3.41) | 10.14 (3.25) | 6.60 (2.63) | 8.33 (2.97) | 10.53 (3.24) | 8.33 (2.86) | 11.13 (3.44) | 10.33 (3.25) | 9.21 (3.06) | 3.68 (3.08) |

**Each value represents mean of 5 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.05 |
| Week | 0.02 | 0.05 |
| Time | 0.03 | 0.08 |
| Insect X Week | 0.03 | 0.10 |
| Insect visitors X Time | 0.05 | 0.14 |
| Week X Time | 0.05 | 0.14 |
| Insect visitors x Week Time | 0.08 | 0.24 |

**Table 18 : Abundance of insect visitors/pollinators on Jamun flowers during 2015**

| S.No. | Insect visitors | Number of insect visitors/$m^2$ branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 23/4/15 | | | | | | Overall mean | 29/4/15 | | | | | | Overall mean | 6/5/15 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Eristalinus obliquus* | 8.20 (3.03) | 14.60 (3.94) | 21.40 (4.72) | 19.80 (4.55) | 15.00 (3.99) | 6.80 (2.79) | 14.30 (3.84) | 7.60 (2.93) | 15.80 (4.09) | 24.60 (5.05) | 23.40 (4.93) | 11.40 (3.51) | 9.60 (3.25) | 15.40 (3.96) | 7.20 (2.86) | 8.20 (3.02) | 21.60 (4.75) | 18.80 (4.44) | 11.80 (3.57) | 7.60 (2.93) | 12.55 (3.59) | 14.07 (3.79) |
| 2 | *Chrysomya megacephala* | 15.40 (4.04) | 11.80 (3.56) | 4.80 (2.40) | 2.80 (1.94) | 10.80 (3.43) | 11.60 (3.54) | 9.53 (3.15) | 9.40 (3.22) | 13.00 (3.74) | 6.80 (2.79) | 4.00 (2.23) | 13.00 (3.74) | 15.20 (4.02) | 10.23 (3.29) | 13.00 (3.74) | 14.60 (3.94) | 5.40 (2.52) | 3.40 (2.09) | 13.40 (3.79) | 16.80 (4.21) | 11.10 (3.38) | 10.28 (3.27) |
| 3 | *Musca* sp. | 4.20 (2.27) | 4.60 (2.36) | 2.80 (1.94) | 1.80 (1.65) | 2.00 (1.72) | 1.60 (1.60) | 2.83 (1.92) | 2.20 (1.77) | 6.00 (2.64) | 6.00 (2.64) | 5.00 (2.44) | 4.20 (2.27) | 5.80 (2.60) | 4.86 (2.39) | 2.40 (1.83) | 3.80 (2.18) | 3.20 (2.04) | 1.80 (1.65) | 5.20 (2.48) | 3.60 (2.14) | 3.33 (2.05) | 3.67 (2.12) |
| | Mean | 9.26 (3.11) | 10.33 (3.29) | 9.66 (3.02) | 8.13 (2.71) | 9.26 (3.05) | 6.66 (2.64) | 8.88 (2.97) | 6.40 (2.64) | 11.60 (3.49) | 12.46 (3.49) | 10.80 (3.20) | 9.53 (3.17) | 10.20 (3.29) | 10.16 (3.21) | 7.53 (2.81) | 8.86 (3.05) | 10.06 (3.10) | 8.00 (2.73) | 10.13 (3.28) | 9.33 (3.09) | 8.98 (3.01) | 9.34 (3.06) |

**Each value represents mean of 5 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.01 | 0.05 |
| Week | 0.01 | 0.05 |
| Time | 0.02 | 0.07 |
| Insect X Week | 0.03 | 0.09 |
| Insect visitors X Time | 0.04 | 0.13 |
| Week X Time | 0.04 | 0.13 |
| Insect visitors x Week Time | 0.08 | 0.22 |

### 4.1.7. Diversity of insect visitors/ pollinators on Sarpagandha

The data on diversity of insect visitors/pollinators on Sarpagandha flowers have been presented in Table 19 and Plate 7. Sarpagandha flowers attracted wide varieties of insects belonging to 4 orders, 10 families, six families, 16 genera and 17 species. Among them nine belongs to order Lepidoptera, one to Coleoptera, two to Diptera, and two to Hymenoptera. The Lepidopterans were the major floral visitors comprising from three families *viz*., Papilionidae (*Papilio demoleus* and *Papilio polytes*), Pieridae (*Eurema hecabe*, *Pieris* sp., *Anaphaeis* sp., *Pieris canidia*,*Belenois aurota*, *Pieris brassicae* and *Colotis etrida* and Hesperiidae (*Pelopidas* sp.). They were followed in order of diversity by Dipterans from two families*viz*., Sarcophagidae(*Sarcophaga* sp.) and Syrphidae (*Eristalinus obscuritarsis*) and two species from one family of Hymenoptera *viz*., Vespidae (*Polistesolivaceus*) and Apidae (*Amegilla zonata*). Coleopteran to Coccinellidae (*Coccinella septempunctata*). Out of 17 insects all were top foragers except *A. zontata* which was side forager also.

**Table 19: Diversity of insect visitors/pollinators of *Rauvolfia serpentina* (Sarpagandha)**

| Order | Family | Insect Species | IP/IV | Working Behaviour |
|---|---|---|---|---|
| Lepidoptera | Papilionidae | *Papilio demoleus* Linnaeus | IP | T |
| | | *Papilio polytes* Linnaeus | IP | T |
| | Pieridae | *Pieris* sp. | IP | T |
| | | *Anaphaeis* sp. | IP | T |
| | | *Pieris canidia* Linnaeus | IP | T |
| | | *Belenois aurota* Fabricius | IV | T |
| | | *Pieris brassicae* Linnaeus | IP | T |
| | | *Colotis etrida* (Boisduval) | IV | T |
| | Hesperiidae | *Pelopidas* sp. | IV | T |
| Coleoptera | Coccinellidae | *Coccinella septempunctata* Linnaeus | IV | T |
| Hymenoptera | Apidae | *Amegilla zonata* (Linnaeus) | IP | T and S |
| | Vespidae | *Polistesolivaceus* De Geer | IV | T |
| | Formicidae | *Monomorium* sp. | IV | S |
| Diptera | Sarcophagidae | *Sarcophaga* sp. | IP | T |
| | Syrphidae | *Eristalinus obscuritarsis* (de Meijere) | IV | S |
| | | *Eristalis* sp. | IV | S |
| Hemiptera | Scutellaridae | *Chrysocoris stolli* Wolff | IV | T |

*IP –Insect Pollinator and IV – Insect Visitor
T – Top and S - Side

**Plate 20**

| | | | |
|---|---|---|---|
| 1. | *Eristalinus obscuritarsus* | 5. | *Pieris* sp. |
| 2. | *Chrysocoris stolli* | 6. | *Pelopidas* sp. |
| 3. | *Amegilla zonata* | 7. | *Polistes olivaceus* |
| 4. | *Anapheis* sp. | 8. | *Coccinella septempunctata* |

### 4.2.7. Abundance of insect visitors/pollinators of Sarpagandha

During 2014, three species of flower visiting insects belonging to two orders, namely Lepidoptera (2), and Hymenoptera (1) were collected from the sarpagandha flowers. The majority belonged to Lepidoptera comprising of *Papilio demoleus and Pieris* sp. Among

Lepidopterans, maximum mean population was of *P. demoleus* (3.70 insects/$m^2$ branch/5min) followed by that of *Pieris* sp. (1.23 insects/$m^2$ branch/5min (Table 20). In Hymenoptera, *A. zonata* was recorded the mean population of (1.83 bees/$m^2$branch/5 min).

Time and week wise, the highest population of *P. demoleus* (6.40 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 2nd week of flowering which was significantly different with 1st week 4.60 insecct s/$m^2$ branch/5min) and 3rd week (5.00 insects/$m^2$ branch/5min). Incase of *Pieris* sp. maximum population (2.60 insects/$m^2$ branch/5min) was recorded at 1000h -12000h during both 2nd and 3rd week which was significantly different with 1st week (1.80 insects/$m^2$ branch/5min) (Table 20). Minimum activity of both lepidopterans (*P. demoleus* and *Pieris* sp.) was recorded between 0600h - 0800h and peak activity was recorded at 1000h – 1200h irrespective of weeks.

Incase of Hymenoptera, highest population of *A. zonata* (4.40 bees/$m^2$ branch/5min) was recorded at 1000h-1200h during 2nd week of flowering which was significantly different with 1st week (3.60 bees/$m^2$ branch/5min) and 3rd week (3.80 bees/$m^2$ branch/5min).

During 2014, highest pooled mean abundance (3.70 insects/$m^2$ branch/5min) was recorded in *p. demoleus* followed by *A. zonata* (1.83 bees/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *Pieris* sp.(1.23 insects/$m^2$ branch/5min).

During 2015, three species of flower visiting insects belonging to two orders, namely Lepidoptera (2), and Hymenoptera (1) were collected from the sarpagandha flowers. The majority belonged to Lepidoptera comprising of *Papilio demoleus* and *Pieris* sp. Among Lepidopterans, maximum mean population was of *P. demoleus* (3.47 insects/$m^2$ branch/5min) followed by that of *Pieris* sp. (1.53 insects/$m^2$ branch/5min (Table 21). In Hymenoptera, *A. zonata* was recorded the mean population of (1.85 bees/$m^2$branch/5 min).

Time and week wise, the highest population of *P. demoleus* (5.80 insects/$m^2$ branch/5min) was recorded at 1000h -1200h during 3rd week of flowering which was significantly different with 2nd week (5.00 insects/$m^2$ branch/5min) and 1st week (3.80 insects/$m^2$ branch/5min). Incase of *Pieris* sp. maximum population (3.00 insects/$m^2$ branch/5min) was recorded at 1000h -12000h during both 3rd week which was significantly different with 1st week (2.00 insects/$m^2$ branch/5min) and 2nd week of flowering (2.60 insects/$m^2$ branch/5min)(Table 20). Minimum activity of both lepidopterans (*P. demoleus* and *Pieris* sp.) was recorded between 0600h - 0800h and peak activity was recorded at 1000h – 1200h irrespective of weeks.

Incase of Hymenoptera, highest population of *A. zonata* (4.20 bees/$m^2$ branch/5min) was recorded at 1000h-1200h during both 2nd and 3rd week of flowering which was significantly different with 1st week (3.40 bees/$m^2$ branch/5min).

**Plate 80: *Chrysocoris stolli* foraging on Sarpagandha flower**

**Plate 81: *Eristalis* sp. foraging on Sarpagandha flower**

**Plate 82: *Colotis etrida* foraging on Sarpagandha flower**

**Plate 83: *Papilio demoleus* foraging on Sarpagandha flower**

**Plate 84: *Amegilla zonata* foraging on Sarpagandha flower**

**Plate 85: *Papilio polytes* foraging on Sarpagandha flower**

**Plate 86: *Pieris* sp. foraging on Sarpagandha flower**

**Plate 87: *Polistes olivaceus* foraging on Sarpagandha flower**

**Plate 88: *Monomorium* sp. foraging on Sarpagandha flower**

**Plate 89: *Anaphaeis* sp. foraging on Sarpagandha flower**

**Plate 90: *Coccinella septempunctata* foraging on Sarpagandha flower**

**Plate 91: *Pelopidas* sp. foraging on Sarpagandha flower**

**Plate 92: *Bagrada hilaris* foraging on Sarpagandha flower**

**Plate 93: *Eristalinus obscuritarsus* foraging on Sarpagandha flower**

During 2015, highest pooled mean abundance (3.47 insects/$m^2$ branch/5min) was recorded in *P. demoleus* followed by *A. zonata* (1.85 bees/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *Pieris* sp.(1.53 insects/$m^2$ branch/5min).

From the present pollination study, it is evident that Lepidopteran insects were most abundant insect pollinators on Sarpagandha flowers. Irrespective of different day hours, significantly maximum number of *P. demoleus* was recorded from sarpagandha flowers followed by *A. zonata* and *Pieris* sp. Peak abundance of *P. demoleus*, *A.zonata* and *Pieris* sp. was recorded at 1000h-1200h irrespective of weeks. Minimum abundance was recorded at 0600h -0800h irrespective of weeks.

**Table 20 : Abundance of insect visitors/pollinators on Sarpagandha flowers during 2014**

| S. No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 28/4/14 | | | | | | Overall mean | 5/5/14 | | | | | | Overall mean | 12/5/14 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Papilio demoleus* | 2.00 (1.72) | 4.60 (2.35) | 4.60 (2.34) | 3.60 (2.13) | 3.40 (2.09) | 2.20 (1.76) | 3.40 (2.07) | 2.80 (1.94) | 5.80 (2.60) | 6.40 (2.71) | 4.60 (2.36) | 3.40 (2.09) | 2.80 (1.94) | 4.30 (2.27) | 1.60 (1.60) | 4.40 (2.31) | 5.00 (2.44) | 3.60 (2.12) | 3.40 (2.08) | 2.40 (1.82) | 3.40 (2.06) | 3.70 (2.13) |
| 2 | *Amegilla zonata* | 0.20 (1.08) | 1.80 (1.65) | 3.60 (2.14) | 1.80 (1.66) | 1.20 (1.47) | 0.40 (1.16) | 1.50 (1.53) | 0.60 (1.24) | 2.60 (1.88) | 4.40 (2.32) | 2.60 (1.89) | 1.40 (1.54) | 1.40 (1.54) | 2.16 (1.73) | 0.20 (1.08) | 1.60 (1.60) | 3.80 (2.18) | 2.20 (1.77) | 1.60 (1.60) | 1.60 (1.60) | 1.83 (1.64) | 1.83 (1.63) |
| 3 | *Pieris* sp. | 0.20 (1.08) | 0.60 (1.22) | 1.80 (1.66) | 1.20 (1.45) | 0.60 (1.24) | 0.60 (1.24) | 0.83 (1.32) | 0.40 (1.16) | 1.20 (1.45) | 2.60 (1.89) | 2.00 (1.72) | 2.00 (1.71) | 1.20 (1.45) | 1.56 (1.56) | 0.20 (1.08) | 0.60 (1.24) | 2.60 (1.89) | 1.60 (1.60) | 1.60 (1.60) | 1.20 (1.45) | 1.30 (1.48) | 1.23 (1.45) |
| | Mean | 0.80 (3.11) | 2.33 (3.29) | 3.33 (3.02) | 2.20 (2.71) | 1.73 (3.05) | 1.06 (2.64) | 1.91 (1.64) | 1.26 (2.64) | 3.20 (3.49) | 4.46 (3.49) | 3.06 (3.20) | 2.26 (3.17) | 1.80 (3.29) | 2.67 (1.86) | 0.66 (2.81) | 2.20 (3.05) | 3.80 (3.10) | 2.46 (2.73) | 2.20 (3.28) | 1.73 (3.09) | 2.17 (1.73) | 1.91 (1.74) |

**Each value represents mean of 5 observations**

***Figures in parentheses are square root transformed values**

| Factor | Sem (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.06 |
| Week | 0.02 | 0.06 |
| Time | 0.03 | 0.09 |
| Insect X Week | 0.04 | N.S. |
| Insect visitors X Time | 0.05 | 0.15 |
| Week X Time | 0.05 | N.S. |
| Insect visitors x Week Time | 0.09 | N.S. |

**Table 21 : Abundance of insect visitors/pollinators on Sarpagandha flowers during 2015**

| S. No. | Insect visitors | Number of insect visitors/$m^2$branch of a tree/5minutes | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 23/4/15 | | | | | | Overall mean | 30/4/15 | | | | | | Overall mean | 7/5/15 | | | | | | Overall mean | Pooled mean |
| | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | 0600h-0800h | 0800h-1000h | 1000h-1200h | 1200h-1400h | 1400h-1600h | 1600h-1800h | | |
| 1 | *Papilio demoleus* | 2.00 (1.72) | 3.60 (2.13) | 3.80 (2.18) | 3.00 (1.98) | 2.80 (1.94) | 2.20 (1.77) | 2.90 (1.95) | 2.00 (1.72) | 4.40 (2.31) | 5.00 (2.44) | 3.80 (2.18) | 3.60 (2.14) | 2.20 (1.77) | 3.50 (2.09) | 2.00 (1.72) | 5.20 (2.48) | 5.80 (2.60) | 4.60 (2.36) | 4.40 (2.32) | 2.20 (1.77) | 4.03 (2.21) | 3.47 (2.08) |
| 2 | *Amegilla zonata* | 0.40 (1.16) | 1.60 (1.60) | 3.40 (2.09) | 1.60 (1.60) | 1.40 (1.54) | 0.60 (1.24) | 1.50 (1.54) | 0.40 (1.16) | 1.80 (1.65) | 4.20 (2.27) | 2.00 (1.72) | 1.80 (1.66) | 1.20 (1.47) | 1.90 (1.66) | 0.40 (1.16) | 1.40 (1.54) | 4.20 (2.27) | 2.60 (1.88) | 2.40 (1.83) | 2.00 (1.72) | 2.16 (1.73) | 1.85 (1.64) |
| 3 | *Pieris* sp. | 0.00 (1.00) | 0.40 (1.16) | 2.00 (1.72) | 1.00 (1.39) | 1.40 (1.54) | 1.20 (1.47) | 1.00 (1.38) | 0.00 (1.00) | 1.00 (1.39) | 2.60 (1.89) | 1.60 (1.60) | 2.60 (1.89) | 1.60 (1.60) | 1.56 (1.56) | 0.00 (1.00) | 1.20 (1.47) | 3.00 (1.99) | 2.60 (1.88) | 3.00 (1.99) | 2.40 (1.83) | 2.03 (1.69) | 1.53 (1.54) |
| | Mean | 0.80 (1.29) | 1.86 (1.63) | 3.06 (2.00) | 1.86 (1.66) | 1.86 (1.67) | 1.33 (1.50) | *1.80 (1.62)* | 0.80 (1.29) | 2.40 (1.79) | 3.93 (2.20) | 2.46 (1.83) | 2.66 (1.90) | 1.66 (1.61) | *2.32 (1.77)* | 0.80 (1.29) | 2.60 (1.83) | 4.33 (2.29) | 3.26 (2.04) | 3.26 (2.05) | 2.20 (1.77) | *2.74 (1.88)* | *2.28 (1.75)* |

**Each value represents mean of 5 observations**
**[t]Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Insect visitors | 0.02 | 0.05 |
| Week | 0.02 | 0.05 |
| Time | 0.02 | 0.07 |
| Insect X Week | 0.03 | N.S. |
| Insect visitors X Time | 0.04 | 0.13 |
| Week X Time | 0.04 | 0.13 |
| Insect visitors x Week Time | 0.08 | N.S. |

### 4.2. Foraging behaviour and pollination efficiency of major insect pollinators

#### 4.2.1. Foraging rate of *Apis florea* on Aonla during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *A. florea* on aonla during 2014 at different times of the day was studied at weekly interval throughout the flowering period. The mean number of flowers visited by an individual bee forager have been recorded (Table 22). Irrespective of different times of the day and weeks, the foraging rate ranged between 0.00 to 28.10 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 12.70 to 14.61 flowers/min corresponding to 2$^{nd}$and 3$^{rd}$ week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 3$^{rd}$ week (14.61 flowers/min) followed by 1$^{st}$ week (14.23 flowers/min) and 2$^{nd}$ week (12.70 flowers/min). Irrespective of weeks, mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum foraging rate (25.50 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000 h (22.63 flowers/min), 1200h-1400h (15.83 flowers/min), 1400h-1600h (10.13 flowers/min), 0600h-0800h (4.63 flowers/min) and 1600h-1800h (4.36 flowers/min).

During 2015, the foraging rate of *A. florea* followed the similar trend that wererecorded in the year 2014. Irrespective of different times of the day and weeks, the forging rate ranged between 0.00 to 24.60 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *A. florea* varied between 12.05 and 16.25 flowers/min corresponding to 2$^{nd}$ and 3$^{rd}$ week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *A. florea* was observed during 3$^{rd}$ week (16.25 flowers/min), followed by 1$^{st}$ week (13.35 flowers/min) and 2$^{nd}$ week (12.05 flowers/min).

Irrespective of weeks,mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum (22.93 flowers/min) between 1000h-1200h, followed by 0800h-1000h (20.63 flowers/min), 1200h-1400h (14.70 flowers/min), 1400h-1600h (10.80 flowers/min), 0600-0800h (8.16 flowers/min) and 1600h-1800h (6.06 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. florea* observed during 3$^{rd}$ week (15.43 flowers/min), followed by 1$^{st}$ week (13.79 flowers/min) and 2$^{nd}$ week (12.37 flowers/min). Time wise, the foraging rate was significantly the maximum (24.21 flowers/min) at 1000h-1200h followed by 0800h-1000h (21.63 flowers/min), 1200h-1400h (15.26 flowers/min), 1400h-1600h (10.46 flowers/min) and 0600h-0800h (6.40 flowers/min) and 1600h-1800h (5.21 flowers/min). During 2014, no activity of *A. florea* was recorded at 0600-0800h of 1$^{st}$ and 3$^{rd}$ week and 1600-1800h of 1$^{st}$ week of flowering.

**4.2.2. Foraging speed of *Apis florea* on Aonla during 2014 and 2015**

The data on foraging speed, i.e., time spent by *A. florea* on aonla flowers during 2014 have been narrated in Table 23. Foraging speed of *A. florea* on aonla recorded during different weeks over the times revealed that the foraging speed ranged between 0.00 to 3.17 seconds/flower. The mean weekly foraging speed ranged between 1.40 to 2.84 seconds/flower corresponding to 1st and 2nd week of the crop flowering, respectively (Table 23). It was found that maximum mean foraging speedwas recorded during 2nd week (2.84 seconds/flower) followed by 3rd week (1.65 seconds/flower). Foraging speed of *A. florea* was recorded minimum during 1st week (1.40 seconds/flower).

As far as time of the day were concerned, significantly maximum foraging speed (3.04 seconds/flower) was recorded at 1000h-1200h followed at 1200h-1400h (2.62 seconds/flower), 1400h-1600h (2.38 seconds/flower), 1600h-1800h (1.50 seconds/flower) and 0800h-1000h (1.39 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (0.86 seconds/flower). During 2015, the foraging speed of *A. florea* followed the similar trend that recorded in 2014. The foraging speed during this year ranged between 0.00 to 3.88 seconds/flower. Mean weekly foraging speed of *A. florea* varied between 1.71 and 2.76 seconds/flower corresponding to 1st and 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *A. florea* was observed during 2nd week (2.76 seconds/ flower) and minimum foraging speed was observed at 1st week (1.71 seconds/flower). The foraging speed of *A. florea* recorded during different times of a day revealed it to be significantly maximum (3.31 seconds/ flower) between 1200h-1400h, followed by 1000h-1200h (2.85 seconds/flower), 1400h-1600h (2.65seconds/flower), 1600h-1800h (2.55 seconds/flower), 1000-1200h (1.53 seconds/flower). Lowest foraging speed was recorded at 0600h-0800h (1.16 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *A. florea* observed during 2ndweek (2.80seconds/flower), followed by 3rdweek (2.11 seconds/flower). Minimum foraging speed was observed during 1st week (1.55 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.96 seconds/flower) at 1200h-1400h followed by 1000h-1200h (2.95 seconds/flower), 1400h-1600h (2.52 seconds/flower), 1600h-1800h (2.03seconds/flower) and 0800h-1000h (1.46 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (1.01 seconds/flower).

**Table 22: Foraging rate of *Apis florea* on Aonla during March 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | WK1 25/3/14 | WK2 1/4/14 | WK3 8/4/14 | Mean | WK1 27/3/15 | WK2 3/4/15 | WK3 11/4/15 | Mean | Pooled mean |
| 0600-0800 | 0.00 (1.00) | 13.90 (3.85) | 0.00 (1.00) | 4.63 (1.95) | 0.00 (1.00) | 11.80 (3.57) | 12.70 (3.69) | 8.16 (2.84) | 6.40 (2.35) |
| 0800-1000 | 26.50 (5.23) | 14.10 (3.88) | 27.30 (5.31) | 22.63 (4.81) | 22.90 (4.88) | 14.40 (3.92) | 24.60 (5.05) | 20.63 (4.62) | 21.63 (4.71) |
| 1000-1200 | 28.10 (5.38) | 20.40 (4.62) | 28.00 (5.37) | 25.50 (5.12) | 24.20 (5.01) | 20.60 (4.64) | 24.00 (4.99) | 22.93 (4.88) | 24.21 (5.00) |
| 1200-1400 | 18.80 (4.44) | 9.80 (3.28) | 18.90 (4.45) | 15.83 (4.05) | 16.10 (4.12) | 9.00 (3.16) | 19.00 (4.46) | 14.70 (3.91) | 15.26 (3.98) |
| 1400-1600 | 12.00 (3.60) | 9.40 (3.22) | 9.00 (3.16) | 10.13 (3.32) | 11.90 (3.59) | 8.70 (3.11) | 11.80 (3.57) | 10.80 (3.42) | 10.46 (3.37) |
| 1600-1800 | 0.00 (1.00) | 8.60 (3.09) | 4.50 (2.34) | 4.36 (2.14) | 5.00 (1.00) | 7.80 (2.96) | 5.40 (2.52) | 6.06 (2.64) | 5.21 (2.39) |
| Mean | 14.23 (3.44) | 12.70 (3.66) | 14.61 (3.60) | 13.85 (3.57) | 13.35 (3.51) | 12.05 (3.56) | 16.25 (4.05) | 13.88 (3.70) | 13.61 (3.60) |
| Pooled mean | 13.79 (3.47) | 12.37 (3.61) | 15.43 (3.83) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SE(m) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | 0.06 |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.15 |

**Table 23: Foraging speed of *Apis florea* on Aonla during March 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | WK1 25/3/14 | WK2 1/4/14 | WK3 8/4/14 | Mean | WK1 27/3/15 | WK2 3/4/15 | WK3 11/4/15 | Mean | Pooled mean |
| 0600-0800 | 0.00 (1.00) | 2.59 (1.89) | 0.00 (1.00) | 0.86 (1.29) | 0.00 (1.00) | 2.16 (1.77) | 1.32 (1.52) | 1.16 (1.43) | 1.01 (1.36) |
| 0800-1000 | 1.53 (1.58) | 1.37 (1.54) | 1.26 (1.50) | 1.39 (1.54) | 1.79 (1.66) | 1.43 (1.56) | 1.38 (1.54) | 1.53 (1.59) | 1.46 (1.56) |
| 1000-1200 | 2.78 (1.93) | 4.58 (2.36) | 1.75 (1.65) | 3.04 (1.98) | 1.96 (1.71) | 3.83 (2.19) | 2.76 (1.93) | 2.85 (1.95) | 2.95 (1.96) |
| 1200-1400 | 2.61 (1.89) | 3.02 (2.00) | 2.22 (1.79) | 2.62 (1.89) | 3.21 (2.04) | 2.84 (1.95) | 3.88 (2.21) | 3.31 (2.07) | 2.96 (1.98) |
| 1400-1600 | 1.50 (1.58) | 3.17 (2.04) | 2.47 (1.86) | 2.38 (1.82) | 1.27 (1.50) | 3.19 (2.04) | 3.50 (2.11) | 2.65 (1.89) | 2.52 (1.85) |
| 1600-1800 | 0.00 (1.00) | 2.32 (1.81) | 2.20 (1.78) | 1.50 (1.53) | 2.01 (1.73) | 3.09 (2.02) | 2.56 (1.88) | 2.55 (1.88) | 2.03 (1.70) |
| Mean | 1.40 (1.50) | 2.84 (1.94) | 1.65 (1.60) | 1.96 (1.68) | 1.71 (1.61) | 2.76 (1.92) | 2.57 (1.86) | 2.34 (1.80) | 2.15 (1.74) |
| Pooled mean | 1.55 (1.55) | 2.80 (1.93) | 2.11 (1.73) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SE(m) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | 0.03 |
| Year X Time | 0.01 | 0.05 |
| Week x Time | 0.02 | 0.06 |
| Year x Week x Time | 0.03 | 0.08 |

### 4.2.3. Foraging rate of *Episyrphus* sp.on Aonla during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Episyrphus* sp. on aonla during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 24). Irrespective of different times of the day and weeks, the foraging rate ranged between 5.20 to 20.60 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 11.35 to 15.76 flowers/min corresponding to 3$^{rd}$ and2$^{nd}$week of the crop flowering, respectively. Maximum foraging rate was recorded during 2$^{nd}$ week (15.76 flowers/min) followed by 1$^{st}$ week (15.15 flowers/min) and 3rd week (11.35 flowers/min). Irrespective of weeks, mean foraging rate of *Episyrphus* sp. recorded during different times of a day revealed to be significantly maximum foraging rate ( 18.06 flowers/min) was recorded between 1200h-1400h followed by 0800h-1000 h (17.50 flowers/min), 0600h-0800h (13.83

flowers/min), 1000h-1200h (13.43 flowers/min), 1400h-1600h (12.26 flowers/min) and 1600h-1800h (9.43 flowers/min).

During 2015, the foraging rate of *Episyrphus* sp. followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the foraging rate ranged between 8.30 to 20.60 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *Episyrphus* sp. varied between 14.50 and 15.96 flowers/min corresponding to 3rd and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *Episyrphus* sp. was observed during 2ndweek (15.96 flowers/min), followed by 1st week (15.15 flowers/min) and 3rdweek (14.50 flowers/min). Irrespective of weeks,mean foraging rate of *Episyrphus* sp. recorded during different times of a day revealed it to be significantly the maximum (19.33 flowers/min) between 0800h-1000h, followed by 1200h-1400h (18.36 flowers/min), 0600h-0800h (17.96 flowers/min), 1400h-1600h (13.43 flowers/min), 1000-1200h (12.93 flowers/min) and 1600h-1800h (9.20 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *Episyrphus* sp. observed during 2nd week (15.86 flowers/min), followed by 1st week (15.15 flowers/min) and 3rd week (12.92 flowers/min). Time wise, the foraging rate was significantly the maximum (18.41 flowers/min) at 0800h-1000h followed by 1200h-1400h (18.21 flowers/min), 0600h-0800h (15.90 flowers/min), 1000h-1200h (13.18 flowers/min) and 1400h-1600h (12.85 flowers/min) and 1600h-1800h (9.31 flowers/min).

**4.2.4. Foraging speed of *Episyrphus* sp.on Aonla during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Episyrphus* sp. on aonla flowers during 2014 have been narrated in Table 25. Foraging speed of *Episyrphus* sp. on aonla recorded during different weeks over the times revealed that the foraging speed ranged between 1.58 to 4.44 seconds/flower. The mean weekly foraging speed ranged between 3.05 to 3.43 seconds/flower corresponding to 3rd and 2nd week of the crop flowering, respectively (Table 25). It was found that maximum mean foraging speed recorded during 2nd week (3.43 seconds/flower) followed by 1st week (3.16 seconds/flower). Foraging speed of *Episyrphus* sp.was recorded minimum during 3rd week (3.05 seconds/flower).

As far as time of the day were concerned, significantly the maximum mean foraging speed ( 3.55 seconds/flower) was recorded at 1600h-1800h followed at 0600h-0800h (3.53 seconds/flower), 1200h-1400h (3.31 seconds/flower), 0800h-1000h (3.08 seconds/flower) and 1400h-1600h (2.94 seconds/flower). Minimum foraging speed was recorded at 1000h-1200h (2.88 seconds/flower).

During 2015, the foraging speed of *Episyrphus* sp. ranged between 1.58 to 4.44 seconds/flower. Mean weekly foraging speed of *Episyrphus* sp. varied between 2.94 and 3.43 seconds/flower corresponding to 2nd and 3rd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *Episyrphus* sp.was observed

during 3rd week (3.43 seconds/ flower) followed by 1st week (3.26 seconds/flower) and minimum foraging speed was observed at 2nd week (2.94 seconds/flower).

The mean foraging speed of *Episyrphus* sp. recorded during different times of a day revealed it to be significantly the maximum (3.98 seconds/ flower) between 1000h-1200h, followed by 0600h-0800h (3.44 seconds/flower), 0800h-1000h (3.10 seconds/flower), 1600h-1800h (3.01 seconds/flower), 1200h-1400h (2.99 seconds/flower). Lowest forging speed was recorded at 1400h-1600h (2.74 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *Episyrphus* sp.observed during 3rd week (3.24 seconds/flower), followed by 1st week (3.21 seconds/flower). Minimum foraging speed was observed during 2nd week (3.19 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.48 seconds/flower) at 0600h-0800h followed by 1000h-1200h (3.43 seconds/flower), 1600h-1800h (3.28 seconds/flower), 1200h-1400h (3.15 seconds/flower) and 0800h-1000h (3.09 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (2.84 seconds/flower).

**Table 24: Foraging rate of *Episyrphus* sp.on Aonla during March 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/3/14 | 1/4/14 | 8/4/14 | Mean | 27/3/15 | 3/4/15 | 11/4/15 | Mean | Pooled mean |
| 0600-0800 | 19.10 (4.48) | 17.20 (4.26) | 5.20 (2.48) | 13.83 (3.74) | 18.00 (4.35) | 18.80 (4.44) | 17.10 (4.25) | 17.96 (4.35) | 15.90 (4.04) |
| 0800-1000 | 17.90 (4.33) | 19.20 (4.49) | 15.40 (4.04) | 17.50 (4.29) | 18.40 (4.40) | 20.60 (4.64) | 19.00 (4.47) | 19.33 (4.50) | 18.41 (4.39) |
| 1000-1200 | 12.70 (3.69) | 15.90 (4.10) | 11.70 (3.55) | 13.43 (3.78) | 12.50 (3.66) | 14.60 (3.94) | 11.70 (3.55) | 12.93 (3.72) | 13.18 (3.75) |
| 1200-1400 | 20.60 (4.64) | 18.40 (4.40) | 15.20 (4.02) | 18.06 (4.35) | 19.90 (4.56) | 18.30 (4.39) | 16.90 (4.22) | 18.36 (4.39) | 18.21 (4.37) |
| 1400-1600 | 12.20 (3.62) | 12.90 (3.72) | 11.70 (3.56) | 12.26 (3.63) | 13.80 (3.84) | 13.50 (3.80) | 13.00 (3.74) | 13.43 (3.79) | 12.85 (3.71) |
| 1600-1800 | 8.40 (3.06) | 11.00 (3.46) | 8.90 (3.14) | 9.43 (3.22) | 8.30 (3.03) | 10.00 (3.31) | 9.30 (3.20) | 9.20 (3.18) | 9.31 (3.20) |
| Mean | 15.15 (3.97) | 15.76 (4.07) | 11.35 (3.47) | 14.08 (3.84) | 15.15 (3.97) | 15.96 (4.09) | 14.50 (3.99) | 15.20 (3.99) | 14.64 (3.91) |
| Pooled mean | 15.15 (3.97) | 15.86 (4.08) | 12.92 (3.68) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | 0.06 |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.15 |

**Table 25: Foraging speed of *Episyrphus* sp. in Aonla during March 2014 and 2015**

| Time (hr) | Time spent /flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/3/14 | 1/4/14 | 8/4/14 | Mean | 27/3/15 | 3/4/15 | 11/4/15 | Mean | Pooled mean |
| 0600-0800 | 3.04 (2.00) | 4.05 (2.24) | 3.49 (2.11) | 3.53 (2.12) | 3.24 (2.05) | 3.42 (2.10) | 3.66 (2.15) | 3.44 (2.10) | 3.48 (2.11) |
| 0800-1000 | 2.99 (1.99) | 3.01 (2.00) | 3.24 (2.05) | 3.08 (2.01) | 3.51 (2.12) | 2.85 (1.96) | 2.95 (1.98) | 3.10 (2.02) | 3.09 (2.02) |
| 1000-1200 | 4.44 (2.32) | 2.62 (1.90) | 1.58 (1.60) | 2.88 (1.94) | 4.58 (2.35) | 2.86 (1.96) | 4.50 (2.34) | 3.98 (2.22) | 3.43 (2.08) |
| 1200-1400 | 3.07 (2.01) | 4.42 (2.32) | 2.44 (1.85) | 3.31 (2.06) | 3.32 (2.07) | 3.30 (2.07) | 2.35 (1.82) | 2.99 (1.99) | 3.15 (2.02) |
| 1400-1600 | 1.88 (1.69) | 2.93 (1.98) | 4.01 (2.23) | 2.94 (1.96) | 2.19 (1.78) | 2.19 (1.78) | 3.84 (2.19) | 2.74 (1.92) | 2.84 (1.94) |
| 1600-1800 | 3.55 (2.12) | 3.56 (2.13) | 3.53 (2.12) | 3.55 (2.12) | 2.72 (1.92) | 3.01 (2.00) | 3.30 (2.07) | 3.01 (2.00) | 3.28 (2.06) |
| Mean | 3.16 (2.02) | 3.43 (2.09) | 3.05 (2.00) | 3.21 (2.04) | 3.26 (2.05) | 2.94 (1.98) | 3.43 (2.09) | 3.21 (2.04) | 3.21 (2.04) |
| Pooled mean | 3.21 (2.04) | 3.19 (2.03) | 3.24 (2.04) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | N.S. |
| Week | 0.01 | N.S. |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | 0.04 |
| Year X Time | 0.02 | 0.05 |
| Week x Time | 0.02 | 0.07 |
| Year x Week x Time | 0.03 | 0.10 |

### 4.2.5. Foraging rate of *Sphaerophoria* sp.on Aonla during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Sphaerophoria* sp. on aonla during 2014 at different times of the day was studied at weekly interval throughout the flowering period (Table 26). Irrespective of different times of the day and weeks, the foraging rate ranged between 7.80 to 12.50 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 9.40 to 11.00 flowers/min corresponding to 1$^{st}$and 3$^{rd}$week of the crop flowering, respectively.

It was found that maximum foraging rate was recorded during 3$^{rd}$ week (11.00 flowers/min) followed by 2$^{nd}$week (9.83 flowers/min) and 1$^{st}$week (9.40 flowers/min).

Irrespective of weeks, mean foraging rate of *Sphaerophoria*sp. recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 11.43 flowers/min) was recorded between 0800h-1000h followed by 1000h-1200 h and 1200-

1400h(10.60 flowers/min), 0600h-0800h and 1400h-1600h (9.40 flowers/min)and 1600h-1800h (9.03 flowers/min).

During 2015, the foraging rate of *Spherophoria*sp. followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the forging rate ranged between 8.00 to 13.00 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *Sphaerophoria* sp. varied between 9.15 and 11.13 flowers/min corresponding to 1st and 3rd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *Sphaerophoria* sp. was observed during 3rd week (11.13 flowers/min), followed by 2nd week (9.80 flowers/min) and 1st week (9.15 flowers/min).

Irrespective of weeks,mean foraging rate of *Sphaerophoria* sp. recorded during different times of a day revealed it to be significantly the maximum (11.96 flowers/min) between 0800h-1000h, followed by 1000h-1200h (11.30 flowers/min), 1200h-1400h (10.23 flowers/min), 0600h-0800h (9.23 flowers/min), 1400-1600h (8.73 flowers/min) and 1600h-1800h (8.70 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *Sphaerophoria* sp. observed during 3rd week (11.06 flowers/min), followed by 2nd week (9.81 flowers/min) and 1st week (9.27 flowers/min). Time wise, the foraging rate was significantly the maximum (11.70 flowers/min) at 0800h-1000h followed by 1000h-1200h (10.95 flowers/min), 1200h-1400h (10.41 flowers/min), 0600h-0800h (9.31 flowers/min) and 1400h-1600h (9.06 flowers/min) and 1600h-1800h (8.86 flowers/min).

**4.2.6. Foraging speed of *Sphaerophoria* sp. on Aonla during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Sphaerophoria* sp. on aonla flowers during 2014 have been narrated in Table 27. Foraging speed of *Sphaerophoria* sp. on aonla recorded during different weeks over the times revealed that the foraging speed ranged between 1.41 to 4.85 seconds/flower. The mean weekly foraging speed ranged between 3.02 to 3.40 seconds/flower during the crop flowering, respectively (Table 27). Maximum foraging speed recorded during 1st week (3.40 seconds/flower) followed by 2nd and 3rd week (3.02 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (4.25 seconds/flower) was recorded at 0800h-1000h followed at 0600h-0800h (3.54 seconds/flower), 1000h-1200h (3.22 seconds/flower), 1600h-1800h (3.12 seconds/flower) and 1400h-1600h (2.98 seconds/flower). Minimum foraging speed was recorded at 1200h-1400h (1.76 seconds/flower).During 2015, the foraging speed of *Sphaerophoria* sp. ranged between 1.60 to 3.86 seconds/flower. Mean weekly foraging speed of *Sphaerophoria* sp. varied between 2.54 and 3.31 seconds/flower corresponding to 3rd and 1st week of crop blooming period, respectively.

Week wise, significantly maximum mean foraginig speed of *Sphaerophoria* sp.was observed during 1st week (3.31 seconds/ flower) followed by 2nd week (3.00 seconds/flower) and minimum foraging speed was observed at 3rd week (2.54 seconds/flower). The foraging speed of *Sphaerophoria* sp. recorded during different times of a day revealed it to be significantly the maximum (3.68 seconds/ flower) between 0800h-1000h, followed by 1000h-1200h (3.35 seconds/flower), 0600h-0800h (3.21 seconds/flower), 1600h-1800h (2.86 seconds/flower), 1400h-

1600h (2.62 seconds/flower). Lowest forging speed was recorded at 1200h-1400h (1.98 seconds/flower).The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *Sphaerophoria* sp.observed during 1st week (3.35 seconds/flower), followed by 2nd week (3.01 seconds/flower). Minimum foraging speed was observed during 3rd week (2.78 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.97 seconds/flower) at 0800h-1000h followed by 0600h-0800h (3.37 seconds/flower), 1000h-1200h (3.28 seconds/flower), 1600h-1800h (2.99 seconds/flower) and

1400h-1600h (2.80 seconds/flower). Minimum foraging speed was recorded at 1200h-1400h (1.87 seconds/flower).

**Table 26: Foraging rate of *Sphaerophoria* sp. in Aonla during March 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/3/14 | 1/4/14 | 8/4/14 | Mean | 27/3/15 | 3/4/15 | 11/4/15 | Mean | Pooled mean |
| 0600-0800 | 8.30 (3.03) | 8.40 (3.06) | 11.50 (3.53) | 9.40 (3.21) | 8.00 (2.98) | 8.30 (3.04) | 11.40 (3.51) | 9.23 (3.18) | 9.31 (3.19) |
| 0800-1000 | 11.50 (3.53) | 12.00 (3.60) | 10.80 (3.43) | 11.43 (3.52) | 11.60 (3.54) | 11.90 (3.59) | 12.40 (3.65) | 11.96 (3.59) | 11.70 (3.56) |
| 1000-1200 | 7.80 (2.96) | 11.50 (3.53 | 12.50 (3.67) | 10.60 (3.38) | 8.00 (2.99) | 12.90 (3.72) | 13.00 (3.74) | 11.30 (3.48) | 10.95 (3.43) |
| 1200-1400 | 10.90 (3.44) | 10.00 (3.31) | 10.90 (3.44) | 10.60 (3.40) | 9.80 (3.28) | 9.40 (3.22) | 11.50 (3.53) | 10.23 (3.34) | 10.41 (3.37) |
| 1400-1600 | 8.90 (3.14) | 9.30 (3.20) | 10.00 (3.31) | 9.40 (3.22) | 9.40 (3.22) | 8.30 (3.04) | 8.50 (3.08) | 8.73 (3.11) | 9.06 (3.16) |
| 1600-1800 | 9.00 (3.16) | 7.80 (2.96) | 10.30 (3.35) | 9.03 (3.16) | 8.10 (3.04) | 8.00 (2.99) | 10.00 (3.31) | 8.70 (3.10) | 8.86 (3.13) |
| Mean | 9.40 (3.21) | 9.83 (3.28) | 11.00 (3.45) | 10.07 (3.31) | 9.15 (3.17) | 9.80 (3.27) | 11.13 (3.47) | 10.02 (3.30) | 10.04 (3.30) |
| Pooled mean | 9.27 (3.19) | 9.81 (3.27) | 11.06 (3.46) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | N.S. |
| Week | 0.01 | 0.03 |
| Time | 0.02 | 0.05 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.02 | 0.07 |
| Week x Time | 0.03 | 0.09 |
| Year x Week x Time | 0.04 | 0.13 |

**Table 27: Foraging speed of *Sphaerophoria* sp. in Aonla during March 2014 and 2015**

| Time (hr) | Time spent /flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/3/14 | 1/4/14 | 8/4/14 | Mean | 27/3/15 | 3/4/15 | 11/4/15 | Mean | Pooled mean |
| 0600-0800 | 4.63 (2.37) | 2.19 (1.78) | 3.80 (2.18) | 3.54 (2.11) | 3.64 (2.15) | 2.76 (1.93) | 3.21 (2.05) | 3.21 (2.04) | 3.37 (2.08) |
| 0800-1000 | 4.46 (2.33) | 3.45 (2.10) | 4.85 (2.41) | 4.25 (2.28) | 3.80 (2.19) | 3.38 (2.09) | 3.86 (2.20) | 3.68 (2.16) | 3.97 (2.22) |
| 1000-1200 | 3.88 (2.20) | 4.18 (2.27) | 1.59 (1.60) | 3.22 (2.02) | 3.84 (2.19) | 4.62 (2.37) | 1.60 (1.61) | 3.35 (2.06) | 3.28 (2.04) |
| 1200-1400 | 1.41 (1.55) | 1.61 (1.61) | 2.25 (1.79) | 1.76 (1.65) | 2.14 (1.77) | 1.90 (1.70) | 1.90 (1.70) | 1.98 (1.72) | 1.87 (1.69) |
| 1400-1600 | 2.87 (1.96) | 3.71 (2.16) | 2.37 (1.83) | 2.98 (1.99) | 3.24 (2.05) | 2.38 (1.83) | 2.25 (1.80) | 2.62 (1.90) | 2.80 (1.94) |
| 1600-1800 | 3.14 (2.03) | 2.95 (1.98) | 3.28 (2.06) | 3.12 (2.02) | 3.21 (2.05) | 2.93 (1.97) | 2.43 (1.84) | 2.86 (1.96) | 2.99 (1.99) |
| Mean | 3.40 (2.07) | 3.02 (1.99) | 3.02 (1.98) | 3.14 (2.01) | 3.31 2.07) | 3.00 (1.98) | 2.54 (1.87) | 2.95 (1.97) | 3.04 (1.99) |
| Pooled mean | 3.35 (2.07) | 3.01 (1.98) | 2.78 (1.92) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SE(m) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | 0.03 |
| Year X Time | 0.01 | 0.05 |
| Week x Time | 0.02 | 0.06 |
| Year x Week x Time | 0.03 | 0.08 |

### 4.2.7. Foraging rate of *Eristalinus obliquus* on Baheda during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Eristalinus obliquus* on Baheda during 2014 at different times of the day was studied at weekly interval throughout the flowering period. The mean number of flowers visited by an individual forager have been recorded (Table 28). Irrespective of different times of the day and weeks, the foraging rate ranged between 2.00 to 12.60 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 5.36 to 7.70 flowers/min corresponding to 3$^{rd}$and 1$^{st}$week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 1$^{st}$ week (7.70 flowers/min) followed by 2$^{nd}$ week (7.16 flowers/min) and 3$^{rd}$ week (5.36 flowers/min).

Irrespective of weeks, mean foraging rate of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 9.83 flowers/min) was recorded between 1000h-1200h followed by 1200h-1400 h (8.26 flowers/min), 1400h-

1600h (7.06 flowers/min), 0800h-1000h (6.50 flowers/min), 0600h-0800h (5.73) and 1600h-1800h (3.06 flowers/min).

During 2015, the foraging rate of *E. obliquus* followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the forging rate ranged between 3.30 to 11.10 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *E. obliquus* varied between 5.26 and 6.75 flowers/min corresponding to 3rdand 1stweek of crop blooming period, respectively.Significantly the maximum mean foraginig rate of *E. obliquus* was observed during 1stweek (6.75 flowers/min), followed by 2nd week (6.50 flowers/min) and 3rdweek (5.26 flowers/min).

Irrespective of weeks, mean foraging rate of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 9.40 flowers/min) was recorded between 1000h-1200h followed by 1200h-1400 h and 0800-1000h (6.80 flowers/min), 1400h-1600h (6.06 flowers/min), 0600h-0800h (4.36) and 1600h-1800h (3.60 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *E. obliquus* observed during 1stweek (7.22 flowers/min), followed by 2nd week (6.83 flowers/min) and 3rdweek (5.31flowers/min). Time wise, the foraging rate was significantly the maximum (9.61 flowers/min) at 1000h-1200h followed by 1200h-1400h (7.53flowers/min), 0800h-1000h (6.65 flowers/min), 1400h-1600h (6.56 flowers/min), 0600h-0800h (5.05 flowers/min) and 1600h-1800h (3.33 flowers/min).

**4.2.8. Foraging speed of *Eristalinus obliquus* on Baheda during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Eristalinus obliquus* on Baheda flowers during 2014 have been narrated in Table 29. Foraging speed of *E. obliquus* on Baheda recorded during different weeks over the times revealed that the foraging speed ranged between 4.48 to 14.54 seconds/flower. The mean weekly foraging speed ranged between 8.96 to 10.84 seconds/flower during the crop flowering, respectively (Table 29). It was found that maximum foraging speed recorded during 3rdweek (10.84 seconds/flower) followed by 2ndweek (9.23) and 1stweek (8.96 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (12.76 seconds/flower) was recorded at 1200h-1400h followed at 1600h-1800h (12.07 seconds/flower), 0600h-0800h (11.87 seconds/flower), 1400h-1600h (7.30 seconds/flower) and 0800h-1000h (7.21 seconds/flower). Minimum foraging speed was recorded at 1000h-1200h (6.86 seconds/flower).

During 2015, the foraging speed of *E. obliquus* ranged between 4.05 to 13.74 seconds/flower. Mean weekly foraging speed of *E. obliquus* varied between 8.53 and 10.55 seconds/flower corresponding to 1stand 3rdweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *E. obliquus* was observed during

3rdweek (10.55 seconds/ flower) followed by 2nd week (8.91 seconds/flower) and minimum foraging speed was observed at 1st week (8.53 seconds/flower). The foraging speed of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum (12.21 seconds/ flower) between 1200h-1400h, followed by 1600h-1800h (11.94 seconds/flower), 0600h-0800h (11.41 seconds/flower), 1400h-1600h (7.13 seconds/flower), 0800h-1000h (6.72 seconds/flower). Lowest foraging speed was recorded at 1000h-1200h (6.59 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *E. obliquus* observed during 3rd week (10.70 seconds/flower), followed by 2ndweek (9.07 seconds/flower). Minimum foraging speed was observed during 1stweek (8.75 seconds/flower). Time wise, the foraging speed was significantly the maximum (12.48 seconds/flower) at 1200h-1400h followed by 1600h-1800h (12.00 seconds/flower), 0600h-0800h (11.64 seconds/flower), 1400h-1600h (7.22 seconds/flower) and 0800h-1000h (6.96 seconds/flower). Minimum foraging speed was recorded at 1000h-1200h (6.72 seconds/flower).

**Table 28: Foraging rate of *Eristalinus obliquus* in Baheda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/4/14 | 2/5/14 | 9/5/14 | Mean | 20/4/15 | 28/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 7.30 (2.87) | 5.10 (2.45) | 4.80 (2.40) | 5.73 (2.57) | 5.20 (2.48) | 4.10 (2.25) | 3.80 (2.18) | 4.36 (2.30) | 5.05 (2.44) |
| 0800-1000 | 7.70 (2.94) | 6.70 (2.76) | 5.10 (2.46) | 6.50 (2.72) | 7.10 (2.84) | 7.90 (2.98) | 5.40 (2.52) | 6.80 (2.78) | 6.65 (2.75) |
| 1000-1200 | 12.60 (3.68) | 9.60 (3.25) | 7.30 (2.87) | 9.83 (3.26) | 9.90 (3.29) | 11.10 (3.47) | 7.20 (2.86) | 9.40 (3.21) | 9.61 (3.24) |
| 1200-1400 | 8.90 (3.13) | 10.80 (3.43) | 5.10 (2.46) | 8.26 (3.01) | 7.90 (2.98) | 6.70 (2.77) | 5.80 (2.60) | 6.80 (2.78) | 7.53 (2.89) |
| 1400-1600 | 7.70 (2.94) | 7.10 (2.84) | 6.40 (2.71) | 7.06 (2.83) | 6.80 (2.79) | 5.90 (2.62) | 5.50 (2.54) | 6.06 (2.65) | 6.56 (2.74) |
| 1600-1800 | 2.00 (1.71) | 3.70 (2.16) | 3.50 (2.11) | 3.06 (2.00) | 3.60 (2.14) | 3.30 (2.06) | 3.90 (2.20) | 3.60 (2.13) | 3.33 (2.07) |
| Mean | 7.70 (2.88) | 7.16 (2.82) | 5.36 (2.50) | 6.74 (2.73) | 6.75 (2.75) | 6.50 (2.69) | 5.26 (2.48) | 6.17 (2.64) | 6.45 (2.68) |
| Pooled mean | 7.22 (2.82) | 6.83 (2.75) | 5.31 (2.49) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.05 |
| Year x Week | 0.02 | 0.05 |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.14 |

**Table 29: Foraging speed of *Eristalinus obliquus* in Baheda during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/4/14 | 2/5/14 | 9/5/14 | Mean | 20/4/15 | 28/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 9.73 (3.27) | 12.67 (3.69) | 13.20 (3.76) | 11.87 (3.57) | 9.13 (3.18) | 12.34 (3.65) | 12.77 (3.70) | 11.41 (3.51) | 11.64 (3.54) |
| 0800-1000 | 4.92 (2.43) | 8.28 (3.04) | 8.43 (3.06) | 7.21 (2.84) | 4.66 (2.37) | 7.73 (2.95) | 7.76 (2.95) | 6.72 (2.76) | 6.96 (2.80) |
| 1000-1200 | 5.35 (2.52) | 4.48 (2.33) | 10.75 (3.42) | 6.86 (2.76) | 5.04 (2.45) | 4.05 (2.24) | 10.68 (3.41) | 6.59 (2.70) | 6.72 (2.73) |
| 1200-1400 | 14.54 (3.94) | 10.44 (3.37) | 13.29 (3.77) | 12.76 (3.69) | 13.74 (3.83) | 9.86 (3.29) | 13.03 (3.74) | 12.21 (3.62) | 12.48 (3.66) |
| 1400-1600 | 7.73 (2.95) | 8.26 (3.04) | 5.92 (2.62) | 7.30 (2.87) | 7.39 (2.89) | 8.17 (3.02) | 5.84 (2.61) | 7.13 (2.84) | 7.22 (2.86) |
| 1600-1800 | 11.50 (3.53) | 11.26 (3.49) | 13.44 (3.80) | 12.07 (3.61) | 11.24 (3.49) | 11.34 (3.51) | 13.24 (3.77) | 11.94 (3.59) | 12.00 (3.60) |
| Mean | 8.96 (3.10) | 9.23 (3.16) | 10.84 (3.41) | 9.68 (3.22) | 8.53 (3.04) | 8.91 (3.11) | 10.55 (3.36) | 9.33 (3.17) | 9.50 (3.19) |
| Pooled mean | 8.75 (3.07) | 9.07 (3.14) | 10.70 (3.39) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.02 | N.S. |
| Week x Time | 0.02 | 0.07 |
| Year x Week x Time | 0.03 | N.S. |

### 4.2.9. Foraging rate of *Chrysomya rufifacies* on Baheda during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Chrysomya rufifacies* on Baheda during 2014 at different times of the day was studied at weekly interval throughout the flowering period. The mean number of flowers visited by an individual forager have been recorded (Table 30). Irrespective of different times of the day and weeks, the foraging rate ranged between 3.30 to 8.50 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 5.01 to 5.61 flowers/min corresponding to 2$^{nd}$and 1$^{st}$week of the crop flowering, respectively. It was found that maximum mean foraging rate was recorded during 1$^{st}$ week (5.61 flowers/min) followed by 3$^{rd}$week (5.31 flowers/min) and 2$^{nd}$week (5.01 flowers/min).Irrespective of weeks, mean foraging rate of *C. rufifacies* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 8.00 flowers/min) was recorded between 0800h-1000h followed by 1000h-1200h

(5.73flowers/min), 1600h-1800h (5.36 flowers/min), 1400h-1600h (4.50 flowers/min), 1200h-1400h (4.43 flowers/min) and 0600h-0800h (3.86 flowers/min).

During 2015, the foraging rate of *C. rufifacies*followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the forging rate ranged between 2.50 to 7.90 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *C. rufifacies* varied between 4.46 and 5.30 flowers/min correspondingto 3rdand 1st week of crop blooming period, respectively.Significantly the maximum mean foraginig rate of *C. rufifacies* was observed during 3rdweek (5.30 flowers/min), followed by 1stweek (4.61 flowers/min) and 2ndweek (4.46 flowers/min).

Irrespective of weeks, mean foraging rate of *C. rufifacies* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 6.96 flowers/min) was recorded between 0800h-1000h followed by 1000h-1200h (5.33 flowers/min), 1600-1800h (4.60 flowers/min), 1200h-1400h (4.43 flowers/min), 1400h-1600h (3.96 flowers/min) and 0600h-0800h (3.46 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *C. rufifacies* observed during 3rdweek (5.30 flowers/min), followed by 1stweek (5.11 flowers/min) and 2ndweek (4.74 flowers/min). Time wise, the foraging rate was significantly the maximum (7.48 flowers/min) at 0800h-1000h followed by 1000h-1200h (5.53flowers/min), 1600h-1800h (4.98 flowers/min), 1200h-1400h (4.43 flowers/min), 1400h-1600h (4.23 flowers/min) and 0600h-0800h (3.66 flowers/min).

**4.2.10. Foraging speed of *Chrysomya rufifacies* on Baheda during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Chrysomya rufifacies* on Baheda flowers during 2014 have been narrated in Table 31. Foraging speed of *C. rufifacies*on Baheda recorded during different weeks over the times revealed that the foraging speed ranged between 4.14 to 12.22 seconds/flower. The mean weekly foraging speed ranged between 7.63 to 7.69 seconds/flower during the crop flowering, respectively (Table 31). It was found that maximum mean foraging speed recorded during 2ndweek (7.69 seconds/flower) followed by 3rd week (7.66 seconds/flower) and 1st week (7.63 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (11.88 seconds/flower) was recorded at 1400h-1600h followed at 1000h-1200h (11.01 seconds/flower), 0600h-0800h (7.85 seconds/flower), 1200h-1400h (5.46 seconds/flower) and 0800h-1000h (4.90 seconds/flower). Minimum foraging speed was recorded at 1600h-1800h (4.85 seconds/flower).

During 2015, the foraging speed of *C. rufifacies* ranged between 4.25 to 12.81 seconds/flower. Mean weekly foraging speed of *C. rufifacies* varied between 7.30 and 7.79 seconds/flower corresponding to 1st and 2ndweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *C. rufifacies*was observed

during 2nd week (7.79 seconds/ flower) followed by 3rd week (7.74 seconds/flower) and minimum foraging speed was observed at 1st week (7.30 seconds/flower).The foraging speed of *C. rufifacies* recorded during different times of a day revealed it to be significantly the maximum (11.76 seconds/ flower) between 1400h-1600h, followed by 1000h-1200h (10.93 seconds/flower), 0600h-0800h (7.71 seconds/flower) and 1200h-1400h (5.06 seconds/flower). Lowest foraging speed was recorded at 0800h-1000h and 1600h -1800h (4.83 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*C. rufifacies* observed during 2nd week (7.74 seconds/flower), followed by 3rd week (7.56 seconds/flower). Minimum foraging speed was observed during 1st week (7.47 seconds/flower). Time wise, the foraging speed was significantly the maximum (11.82 seconds/flower) at 1400h-1600h followed by 1000h-1200h (10.97 seconds/flower), 0600h-0800h (7.78 seconds/flower), 1200h-1400h (5.26 seconds/flower) and 0800h-1000h (4.86 seconds/flower). Minimum foraging speed was recorded at 1600h-1800h (4.84 seconds/flower).

**Table 30: Foraging rate of *Chrysomya rufifacies* Baheda during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/4/14 | 2/5/14 | 9/5/14 | Mean | 20/4/15 | 28/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 6.84 (2.79) | 10.38 (3.37) | 6.34 (2.70) | 7.85 (2.95) | 6.42 (2.73) | 11.26 (3.50) | 5.46 (2.53) | 7.71 (2.92) | 7.78 (2.93) |
| 0800-1000 | 5.03 (2.45) | 4.47 (2.33) | 5.21 (2.49) | 4.90 (2.42) | 5.36 (2.52) | 4.28 (2.29) | 4.82 (2.41) | 4.83 (2.41) | 4.86 (2.41) |
| 1000-1200 | 11.13 (3.48) | 10.43 (3.37) | 11.47 (3.53) | 11.01 (3.46) | 10.80 (3.43) | 10.26 (3.35) | 11.71 (3.56) | 10.93 (3.45) | 10.97 (3.45) |
| 1200-1400 | 5.24 (2.49) | 5.38 (2.52) | 5.75 (2.59) | 5.46 (2.53) | 4.25 (2.28) | 5.11 (2.47) | 5.81 (2.61) | 5.06 (2.45) | 5.26 (2.49) |
| 1400-1600 | 12.12 (3.62) | 11.32 (3.50) | 12.22 (3.63) | 11.88 (3.58) | 11.76 (3.57) | 11.33 (3.51) | 12.81 (3.63) | 11.76 (3.57) | 11.82 (3.58) |
| 1600-1800 | 5.44 (2.53) | 4.14 (2.26) | 4.98 (2.44) | 4.85 (2.41) | 5.22 (2.49) | 4.52 (2.34) | 4.76 (2.39) | 4.83 (2.41) | 4.84 (2.41) |
| Mean | 7.63 (2.89) | 7.69 (2.89) | 7.66 (2.90) | 7.66 (2.89) | 7.30 (2.83) | 7.79 (2.91) | 7.74 (2.86) | 7.52 (2.87) | 7.59 (2.88) |
| Pooled mean | 7.47 (2.86) | 7.74 (2.90) | 7.56 (2.88) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm(±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.03 |
| Time | 0.02 | 0.05 |
| Year x Week | 0.02 | 0.05 |
| Year X Time | 0.02 | 0.07 |
| Week x Time | 0.03 | 0.09 |
| Year x Week x Time | 0.04 | 0.13 |

**Table 31: Foraging speed of *Chrysomya rufifacies* Baheda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/4/14 | 2/5/14 | 9/5/14 | Mean | 20/4/15 | 28/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 3.90 (2.20) | 3.30 (2.07) | 4.40 (2.31) | 3.86 (2.19) | 3.00 (1.99) | 4.20 (2.27) | 3.20 (2.04) | 3.46 (2.10) | 3.66 (2.15) |
| 0800-1000 | 7.60 (2.92) | 8.50 (3.08) | 7.90 (2.98) | 8.00 (2.99) | 6.10 (2.66) | 6.90 (2.80) | 7.90 (2.98) | 6.96 (2.81) | 7.48 (2.90) |
| 1000-1200 | 5.40 (2.52) | 5.90 (2.62) | 5.90 (2.62) | 5.73 (2.59) | 4.40 (2.31) | 5.30 (2.50) | 6.30 (2.70) | 5.33 (2.50) | 5.53 (2.54) |
| 1200-1400 | 5.60 (2.56) | 3.60 (2.14) | 4.10 (2.24) | 4.43 (2.31) | 6.30 (2.69) | 2.50 (1.86) | 4.50 (2.33) | 4.43 (2.30) | 4.43 (2.30) |
| 1400-1600 | 5.40 (2.52) | 4.70 (2.38) | 3.40 (2.09) | 4.50 (2.33) | 3.30 (2.06) | 5.20 (2.48) | 3.40 (2.09) | 3.96 (2.21) | 4.23 (2.27) |
| 1600-1800 | 5.80 (2.60) | 4.10 (2.25) | 6.20 (2.68) | 5.36 (2.51) | 4.60 (2.36) | 2.70 (1.92) | 6.50 (2.73) | 4.60 (2.34) | 4.98 (2.42) |
| Mean | 5.61 (2.55) | 5.01 (2.42) | 5.31 (2.49) | 5.31 (2.49) | 4.61 (2.35) | 4.46 (2.31) | 5.30 (2.48) | 4.79 (2.38) | 5.05 (2.43) |
| Pooled mean | 5.11 (2.45) | 4.74 (2.36) | 5.30 (2.48) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.01 | N.S. |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.02 | N.S. |
| Week x Time | 0.02 | 0.07 |
| Year x Week x Time | 0.03 | 0.10 |

### 4. 2.11. Foraging rate of *Eristalinus obscuritarsus* on Baheda during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Eristalinus obscuritarsus* on Baheda during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 32). Irrespective of different times of the day and weeks, the foraging rate ranged between 4.00 to 14.40 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 5.18 to 6.85 flowers/min corresponding to 2$^{nd}$ and 3$^{rd}$week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 3$^{rd}$week (6.85 flowers/min) followed by 1$^{st}$week (5.98 flowers/min) and 2$^{nd}$ week (5.18 flowers/min).Irrespective of weeks, mean foraging rate of *E. obscuritarsus* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 9.63 flowers/min) was recorded between 0800h-1000h followed by 0600h-0800h (6.33

flowers/min), 1600h-1800h (5.70 flowers/min), 1000h-1200h (5.53 flowers/min), 1400h-1600h (4.50 flowers/min) and 1200h-1400h (4.33 flowers/min).

During 2015, the foraging rate of *E. obscuritarsus*followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the forging rate ranged between 3.50 to 13.80 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *E. obscuritarsus* varied between 4.81 and 6.58 flowers/min corresponding to 2nd and 3rdweek of crop blooming period, respectively.Significantly the maximum mean foraginig rate of *E. obscuritarsus* was observed during 3rd week (6.58 flowers/min), followed by 1st week (5.71 flowers/min) and 2nd week (4.81 flowers/min). Irrespective of weeks, mean foraging rate of *E. obscuritarsus* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.80 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (6.33 flowers/min), 0600-0800h (6.30 flowers/min), 1200h-1400h (4.53 flowers/min), 1600h-1800h (4.30 flowers/min) and 1400h-1600h (3.96 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *E. obscuritarsus* observed during 3rd week (6.71 flowers/min), followed by 1st week (5.85 flowers/min) and 3rdweek (5.00 flowers/min). Time wise, the foraging rate was significantly the maximum (7.98 flowers/min) at 0800h-1000h followed by 1000h-1200h (7.16 flowers/min), 0600h-0800h (6.31 flowers/min), 1600h-1800h (5.00 flowers/min), 1200h-1400h (4.43 flowers/min) and 1400h-1600h (4.23 flowers/min).

**4.2.12. Foraging speed of *Eristalinus obscuritarsus* on Baheda during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Eristalinus obscuritarsus* on Baheda flowers during 2014 have been narrated in Table 33. Foraging speed of *E. obscuritarsus*on Baheda recorded during different weeks over the times revealed that the foraging speed ranged between 2.95 to 12.59seconds/flower. The mean weekly foraging speed ranged between 3.39to 6.44 seconds/flower during the crop flowering, respectively (Table 33). It was found that maximum foraging speed recorded during 2ndweek (6.44 seconds/flower) followed by 3rdweek (6.24seconds/flower) and 1stweek (3.39 seconds/flower).As far as time of the day were concerned, significantly the maximum foraging speed (10.01 seconds/flower) was recorded at 0600h-0800h followed at 1000h-1200h (9.27 seconds/flower), 0800h-1000h (6.59seconds/flower), 1400h-1600h (3.93 seconds/flower) and 1200h-1400h (3.29 seconds/flower). Minimum foraging speed was recorded at 1600h-1800h (3.05 seconds/flower).

During 2015, the foraging speed of *E. obscuritarsus* ranged between 2.55 to 12.10 seconds/flower. Mean weekly foraging speed of *E. obscuritarsus* varied between 5.01 and 6.28 seconds/flower corresponding to 1stand 2ndweek of crop blooming period, respectively.

Week wise, significantly the maximum mean foraginig speed of *E. obscuritarsus*was observed during 2nd week (6.28 seconds/ flower) followed by 3rd week (6.10seconds/flower) and minimum foraging speed was observed at1st week (5.01 seconds/flower).

The foraging speed of *E. obscuritarsus* recorded during different times of a day revealed it to be significantly the maximum (9.81 seconds/ flower) between 0600h-0800h, followed by 1000h-1200h (8.80 seconds/flower), 0800h-1000h (6.33 seconds/flower) and 1400h-1600h (3.68 seconds/flower) and 1200h -1400h (3.09 seconds/flower). Lowest foraging speed was recorded at 1600h-1800h (3.06 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*E. obscuritarsus*observed during 2nd week (6.36 seconds/flower), followed by 3rd week (6.17 seconds/flower). Minimum foraging speed was observed during 1st week (5.20 seconds/flower). Time wise, the foraging speed was significantly the maximum (9.91 seconds/flower) at 0600h-0800h followed by 1000h-1200h (9.03seconds/flower), 0800h-1000h (6.46 seconds/flower), 1400h-1600h (3.80 seconds/flower) and 1200h-1400h (3.19 seconds/flower). Minimum foraging speed was recorded at 1600h-1800h (3.06 seconds/flower).

**Table 32: Foraging rate of *Eristalinus obscuritarsus* (de Meijre) in Baheda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | Wk1 | Wk2 | Wk3 | Mean | Wk1 | Wk2 | Wk3 | Mean | Pooled mean |
| 0600-0800 | 7.50 (2.91) | 4.70 (2.38) | 6.80 (2.79) | 6.33 (2.69) | 7.80 (2.96) | 5.40 (2.52) | 5.70 (2.58) | 6.30 (2.69) | 6.31 (2.69) |
| 0800-1000 | 7.70 (2.94) | 6.80 (2.79) | 14.40 (3.91) | 9.63 (3.21) | 7.20 (2.85) | 4.50 (2.34) | 7.30 (2.88) | 6.33 (2.69) | 7.98 (2.95) |
| 1000-1200 | 6.40 (2.71) | 5.00 (2.44) | 5.20 (2.48) | 5.53 (2.54) | 6.40 (2.71) | 6.20 (2.68) | 13.80 (3.84) | 8.80 (3.08) | 7.16 (2.81) |
| 1200-1400 | 4.00 (2.22) | 4.70 (2.38) | 4.30 (2.29) | 4.33 (2.30) | 4.20 (2.27) | 4.80 (2.40) | 4.60 (2.36) | 4.53 (2.34) | 4.43 (2.32) |
| 1400-1600 | 5.00 (2.44) | 4.00 (2.23) | 4.50 (2.34) | 4.50 (2.33) | 3.50 (2.11) | 4.40 (2.32) | 4.00 (2.23) | 3.96 (2.22) | 4.23 (2.28) |
| 1600-1800 | 5.30 (2.50) | 5.90 (2.62) | 5.90 (2.62) | 5.70 (2.58) | 5.20 (2.48) | 3.60 (2.14) | 4.10 (2.24) | 4.30 (2.29) | 5.00 (2.43) |
| Mean | 5.98 (2.62) | 5.18 (2.47) | 6.85 (2.74) | 6.00 (2.61) | 5.71 (2.56) | 4.81 (2.40) | 6.58 (2.69) | 5.70 (2.55) | 5.85 (2.58) |
| Pooled mean | 5.85 (2.59) | 5.00 (2.43) | 6.71 (2.71) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.02 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.02 | 0.08 |
| Week x Time | 0.03 | 0.09 |
| Year x Week x Time | 0.05 | 0.13 |

**Table 33: Foraging speed of *Eristalinus obscuritarsus* (de Meijre) in Baheda during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/4/14 | 2/5/14 | 9/5/14 | Mean | 20/4/15 | 28/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 5.84 (2.61) | 12.59 (3.68) | 11.60 (3.54) | 10.01 (3.28) | 5.68 (2.58) | 12.10 (3.61) | 11.66 (3.55) | 9.81 (3.25) | 9.91 (3.26) |
| 0800-1000 | 6.47 (2.73) | 7.26 (2.87) | 6.03 (2.65) | 6.59 (2.75) | 5.89 (2.62) | 7.32 (2.88) | 5.79 (2.60) | 6.33 (2.70) | 6.46 (2.72) |
| 1000-1200 | 9.84 (2.29) | 8.91 (3.14) | 9.05 (3.17) | 9.27 (3.20) | 9.11 (3.17) | 8.59 (3.09) | 8.70 (3.11) | 8.80 (3.13) | 9.03 (3.16) |
| 1200-1400 | 3.04 (2.00) | 2.98 (1.99) | 3.84 (2.18) | 3.29 (2.06) | 2.55 (1.88) | 2.91 (1.97) | 3.81 (2.17) | 3.09 (2.01) | 3.19 (2.03) |
| 1400-1600 | 4.11 (2.25) | 3.91 (2.21) | 3.77 (2.17) | 3.93 (2.21) | 3.92 (2.21) | 3.70 (2.16) | 3.41 (2.09) | 3.68 (2.16) | 3.80 (2.18) |
| 1600-1800 | 3.07 (2.01) | 2.95 (1.98) | 3.14 (2.03) | 3.05 (2.01) | 2.91 (1.97) | 3.04 (2.00) | 3.24 (2.05) | 3.06 (2.01) | 3.06 (2.01) |
| Mean | 3.39 (2.48) | 6.44 (2.65) | 6.24 (2.62) | 6.02 (2.58) | 5.01 (2.41) | 6.28 (2.62) | 6.10 (2.60) | 5.80 (2.54) | 5.91 (2.56) |
| Pooled mean | 5.20 (2.44) | 6.36 (2.63) | 6.17 (2.61) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.02 | N.S. |
| Week x Time | 0.02 | 0.07 |
| Year x Week x Time | 0.03 | N.S. |

### 4. 2.13. Foraging rate of *Apis florea* on Baheda during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Apis florea* on Baheda during 2014atdifferent times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 34). Irrespective of different times of the day and weeks, the foraging rate ranged between 0.00 to 13.50 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 4.35to 6.38 flowers/min corresponding to 2$^{nd}$ and 1$^{st}$week of the crop flowering, respectively. It was found that maximum mean foraging rate was recorded during 1$^{st}$ week (6.38 flowers/min) followed by 3$^{rd}$week (5.30 flowers/min) and 2$^{nd}$ week (4.35 flowers/min).Irrespective of weeks, mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum mean foraging rate (12.10 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (6.66 flowers/min), 1200h-1400h (4.26 flowers/min), 1400h-1600h (3.63 flowers/min), 1600h-1800h (3.43 flowers/min) and 0600h-0800h (1.96 flowers/min).

During 2015, the foraging rate of *A. florea*followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the foraging rate ranged between 3.00 to 13.10 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *A. florea* varied between 4.78 and 5.78 flowers/min corresponding to 3rdand 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *A. florea* was observed during 1stweek (5.78 flowers/min), followed by 3rdweek (5.56 flowers/min) and 2nd week (4.78 flowers/min). Irrespective of weeks, mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum foraging rate (11.40 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (6.36 flowers/min), 1200-1400h (4.10 flowers/min), 1600h-1800h (3.63 flowers/min), 0600h-0800h (3.46 flowers/min) and 1400h-1600h (3.30 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. florea* observed during 1stweek (6.08 flowers/min), followed by 3rd week (5.43 flowers/min) and 2ndweek (4.56 flowers/min). Time wise, the foraging rate was significantly the maximum (11.75 flowers/min) at 1000h-1200h followed by 0800h-1000h (6.51 flowers/min), 1200h-1400h (4.18 flowers/min), 1600h-1800h (3.53 flowers/min), 1400h-1600h (3.46 flowers/min) and 0600h-0800h (2.71 flowers/min).

**4.2.14. Foraging speed of *Apis florea*on Baheda during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Apis florea* on Baheda flowers during 2014 have been narrated in Table 35. Foraging speed of *A. florea*on Baheda recorded during different weeks over the times revealed that the foraging speed ranged between 0.00 to 6.80 seconds/flower. The mean weekly foraging speed ranged between 3.36 to 4.03 seconds/flower during the crop flowering, respectively (Table 35). It was found that maximum mean foraging speed recorded during 1stweek (4.03 seconds/flower) followed by 3rd week (3.63 seconds/flower) and 2nd week (3.36 seconds/flower). As far as time of the day were concerned, significantly the maximum mean foraging speed (6.09 seconds/flower) was recorded at 1000h-1200h followed at 1200h-1400h (4.32 seconds/flower), 1400h-1600h (3.78 seconds/flower), 0800h-1000h (3.60 seconds/flower) and 1600h-1800h (2.85 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (1.40 seconds/flower).

During 2015, the foraging speed of *A. florea* ranged between 2.12 to 6.83 seconds/flower. Mean weekly foraging speed of *A. florea* varied between 3.33 and 3.93 seconds/flower corresponding to 2nd and 3rd week of crop blooming period, respectively.Week wise, significantly the maximum mean foraginig speed of *A. florea*was observed during 3rd week (3.93 seconds/ flower) followed by 1st week (3.84 seconds/flower) and minimum foraging speed was observed at 2nd week (3.33 seconds/flower). The mean foraging speed of *A. florea* recorded during different times of a day revealed it to be significantly the maximum

(5.81 seconds/ flower) between 1000h-1200h, followed by 1200h-1400h (4.11 seconds/flower), 1400h-1600h (3.53 seconds/flower), 0800h-1000h (3.46 seconds/flower) and 1600h-1800h (3.08 seconds/flower). Lowest foraging speed was recorded at 0600h -0800h (2.22 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*A. florea* observed during 1st week (3.94 seconds/flower), followed by 3rd week (3.78 seconds/flower). Minimum foraging speed was observed during 2nd week (3.35 seconds/flower). Time wise, the foraging speed was significantly the maximum (5.95 seconds/flower) at 1000h-1200h followed by 1200h-1400h (4.21 seconds/flower), 1400h-1600h (3.66 seconds/flower), 0800h-1000h (3.53 seconds/flower) and 1600h-1800h (2.97 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (1.81 seconds/flower).

**Table 34: Foraging rate of *Apis florea* in Baheda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/4/14 | 2/5/14 | 9/5/14 | Mean | 20/4/15 | 28/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 5.90 (2.62) | 0.00 (1.00) | 0.00 (1.00) | 1.96 (1.54) | 3.40 (2.08) | 3.30 (2.06) | 3.70 (2.15) | 3.46 (2.10) | 2.71 (1.82) |
| 0800-1000 | 7.40 (2.89) | 5.30 (2.50) | 7.30 (2.87) | 6.66 (2.75) | 6.90 (2.80) | 5.70 (2.58) | 6.50 (2.73) | 6.36 (2.70) | 6.51 (2.73) |
| 1000-1200 | 13.40 (3.79) | 9.40 (3.22) | 13.50 (3.80) | 12.10 (3.60) | 13.10 (3.75) | 8.60 (3.09) | 12.50 (3.67) | 11.40 (3.50) | 11.75 (3.55) |
| 1200-1400 | 4.30 (2.29) | 4.40 (2.32) | 4.10 (2.25) | 4.26 (2.29) | 4.00 (2.22) | 4.10 (2.25) | 4.20 (2.27) | 4.10 (2.25) | 4.18 (2.27) |
| 1400-1600 | 3.40 (2.09) | 3.70 (2.16) | 3.80 (2.18) | 3.63 (2.14) | 3.00 (1.99) | 3.40 (2.09) | 3.50 (2.11) | 3.30 (2.06) | 3.46 (2.10) |
| 1600-1800 | 3.90 (2.20) | 3.30 (2.06) | 3.10 (2.01) | 3.43 (2.09) | 4.30 (2.29) | 3.60 (2.14) | 3.00 (1.99) | 3.63 (2.14) | 3.53 (2.12) |
| Mean | 6.38 (2.65) | 4.35 (2.21) | 5.30 (2.35) | 5.34 (2.40) | 5.78 (2.52) | 4.78 (2.37) | 5.56 (2.49) | 5.37 (2.46) | 5.35 (2.43) |
| Pooled mean | 6.08 (2.58) | 4.56 (2.29) | 5.43 (2.42) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.05 | 0.03 |
| Week | 0.06 | 0.04 |
| Time | 0.09 | 0.05 |
| Year x Week | 0.09 | 0.05 |
| Year X Time | 0.12 | 0.08 |
| Week x Time | 0.15 | 0.09 |
| Year x Week x Time | 0.22 | 0.13 |

**Table 35: Foraging speed of *Apis florea* in Baheda during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 25/4/14 | 2/5/14 | 9/5/14 | Mean | 20/4/15 | 28/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 2.09 (1.76) | 2.11 (1.76) | 0.00 (1.00) | 1.40 (1.50) | 2.28 (1.81) | 2.12 (1.76) | 2.26 (1.80) | 2.22 (1.79) | 1.81 (1.65) |
| 0800-1000 | 3.43 (2.10) | 3.19 (2.04) | 4.19 (2.27) | 3.60 (2.14) | 3.05 (2.01) | 3.17 (2.04) | 4.15 (2.26) | 3.46 (2.10) | 3.53 (2.12) |
| 1000-1200 | 6.54 (2.74) | 4.92 (2.43) | 6.80 (2.79) | 6.09 (2.65) | 5.94 (2.63) | 4.65 (2.37) | 6.83 (2.79) | 5.81 (2.60) | 5.95 (2.62) |
| 1200-1400 | 4.84 (2.41) | 3.62 (2.14) | 4.49 (2.34) | 4.32 (2.30) | 4.78 (2.40) | 3.54 (2.12) | 4.01 (2.23) | 4.11 (2.25) | 4.21 (2.27) |
| 1400-1600 | 4.21 (2.27) | 3.23 (2.05) | 3.90 (2.21) | 3.78 (2.18) | 3.12 (2.02) | 3.60 (2.14) | 3.88 (2.21) | 3.53 (2.12) | 3.66 (2.15) |
| 1600-1800 | 3.09 (2.01) | 3.07 (2.01) | 2.41 (1.84) | 2.85 (1.95) | 3.86 (2.20) | 2.93 (1.98) | 2.45 (1.85) | 3.08 (2.01) | 2.97 (1.98) |
| Mean | 4.03 (2.22) | 3.36 (2.07) | 3.63 (2.07) | 3.67 (2.12) | 3.84 (2.18) | 3.33 (2.07) | 3.93 (2.19) | 3.70 (2.15) | 3.68 (2.13) |
| Pooled mean | 3.94 (2.20) | 3.35 (2.07) | 3.78 (2.13) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | 0.03 |
| Year X Time | 0.01 | 0.05 |
| Week x Time | 0.02 | 0.06 |
| Year x Week x Time | 0.03 | 0.08 |

**4. 2.15. Foraging rate of *Apis cerana* on Lasora during 2014 and 2015**

Foraging rate (number of flowers of visited/min) of *Apis cerana* on Lasora during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager has been recorded (Table 36). Irrespective of different times of the day and weeks, the foraging rate ranged between 0.00 to 15.90 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 8.10 to 9.93 flowers/min corresponding to 3rdand 1st week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 1st week (9.93 flowers/min) followed by 2ndweek (8.83 flowers/min) and 3rdweek (8.10 flowers/min). Irrespective of weeks, mean foraging rate of *A. cerana* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 15.06 flowers/min) was recorded between 1000h-1200h followed by 1200h-1400h

(12.63flowers/min), 0800h-1000h (12.00 flowers/min), 1400h-1600h (11.23 flowers/min), 0600h-0800h (2.80 flowers/min) and 1600h-1800h (0.00 flowers/min).

During 2015, the foraging rate of *A. cerana*followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the foraging rate ranged between 0.00 to 14.80 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *A. cerana* varied between 7.71 and 7.90 flowers/min corresponding to 3rd and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *A. cerana* was observed during 2ndweek (7.90 flowers/min), followed by 1st week (7.76 flowers/min) and 3rd week (7.71 flowers/min). Irrespective of weeks, mean foraging rate of *A. cerana* recorded during different times of a day revealed it to be significantly the maximum foraging rate (14.23 flowers/min) was recorded between 1000h-1200h followed by 1200h-1400h (11.43 flowers/min), 0800-1000h (11.16 flowers/min), 1400h-1600h (9.93 flowers/min). No activity of *A. cerana* was recorded at 0600h-0800h and 1600h-1800h(0.00 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. cerana* observed during 1st week (8.85 flowers/min), followed by 2ndweek (8.36 flowers/min) and 3rdweek (7.90 flowers/min). Time wise, the foraging rate was significantly the maximum (14.65 flowers/min) at 1000h-1200h followed by 1200h-1400h (12.03 flowers/min), 0800h-1000h (11.58 flowers/min), 1400h-1600h (10.58 flowers/min), 0600h-0800h (1.40 flowers/min) and no activity was observed at 1600h-1800h (0.00 flowers/min).

**4.2.16. Foraging speed of *Apis cerana* on Lasora during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Apis cerana* on Lasora flowers during 2014 have been narrated in Table 37. Foraging speed of *A. cerana*on Lasora recorded during different weeks over the times revealed that the foraging speed ranged between 0.00 to 3.59 seconds/flower. The mean weekly foraging speed ranged between 1.42 to 1.73 seconds/flower during the crop flowering, respectively (Table 37). It was found that maximum foraging speed recorded during 1st week (1.73 seconds/flower) followed by 2nd week (1.45 seconds/flower) and 3rd week (1.42 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (3.42 seconds/flower) was recorded at 0800h-1000h followed at 1000h-1200h (2.38 seconds/flower), 1400h-1600h (1.55 seconds/flower), 1200h-1400h (1.44 seconds/flower) and 0600h-0800h (0.41 seconds/flower). Minimum foraging speed was recorded at 1600h-1800h (0.00 seconds/flower).

During 2015, the foraging speed of *A. cerana* ranged between 0.00 to 3.80 seconds/flower. Mean weekly foraging speed of *A. cerana* varied between 1.61to 1.64 seconds/flower corresponding to 1st, 3rd and2ndweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *A. cerana*was observed during 2nd week (1.64 seconds/ flower) followed by 1stand 2nd week (1.61 seconds/flower).

The mean foraging speed of *A. cerana* recorded during different times of a day revealed it to be significantly the maximum (3.60 seconds/ flower) between 0800h-1000h, followed by 1000h-1200h (2.70 seconds/flower), 1400h-1600h (1.82 seconds/flower) and 1200h-1400h (1.62 seconds/flower).No activity of *A. cerana*was recorded at 0600h -0800h and 1600h-1800h (0.00 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*A. cerana* observed during 1st week (1.67 seconds/flower), followed by 2nd week (1.55 seconds/flower). Minimum foraging speed was observed during 3rd week (1.51 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.51 seconds/flower) at 0800h-1000h followed by 1000h-1200h (2.54 seconds/flower), 1400h-1600h (1.68 seconds/flower), 1200h-1400h (1.53 seconds/flower) and 0600h-0800h (0.20 seconds/flower). No activity of *A. cerana*was recorded at 1600h-1800h (0.00 seconds/flower).

**Table 36 : Foraging rate of *Apis cerana* in Lasora during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 8.40 (3.06) | 0.00 (1.00) | 0.00 (1.00) | 2.80 (1.68) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 1.40 (1.34) |
| 0800-1000 | 12.10 (3.61) | 12.90 (3.72) | 11.00 (3.46) | 12.00 (3.60) | 10.60 (3.40) | 11.30 (3.50) | 11.60 (3.54) | 11.16 (3.48) | 11.58 (3.54) |
| 1000-1200 | 15.30 (4.03) | 15.90 (4.11) | 14.00 (3.87) | 15.06 (4.00) | 14.80 (3.97) | 14.60 (3.94) | 13.30 (3.78) | 14.23 (3.90) | 14.65 (3.95) |
| 1200-1400 | 12.30 (3.64) | 12.90 (3.72) | 12.70 (3.70) | 12.63 (3.69) | 11.20 (3.49) | 11.70 (3.56) | 11.40 (3.51) | 11.43 (3.52) | 12.03 (3.60) |
| 1400-1600 | 11.50 (3.53) | 11.30 (3.50) | 10.90 (3.44) | 11.23 (3.49) | 10.00 (3.31) | 9.80 (3.28) | 10.00 (3.31) | 9.93 (3.30) | 10.58 (3.40) |
| 1600-1800 | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) |
| Mean | 9.93 (3.14) | 8.83 (2.84) | 8.10 (2.74) | 8.95 (2.91) | 7.76 (2.69) | 7.90 (2.71) | 7.71 (2.69) | 7.79 (2.70) | 8.37 (2.80) |
| Pooled mean | 8.85 (2.92) | 8.36 (2.78) | 7.90 (2.72) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.01 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | 0.03 |
| Year X Time | 0.02 | 0.05 |
| Week x Time | 0.02 | 0.06 |
| Year x Week x Time | 0.03 | 0.09 |

**Table 37: Foraging speed of *Apis cerana* in Lasora during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 1.25 (1.50) | 0.00 (1.00) | 0.00 (1.00) | 0.41 (1.16) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.20 (1.08) |
| 0800-1000 | 3.59 (2.13) | 3.32 (2.07) | 3.36 (2.08) | 3.42 (2.10) | 3.70 (2.16) | 3.28 (2.07) | 3.80 (2.19) | 3.60 (2.14) | 3.51 (2.12) |
| 1000-1200 | 2.38 (1.84) | 2.37 (1.83) | 2.39 (1.84) | 2.38 (1.83) | 2.46 (1.86) | 2.84 (1.95) | 2.81 (1.95) | 2.70 (1.92) | 2.54 (1.88) |
| 1200-1400 | 1.49 (1.57) | 1.41 (1.55) | 1.42 (1.55) | 1.44 (1.56) | 1.67 (1.63) | 1.63 (1.62) | 1.56 (1.60) | 1.62 (1.61) | 1.53 (1.59) |
| 1400-1600 | 1.66 (1.63) | 1.63 (1.62) | 1.36 (1.53) | 1.55 (1.59) | 1.85 (1.68) | 2.13 (1.76) | 1.48 (1.57) | 1.82 (1.67) | 1.68 (1.63) |
| 1600-1800 | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) |
| Mean | 1.73 (1.61) | 1.45 (1.51) | 1.42 (1.50) | 1.53 (1.54) | 1.61 (1.55) | 1.64 (1.56) | 1.61 (1.55) | 1.62 (1.56) | 1.57 (1.55) |
| Pooled mean | 1.67 (1.58) | 1.55 (1.54) | 1.51 (1.52) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.01 |
| Week | 0.00 | 0.01 |
| Time | 0.00 | 0.02 |
| Year x Week | 0.00 | 0.02 |
| Year X Time | 0.01 | 0.03 |
| Week x Time | 0.01 | 0.04 |
| Year x Week x Time | 0.02 | 0.06 |

### 4. 2.17. Foraging rate of *Apis dorsata* on Lasora during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Apis dorsata* on Lasora during 2014 at differenttimes of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 38). Irrespective of different times of the day and weeks, the foraging rate ranged between 9.90 to 17.00 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 13.11 to 13.65 flowers/min corresponding to 2$^{nd}$and 1$^{st}$ week of the crop flowering, respectively. It was found that maximum mean foraging rate was recorded during 1$^{st}$ week (13.65 flowers/min) followed by 3$^{rd}$week (13.43 flowers/min) and 2$^{nd}$week (13.11flowers/min).Irrespective of weeks, mean foraging rate of *A. dorsata* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 15.96 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (14.90 flowers/min), 1600h-1800h (14.83 flowers/min), 1400h-1600h (12.26 flowers/min), 0600h-0800h (11.53 flowers/min) and 1200h-1400h (10.90 flowers/min).

During 2015, the foraging rate of *A. dorsata*followed the similar trend that recorded in 2014. Irrespective of different times of the day and weeks, the foraging rate ranged between 9.50 to 15.20 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 12.51 to 13.68 flowers/min corresponding to 2nd and 1st week of the crop flowering, respectively. It was found that maximum mean foraging rate was recorded during 1st week (13.68 flowers/min) followed by 3rd week (12.53 flowers/min) and 2nd week (12.51 flowers/min). Irrespective of weeks, mean foraging rate of *A. dorsata* recorded during different times of a day revealed it to be significantly the maximum foraging rate (14.73 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (14.23 flowers/min), 1600h-1800h (14.20 flowers/min), 0600h-0800h (12.03 flowers/min), 1400h-1600h (11.66 flowers/min) and 1200h-1400h (10.60 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. dorsata* observed during 1st week (13.66 flowers/min), followed by 3rdweek (12.98 flowers/min) and 2ndweek (12.81 flowers/min). Time wise, the foraging rate was significantly the maximum (15.35 flowers/min) at 1000h-1200h followed by 0800h-1000h (14.56 flowers/min), 1600h-1800h (14.51 flowers/min), 1400h-1600h (11.96 flowers/min), 0600h-0800h (11.78 flowers/min). Lowest foraging rate was recorded at1200h-1400h (10.75 flowers/min).

**4.2.18. Foraging speed of *Apis dorsata* on Lasora during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Apis dorsata* on Lasora flowers during 2014 have been narrated in Table 39. Foraging speed of *A. dorsata*on Lasora recorded during different weeks over the times revealed that the foraging speed ranged between 1.58 to 3.39 seconds/flower. The mean weekly foraging speed ranged between 2.54 to 2.88 seconds/flower during the crop flowering, respectively (Table 39). It was found that maximum mean foraging speed recorded during 3rdweek (2.88 seconds/flower) followed by 1st week (2.65 seconds/flower) and 2nd week (2.54 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (3.25 seconds/flower) was recorded at 1000h-1200h and 0600-0800 followed at 1200h-1400h (2.89 seconds/flower), 0800h-1000h (2.45 seconds/flower) and 1600h-1800h (2.28 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (2.02 seconds/flower).

During 2015, the foraging speed of *A. dorsata* ranged between 1.52 to 3.47 seconds/flower. Mean weekly foraging speed of *A. dorsata* varied between 2.59to 3.06 seconds/flower corresponding to 2ndand 1stweek of crop blooming period, respectively.

Week wise, significantly the maximum mean foraginig speed of *A. dorsata*was observed during 1st week (3.06 seconds/ flower) followed by 3rd week (2.83 seconds/flower) and 2nd week (2.59 seconds/flower). The foraging speed of *A. dorsata* recorded during

different times of a day revealed it to be significantly the maximum (3.32 seconds/ flower) between 1000h-1200h, followed by 0600h-0800h (3.16 seconds/flower), 1200h-1400h (3.10 seconds/flower) and 0800h-1000h (2.65 seconds/flower) and1600h -1800h (2.60 seconds/flower). Minimum foraging speed recorded at 1400h-1600h (2.14 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*A. dorsata* observed during 3rdweek (2.86 seconds/flower), followed by 1stweek (2.85 seconds/flower). Minimum foraging speed was observed during 2ndweek (2.57 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.28 seconds/flower) at 1000h-1200h followed by 0600h-0800h (3.20 seconds/flower), 1200h-1400h (2.99 seconds/flower), 0800h-1000h (2.55 seconds/flower) and 1600h-1800h (2.44 seconds/flower). Minimum foraging speed recorded at 1400h-1600h (2.08 seconds/flower).

**Table 38 : Foraging rate of *Apis dorsata* in Lasora during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 10.50 (3.38) | 10.90 (3.44) | 13.20 (3.76) | 11.53 (3.53) | 13.20 (3.76) | 11.30 (3.50) | 11.60 (3.54) | 12.03 (3.60) | 11.78 (3.57) |
| 0800-1000 | 14.50 (3.93) | 15.30 (4.03) | 14.90 (3.98) | 14.90 (3.98) | 15.20 (4.02) | 14.20 (3.89) | 13.30 (3.78) | 14.23 (3.90) | 14.56 (3.94) |
| 1000-1200 | 17.00 (4.24) | 15.30 (4.03) | 15.60 (4.07) | 15.96 (4.11) | 15.20 (4.02) | 14.70 (3.96) | 14.30 (3.91) | 14.73 (3.96) | 15.35 (4.04) |
| 1200-1400 | 11.90 (3.59) | 10.90 (3.44) | 9.90 (3.29) | 10.90 (3.44) | 12.20 (3.63) | 10.10 (3.32) | 9.50 (3.23) | 10.60 (3.40) | 10.75 (3.42) |
| 1400-1600 | 12.50 (3.67) | 11.30 (3.50) | 13.00 (3.74) | 12.26 (3.63) | 12.20 (3.63) | 11.20 (3.49) | 11.60 (3.54) | 11.66 (3.55) | 11.96 (3.59) |
| 1600-1800 | 15.50 (4.06) | 15.00 (3.99) | 14.00 (3.87) | 14.83 (3.97) | 14.10 (3.88) | 13.60 (3.82) | 14.90 (3.98) | 14.20 (3.89) | 14.51 (3.93) |
| Mean | 13.65 (3.81) | 13.11 (3.74) | 13.43 (3.78) | 13.40 (3.78) | 13.68 (3.82) | 12.51 (3.66) | 12.53 (3.66) | 12.91 (3.72) | 13.15 (3.75) |
| Pooled mean | 13.66 (3.82) | 12.81 (3.70) | 12.98 (3.72) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | 0.04 |
| Year X Time | 0.02 | 0.06 |
| Week x Time | 0.02 | 0.07 |
| Year x Week x Time | 0.03 | 0.10 |

**Table 39: Foraging speed of *Apis dorsata* in Lasora during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 3.05 (2.00) | 3.30 (2.07) | 3.39 (2.09) | 3.25 (2.05) | 3.04 (2.00) | 3.19 (2.04) | 3.26 (2.06) | 3.16 (2.04) | 3.20 (2.04) |
| 0800-1000 | 2.38 (1.83) | 2.41 (1.84) | 2.56 (1.88) | 2.45 (1.85) | 2.98 (1.99) | 2.48 (1.86) | 2.50 (1.87) | 2.65 (1.91) | 2.55 (1.88) |
| 1000-1200 | 3.21 (2.05) | 2.98 (1.99) | 3.56 (2.13) | 3.25 (2.05) | 3.25 (2.06) | 3.23 (2.05) | 3.47 (2.11) | 3.32 (2.07) | 3.28 (2.06) |
| 1200-1400 | 2.84 (1.95) | 2.81 (1.95) | 3.01 (2.00) | 2.89 (1.96) | 3.29 (2.06) | 3.05 (2.01) | 2.96 (1.98) | 3.10 (2.02) | 2.99 (1.99) |
| 1400-1600 | 2.06 (1.74) | 1.58 (1.60) | 2.42 (1.84) | 2.02 (1.73) | 2.47 (1.86) | 1.52 (1.58) | 2.42 (1.85) | 2.14 (1.76) | 2.08 (1.75) |
| 1600-1800 | 2.34 (1.82) | 2.14 (1.77) | 2.35 (1.83) | 2.28 (1.81) | 3.34 (2.08) | 2.10 (1.76) | 2.37 (1.83) | 2.60 (1.89) | 2.44 (1.85) |
| Mean | 2.65 (1.90) | 2.54 (1.87) | 2.88 (1.96) | 2.69 (1.91) | 3.06 (2.01) | 2.59 (1.88) | 2.83 (1.95) | 2.83 (1.95) | 2.76 (1.93) |
| Pooled mean | 2.85 (1.95) | 2.57 (1.88) | 2.86 (1.96) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.01 |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | 0.03 |
| Year X Time | 0.01 | 0.04 |
| Week x Time | 0.01 | 0.05 |
| Year x Week x Time | 0.02 | 0.07 |

### 4. 2.19. Foraging rate of *Eristalinus obliquus*on Lasora during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Eristalinus obliquus*on Lasora during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 40). Irrespective of different times of the day and weeks, the foraging rate ranged between 4.30 to 15.60 flowers/min.Irrespective of times of the day, mean weekly foraging rate ranged between 9.13 to 10.05 flowers/min corresponding to 2$^{nd}$ and 3$^{rd}$week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 3$^{rd}$ week (10.05 flowers/min) followed by 1$^{st}$week (9.96 flowers/min) and 2$^{nd}$ week (9.13 flowers/min).Irrespective of weeks, mean foraging rate of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 14.56 flowers/min) was recorded between 1600h-1800h followed by 0600h-0800h (14.03 flowers/min), 1400h-1600h (10.43 flowers/min), 0800h-1000h (8.83 flowers/min), 1000h-1200h (5.40 flowers/min) and 1200h-1400h (5.03 flowers/min).

During 2015, the foraging rate of *E. obliquus,* Irrespective of different times of the day and weeks, the foraging rate ranged between 4.50 to 13.90 flowers/min.Irrespective of times of the day, mean weekly foraging rate ranged between 8.33 to 9.63 flowers/min corresponding to 2nd and 3rdweek of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 3rd week (9.63 flowers/min) followed by 1stweek (9.61 flowers/min) and 2nd week (8.33 flowers/min).Irrespective of weeks, mean foraging rate of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum foraging rate ( 13.20 flowers/min) was recorded between 0600h-0800h followed by 1600h-1800h (12.96 flowers/min), 1400h-1600h (9.53 flowers/min), 0800h-1000h (8.50 flowers/min), 1000h-1200h (5.96 flowers/min) and 1200h-1400h (5.00 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *E. obliquus* observed during 3rdweek (9.84 flowers/min), followed by 1stweek (9.79 flowers/min) and 2ndweek (8.73 flowers/min). Time wise, the foraging rate was significantly the maximum (13.76 flowers/min) at 1600h-1800h followed by 0600h-0800h (13.61 flowers/min), 1400h-1600h (9.98 flowers/min), 0800h-1000h (8.66 flowers/min), 1000h-1200h (5.68 flowers/min). Lowest foraging rate was recorded at 1200h-1400h (5.01 flowers/min).

**4.2.20. Foraging speed of *Eristalinus obliquus* on Lasora during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Eristalinus obliquus*on Lasora flowers during 2014 have been narrated in Table 41. Foraging speed of *E. obliquus* on Lasora recorded during different weeks over the times revealed that the foraging speed ranged between 2.94 to 17.08 seconds/flower. The mean weekly foraging speed ranged between 7.78 to 8.29 seconds/flower during the crop flowering, respectively (Table 41). It was found that maximum foraging speed recorded during 1st week (8.29 seconds/flower) followed by 3rdweek (8.16 seconds/flower) and 2nd week (7.78 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (16.91 seconds/flower) was recorded at 1200h-1400h followed at 1000h-1200h (12.79 seconds/flower), 1400h-1600h (6.43 seconds/flower), 1600h-1800h (5.49 seconds/flower) and 0800h-1000h (4.77 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (3.08 seconds/flower).

During 2015, the foraging speed of *E. obliquus* ranged between 3.03 to 17.03 seconds/flower. Mean weekly foraging speed of *E. obliquus* varied between 7.71 to 8.19 seconds/flower corresponding to 2nd and 1st week of crop blooming period, respectively.Week wise, significantly the maximum mean foraginig speed of *E. obliquus* was observed during 1stweek (8.19 seconds/ flower) followed by 3rd week (8.10 seconds/flower) and 2nd week (7.71 seconds/flower). The foraging speed of *E. obliquus* recorded during

different times of a day revealed it to be significantly the maximum (16.70 seconds/ flower) between 1200h-1400h, followed by 1000h-1200h (12.52

seconds/flower), 1400h-1600h (6.43 seconds/flower), 0800h-1000h (4.63 seconds/flower) and 1600h -1800h (4.52 seconds/flower). Minimum foraging speed recorded at 0600h-0800h (3.19 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *E. obliquus* observed during 1st week (8.24 seconds/flower), followed by 3rd week (8.13 seconds/flower). Minimum foraging speed was observed during 2nd week (7.75 seconds/flower). Time wise, the foraging speed was significantly the maximum (16.80 seconds/flower) at 1200h-1400h followed by 1000h-1200h (12.66 seconds/flower), 1400h-1600h (6.43 seconds/flower), 0800h-1000h (4.70 seconds/flower) and 1600h-1800h (4.50 seconds/flower). Minimum foraging speed recorded at 0600h-0800h (3.13 seconds/flower).

**Table 40: Foraging rate of *Eristalinus obliquus* Wiedemann in Lasora during March 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 14.50 (3.93) | 13.50 (3.80) | 14.10 (3.88) | 14.03 (3.87) | 13.60 (3.82) | 12.80 (3.71) | 13.20 (3.76) | 13.20 (3.76) | 13.61 (3.82) |
| 0800-1000 | 9.40 (3.22) | 6.70 (2.76) | 10.40 (3.37) | 8.83 (3.12) | 10.00 (3.31) | 5.70 (2.58) | 9.80 (3.28) | 8.50 (3.06) | 8.66 (3.09) |
| 1000-1200 | 5.10 (2.46) | 5.00 (2.44) | 6.10 (2.66) | 5.40 (2.52) | 5.40 (2.52) | 5.90 (2.62) | 6.60 (2.75) | 5.96 (2.63) | 5.68 (2.57) |
| 1200-1400 | 4.30 (2.29) | 5.90 (2.62) | 4.90 (2.42) | 5.03 (2.44) | 4.50 (2.34) | 4.70 (2.38) | 5.80 (2.60) | 5.00 (2.44) | 5.01 (2.44) |
| 1400-1600 | 10.90 (3.44) | 10.00 (3.31) | 10.40 (3.37) | 10.43 (3.37) | 10.30 (3.35) | 9.70 (3.26) | 8.60 (3.09) | 9.53 (3.24) | 9.98 (3.30) |
| 1600-1800 | 15.60 (4.07) | 13.70 (3.83) | 14.40 (3.92) | 14.56 (3.94) | 13.90 (3.85) | 11.20 (3.49) | 13.80 (3.84) | 12.96 (3.73) | 13.76 (3.83) |
| Mean | 9.96 (3.24) | 9.13 (3.13) | 10.05 (3.27) | 9.71 (3.21) | 9.61 (3.20) | 8.33 (3.01) | 9.63 (3.22) | 9.19 (3.14) | 9.45 (3.17) |
| Pooled mean | 9.79 (3.22) | 8.73 (3.07) | 9.84 (3.24) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.02 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.05 |
| Year x Week | 0.01 | 0.05 |
| Year X Time | 0.02 | 0.07 |
| Week x Time | 0.03 | 0.08 |
| Year x Week x Time | 0.04 | 0.12 |

**Table 41: Foraging speed of *Eristalinus obliquus* Wiedemann in Lasora during March 2014 and2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 3.13 (2.03) | 3.17 (2.04) | 2.94 (1.98) | 3.08 (2.01) | 3.12 (2.03) | 3.41 (2.10) | 3.03 (2.00) | 3.19 (2.04) | 3.13 (2.03) |
| 0800-1000 | 5.01 (2.45) | 4.25 (2.29) | 5.03 (2.45) | 4.77 (2.40) | 4.84 (2.41) | 4.20 (2.28) | 4.84 (2.41) | 4.63 (2.37) | 4.70 (2.38) |
| 1000-1200 | 12.93 (3.73) | 12.43 (3.66) | 13.00 (3.74) | 12.79 (3.71) | 12.35 (3.65) | 12.34 (3.65) | 12.88 (3.72) | 12.52 (3.67) | 12.66 (3.69) |
| 1200-1400 | 17.08 (4.25) | 16.67 (4.20) | 16.98 (4.24) | 16.91 (4.23) | 17.03 (4.24) | 16.15 (4.14) | 16.91 (4.23) | 16.70 (4.20) | 16.80 (4.21) |
| 1400-1600 | 7.26 (2.87) | 5.94 (2.63) | 6.10 (2.66) | 6.43 (2.72) | 7.18 (2.86) | 6.10 (2.66) | 6.02 (2.64) | 6.43 (2.72) | 6.43 (2.72) |
| 1600-1800 | 4.34 (2.30) | 4.22 (2.28) | 4.89 (2.42) | 5.49 (2.34) | 4.60 (2.36) | 4.07 (2.25) | 4.89 (2.42) | 4.52 (2.34) | 4.50 (2.34) |
| Mean | 8.29 (2.94) | 7.78 (2.85) | 8.16 (2.91) | 8.08 (2.90) | 8.19 (2.92) | 7.71 (2.84) | 8.10 (2.90) | 8.00 (2.89) | 8..04 (2.89) |
| Pooled mean | 8.24 (2.93) | 7.75 (2.85) | 8.13 (2.91) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | N.S. |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.01 | N.S. |
| Week x Time | 0.01 | 0.05 |
| Year x Week x Time | 0.02 | N.S. |

### 4. 2.21. Foraging rate of *Apis florea* on Lasora during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Apis florea* on Lasora during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 42). Irrespective of different times of the day and weeks, the foraging rate ranged between 6.00 to 10.70 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 7.93 to 9.26 flowers/min corresponding to 2$^{nd}$ and 3$^{rd}$week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 3$^{rd}$ week (9.26 flowers/min) followed by 1$^{st}$week (8.43 flowers/min) and 2$^{nd}$ week (7.93 flowers/min). Irrespective of weeks, mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum foraging rate (10.00 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (9.40 flowers/min), 1600h-

1800h (9.10 flowers/min), 1400h-1600h (8.16 flowers/min), 0600h-0800h (7.40 flowers/min) and 1200h-1400h (7.20 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *Apis florea*ranged between 5.10 to 11.30 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *A. florea* varied between 6.76 to8.50 flowers/min corresponding to 2nd and 3rd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *A. florea* was observed during 3rd week (8.50 flowers/min), followed by 1st week (8.20 flowers/min) and 2nd week (6.76 flowers/min). Irrespective of weeks, mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.96 flowers/min) was recorded between 0800h-1000h followed by 1000h-1200h (8.70 flowers/min), 1600-1800h (8.53 flowers/min), 0600h-0800h (7.36 flowers/min), 1400h-1600h (6.93 flowers/min) and 1200h-1400h (6.43 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. florea* observed during 3rd week (8.88 flowers/min), followed by 1st week (8.31 flowers/min) and 2nd week (7.35 flowers/min). Time wise, the foraging rate was significantly the maximum (9.35 flowers/min) at 1000h-1200h followed by 0800h-1000h (9.18 flowers/min), 1600h-1800h (8.81 flowers/min), 1400h-1600h (7.55 flowers/min), 060h-0800h (7.38 flowers/min) and 1200h-1400h (6.81 flowers/min).

**4.2.22. Foraging speed of *Apis florea* on Lasora during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Apis florea* on Lasora flowers during 2014 have been narrated in Table 43. Foraging speed of *A. florea* on Lasora recorded during different weeks over the times revealed that the foraging speed ranged between 1.85 to 4.42 seconds/flower. The mean weekly foraging speed ranged between 3.19 to 3.46 seconds/flower during the crop flowering, respectively (Table 43). It was found that maximum foraging speed recorded during 3rd week (4.03 seconds/flower) followed by 2nd week (3.20 seconds/flower) and 1st week (3.19 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (4.41 seconds/flower) was recorded at 1200h-1400h followed at 1000h-1200h (3.70 seconds/flower), 0800h-1000h (3.06 seconds/flower), 1400h-1600h (3.03 seconds/flower) and 1600h-1800h (2.99 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (2.50 seconds/flower).

During 2015, the foraging speed of *A. florea* ranged between 1.64 to 4.83 seconds/flower. Mean weekly foraging speed of *A. florea* varied between 2.91 and 3.13 seconds/flower corresponding to 1st and 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *A. florea* was observed during 2nd week (3.13 seconds/ flower) followed by 3rd week (2.93 seconds/flower) and minimum

foraging speed was observed at 1st week (2.91 seconds/flower). The foraging speed of *A. florea* recorded during different times of a day revealed it to be significantly the maximum (4.22 seconds/ flower) between 1200h-1400h, followed by 1000h-1200h (3.30 seconds/flower), 1400h-1600h and 1600h-1800h (3.06 seconds/flower) and 0800h-1000h (2.53 seconds/flower). Lowest forging speed was recorded at 0600h -0800h (1.76 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *A. florea* observed during 3rdweek (3.19 seconds/flower), followed by 2ndweek (3.17 seconds/flower). Minimum foraging speed was observed during 1stweek (3.05 seconds/flower). Time wise, the foraging speed was significantly the maximum (4.32 seconds/flower) at 1200h-1400h followed by 1000h-1200h (3.50 seconds/flower), 1400h-1600h (3.05 seconds/flower), 1600h-1800h (3.03 seconds/flower) and 0800h-1000h (2.80 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (2.13 seconds/flower).

**Table 42 : Foraging rate of *Apis florea* in Lasora during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 7.10 (2.84) | 6.30 (2.69) | 8.80 (3.12) | 7.40 (2.88) | 7.60 (2.92) | 5.10 (2.46) | 9.40 (3.22) | 7.36 (2.87) | 7.38 (2.88) |
| 0800-1000 | 10.10 (3.32) | 8.40 (3.06) | 9.70 (3.26) | 9.40 (3.21) | 11.30 (3.50) | 6.50 (2.73) | 9.10 (3.17) | 8.96 (3.13) | 9.18 (3.17) |
| 1000-1200 | 9.30 (3.20) | 10.00 (3.31) | 10.70 (3.41) | 10.00 (3.31) | 8.10 (3.01) | 8.90 (3.14) | 9.10 (3.17) | 8.70 (3.11) | 9.35 (3.21) |
| 1200-1400 | 7.00 (2.82) | 6.00 (2.64) | 8.60 (3.09) | 7.20 (2.85) | 5.90 (2.62) | 5.60 (2.56) | 7.80 (2.96) | 6.43 (2.71) | 6.81 (2.78) |
| 1400-1600 | 8.10 (3.01) | 8.20 (3.03) | 8.20 (3.03) | 8.16 (3.02) | 7.00 (2.82) | 7.00 (2.82) | 6.80 (2.79) | 6.93 (2.81) | 7.55 (2.91) |
| 1600-1800 | 9.00 (3.15) | 8.70 (3.11) | 9.60 (3.25) | 9.10 (3.17) | 9.30 (3.20) | 7.50 (2.91) | 8.80 (3.12) | 8.53 (3.08) | 8.81 (3.12) |
| Mean | 8.43 (3.06) | 7.93 (2.97) | 9.26 (3.20) | 8.54 (3.07) | 8.20 (3.01) | 6.76 (2.77) | 8.50 (3.07) | 7.82 (2.95) | 8.18 (3.01) |
| Pooled mean | 8.31 (3.03) | 7.35 (2.87) | 8.88 (3.13) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.05 |
| Year x Week | 0.01 | 0.05 |
| Year X Time | 0.02 | 0.07 |
| Week x Time | 0.03 | 0.08 |
| Year x Week x Time | 0.04 | 0.12 |

**Table 43 : Foraging speed of *Apis florea* in Lasora during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 19/4/14 | 26/4/14 | 3/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 1.85 (1.69) | 1.85 (1.68) | 3.80 (1.99) | 2.50 (1.79) | 1.64 (1.62) | 1.68 (1.63) | 1.95 (1.71) | 1.76 (1.66) | 2.13 (1.72) |
| 0800-1000 | 3.14 (2.03) | 2.68 (1.91) | 3.37 (2.08) | 3.06 (2.01) | 2.32 (1.82) | 2.84 (1.95) | 2.43 (1.85) | 2.53 (1.87) | 2.80 (1.94) |
| 1000-1200 | 3.76 (2.18) | 4.07 (2.25) | 3.26 (2.06) | 3.70 (2.16) | 3.30 (2.07) | 3.57 (2.13) | 3.02 (2.00) | 3.30 (2.07) | 3.50 (2.11) |
| 1200-1400 | 4.42 (2.32) | 4.80 (2.40) | 4.00 (2.23) | 4.41 (2.32) | 4.28 (2.29) | 4.83 (2.41) | 3.56 (2.13) | 4.22 (2.28) | 4.32 (2.30) |
| 1400-1600 | 3.32 (2.07) | 2.82 (1.95) | 2.95 (1.98) | 3.03 (2.00) | 3.00 (1.99) | 2.86 (1.96) | 3.33 (2.07) | 3.06 (2.01) | 3.05 (2.00) |
| 1600-1800 | 2.64 (1.90) | 2.97 (1.99) | 3.37 (2.08) | 2.99 (1.99) | 2.89 (1.97) | 3.02 (2.00) | 3.28 (2.06) | 3.06 (2.01) | 3.03 (2.00) |
| Mean | 3.19 (2.03) | 3.20 (2.03) | 3.46 (2.07) | 3.28 (2.04) | 2.91 (1.96) | 3.13 (2.01) | 2.93 (1.97) | 2.99 (1.98) | 3.13 (2.01) |
| Pooled mean | 3.05 (2.00) | 3.17 (2.02) | 3.19 (2.02) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | N.S. |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.03 | N.S. |
| Week x Time | 0.04 | 0.11 |
| Year x Week x Time | 0.05 | N.S. |

### 4. 2.23. Foraging rate of *Papilio demoleus* on Karonda during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Papilio demoleus* on Karonda during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 44). Irrespective of different times of the day and weeks, the foraging rate ranged between 20.10 to 40.90 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 28.68 to 32.66 flowers/min corresponding to 3$^{rd}$ and 2$^{nd}$ week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2$^{nd}$ week (32.66 flowers/min) followed by 1$^{st}$ week (32.03 flowers/min) and 3$^{rd}$ week (28.68 flowers/min). Irrespective of weeks, mean foraging rate of *P. demoleus* recorded during different times of a day revealed it to be significantly the maximum foraging rate (39.56 flowers/min) was recorded between 0800h-1000h followed by 1400h-1600h (38.73 flowers/min), 1000h-1200h (33.50 flowers/min), 1200h-1400h (27.66 flowers/min) and 1600h-1800h (26.53 flowers/min). Minimum foraging rate was recorded at 0600h-0800h (20.76 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *P. demoleus* ranged between 20.40 to 40.30 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *P. demoleus* varied between 28.43 to 32.28 flowers/min corresponding to 3rd and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *P. demoleus* was observed during 2nd week (32.28 flowers/min), followed by 1st week (31.83 flowers/min) and 3rd week (28.43 flowers/min). Irrespective of weeks, mean foraging rate of *P. demoleus* recorded during different times of a day revealed it to be significantly the maximum foraging rate (39.13 flowers/min) was recorded between 0800h-1000h followed by 1400h-1600h (38.53 flowers/min), 1000h-1200h (32.60 flowers/min), 1200h-1400h (27.40 flowers/min), 1600h-1800h (26.60 flowers/min) and 0600h-0800h (20.83 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *P. demoleus* observed during 2nd week (2.47 flowers/min), followed by 1st week (31.93 flowers/min) and 3rd week (28.55 flowers/min). Time wise, the foraging rate was significantly the maximum (39.35 flowers/min) at 0800h-1000h followed by 1400h-1600h (38.63 flowers/min), 1000h-1200h (33.05 flowers/min), 1200h-1400h (27.53 flowers/min), 1600h-1800h (26.56 flowers/min) and 0600h-0800h (20.80 flowers/min).

**4.2.24. Foraging speed of *Papilio demoleus* on Karonda during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Papilio demoleus* on Karonda flowers during 2014 have been narrated in Table 45. Foraging speed of *P. demoleus* on Karonda recorded during different weeks over the times revealed that the foraging speed ranged between 0.82 to 2.14 seconds/flower. The mean weekly foraging speed ranged between 1.29 to 1.39 seconds/flower during the crop flowering, respectively (Table 45). It was found that maximum foraging speed recorded during 1st week (1.39 seconds/flower) followed by 2nd week (1.35 seconds/flower) and 3rd week (1.29 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (2.05 seconds/flower) was recorded at 0600h-0800h followed at 0800h-1000h (1.48 seconds/flower), 1000h-1200h (1.38 seconds/flower), 1200h-1400h (1.32 seconds/flower) and 1600h-1800h (1.08 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (1.01 seconds/flower).

During 2015, the foraging speed of *P. demoleus* ranged between 0.83 to 2.15 seconds/flower. Mean weekly foraging speed of *P. demoleus* varied between 1.28 and 1.41 seconds/flower corresponding to 3rd and 1stweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *P. demoleus* was observed during 1stweek (1.41 seconds/ flower) followed by 2nd week (1.34 seconds/flower) and minimum foraging speed was observed at 3rd week (1.28 seconds/flower).

The foraging speed of *P. demoleus* recorded during different times of a day revealed it to be significantly the maximum (2.07 seconds/ flower) between 0600h-0800h, followed by 0800h-1000h (1.47 seconds/flower), 1200h-1400h (1.33 seconds/flower), 1000h-1200h (1.21 seconds/flower) and 1600h-1800h (1.08 seconds/flower). Lowest foraging speed was recorded at 1400h-1600h (1.01 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *P. demoleus* observed during 1st week (1.40 seconds/flower), followed by 2nd week (0.88 seconds/flower) and 3rd week (1.29 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.06 seconds/flower) at 0600h-0800h followed by 0800h-1000h (1.47 seconds/flower), 1200h-1400h (1.33 seconds/flower), 1000h-1200h (1.13 seconds/flower) and 1600h-1800h (1.08 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (1.01 seconds/flower).

**Table 44 : Foraging rate of *Papilio demoleus* in Karonda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 21/4/14 | 28/4/14 | 5/5/14 | Mean | 17/4/15 | 24/4/15 | 1/5/15 | Mean | Pooled mean |
| 0600-0800 | 20.10 (4.58) | 21.60 (4.75) | 20.60 (4.64) | 20.76 (4.66) | 20.60 (4.64) | 21.50 (4.74) | 20.40 (4.62) | 20.83 (4.67) | 20.80 (4.66) |
| 0800-1000 | 40.60 (6.44) | 40.90 (6.47) | 37.20 (6.17) | 39.56 (6.36) | 40.20 (6.41) | 40.30 (6.42) | 36.90 (6.15) | 39.13 (6.33) | 39.35 (6.35) |
| 1000-1200 | 37.20 (6.17) | 37.80 (6.22) | 25.50 (5.13) | 33.50 (5.84) | 36.40 (6.10) | 36.90 (6.15) | 24.50 (5.03) | 32.60 (5.76) | 33.05 (5.80) |
| 1200-1400 | 27.70 (5.35) | 28.20 (5.40) | 27.10 (5.29) | 27.66 (5.35) | 27.30 (5.31) | 28.30 (5.41) | 26.60 (5.25) | 27.40 (5.32) | 27.53 (5.33) |
| 1400-1600 | 39.80 (6.38) | 39.50 (6.36) | 36.90 (6.15) | 38.73 (6.30) | 39.30 (6.34) | 39.30 (6.34) | 37.00 (6.16) | 38.53 (6.28) | 38.63 (6.29) |
| 1600-1800 | 26.80 (5.26) | 28.00 (5.38) | 24.80 (5.07) | 26.53 (5.24) | 27.20 (5.30) | 27.40 (5.32) | 25.20 (5.11) | 26.60 (5.25) | 26.56 (5.24) |
| Mean | 32.03 (5.70) | 32.66 (5.76) | 28.68 (5.41) | 31.12 (5.62) | 31.83 (5.69) | 32.28 (5.73) | 28.43 (5.39) | 30.85 (5.60) | 30.98 (5.61) |
| Pooled mean | 31.93 (5.69) | 32.47 (5.75) | 28.55 (5.40) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SE(m) | C.D. |
|---|---|---|
| Year | 0.01 | N.S. |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.03 | N.S. |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | N.S. |

**Table 45 : Foraging speed of *Papilio demoleus* in Karonda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 | | | | 2014-15 | | | | |
| | Wk1 | Wk2 | Wk3 | Mean | Wk1 | Wk2 | Wk3 | Mean | Pooled mean |
| 0600-0800 | 2.13 (1.76) | 1.89 (1.70) | 2.14 (1.77) | 2.05 (1.74) | 2.15 (1.77) | 1.90 (1.70) | 2.15 (1.77) | 2.07 (1.75) | 2.06 (1.75) |
| 0800-1000 | 1.55 (1.59) | 2.07 (1.74) | 0.82 (1.35) | 1.48 (1.56) | 1.58 (1.60) | 2.00 (1.73) | 0.83 (1.35) | 1.47 (1.56) | 1.47 (1.56) |
| 1000-1200 | 1.02 (1.42) | 0.99 (1.41) | 1.40 (1.54) | 1.38 (1.46) | 1.01 (1.42) | 1.00 (1.41) | 1.34 (1.52) | 1.21 (1.45) | 1.13 (1.45) |
| 1200-1400 | 1.68 (1.63) | 1.11 (1.45) | 1.17 (1.47) | 1.32 (1.52) | 1.71 (1.64) | 1.14 (1.46) | 1.16 (1.47) | 1.33 (1.52) | 1.33 (1.52) |
| 1400-1600 | 0.89 (1.37) | 0.99 (1.41) | 1.15 (1.46) | 1.01 (1.41) | 0.91 (1.38) | 1.01 (1.42) | 1.12 (1.45) | 1.01 (1.42) | 1.01 (1.41) |
| 1600-1800 | 1.10 (1.44) | 1.07 (1.44) | 1.08 (1.44) | 1.08 (1.44) | 1.13 (1.45) | 1.01 (1.41) | 1.11 (1.45) | 1.08 (1.44) | 1.08 (1.44) |
| Mean | 1.39 (1.54) | 1.35 (1.52) | 1.29 (1.50) | 1.35 (1.52) | 1.41 (1.54) | 1.34 (1.52) | 1.28 (1.50) | 1.35 (1.52) | 1.35 (1.52) |
| Pooled mean | 1.40 (1.54) | 1.35 (1.52) | 1.29 (1.50) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SE(m) | C.D. |
|---|---|---|
| Year | 0.00 | N.S. |
| Week | 0.00 | 0.01 |
| Time | 0.00 | 0.02 |
| Year x Week | 0.00 | N.S. |
| Year X Time | 0.01 | N.S. |
| Week x Time | 0.01 | 0.03 |
| Year x Week x Time | 0.02 | N.S. |

**Table 46 : Foraging rate of *Helicoverpa armigera* in Karonda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 21/4/14 | 28/4/14 | 5/5/14 | Mean | 17/4/15 | 24/4/15 | 1/5/15 | Mean | Pooled mean |
| 0600-0800 | 13.30 (3.78) | 12.90 (3.72) | 11.50 (3.53) | 12.56 (3.67) | 12.40 (3.65) | 13.30 (3.78) | 12.20 (3.63) | 12.63 (3.68) | 12.60 (3.68) |
| 0800-1000 | 15.80 (4.09) | 15.70 (4.08) | 15.60 (4.07) | 15.72 (4.08) | 15.50 (4.05) | 15.80 (4.09) | 15.30 (4.03) | 15.53 (4.06) | 15.61 (4.07) |
| 1000-1200 | 17.50 (4.29) | 16.90 (4.22) | 18.30 (4.39) | 17.56 (4.30) | 15.80 (4.09) | 16.40 (4.17) | 18.10 (4.36) | 16.76 (4.21) | 17.16 (4.25) |
| 1200-1400 | 16.40 (4.16) | 13.80 (3.84) | 17.10 (4.25) | 15.76 (4.08) | 26.70 (4.88) | 13.40 (3.79) | 16.30 (4.15) | 18.80 (4.27) | 17.28 (4.18) |
| 1400-1600 | 16.30 (4.15) | 17.20 (4.26) | 14.80 (3.97) | 16.10 (4.13) | 17.10 (4.25) | 16.90 (4.23) | 14.50 (3.93) | 16.16 (4.14) | 16.13 (4.13) |
| 1600-1800 | 12.80 (3.71) | 13.20 (3.76) | 13.00 (3.74) | 13.00 (3.74) | 13.30 (3.78) | 13.10 (3.75) | 13.20 (3.76) | 13.20 (3.76) | 13.10 (3.75) |
| Mean | 15.35 (4.03) | 14.95 (3.98) | 15.05 (3.99) | 15.11 (4.00) | 16.80 (4.12) | 14.81 (3.97) | 14.93 (3.98) | 15.51 (4.02) | 15.31 (4.01) |
| Pooled mean | 16.05 (4.07) | 14.88 (3.97) | 14.99 (3.98) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.02 | N.S. |
| Week | 0.03 | N.S. |
| Time | 0.04 | 0.13 |
| Year x Week | 0.04 | N.S. |
| Year X Time | 0.06 | N.S. |
| Week x Time | 0.08 | 0.22 |
| Year x Week x Time | 0.11 | N.S. |

### 4. 2.25. Foraging rate of *Helicoverpa armigera* on Karonda during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Helicoverpa armigera* on Karonda during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 46). Irrespective of different times of the day and weeks, the foraging rate ranged between 12.80 to 18.30 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 14.95 to 15.35 flowers/min corresponding to 2$^{nd}$and 1$^{st}$week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 1$^{st}$ week (15.35 flowers/min) followed by 3$^{rd}$week ( 15.05flowers/min) and 2$^{nd}$week (14.95 flowers/min). Irrespective of weeks, mean foraging rate of *H. armigera* recorded during different times of a day revealed it to be significantly the maximum foraging rate (17.56 flowers/min) was recorded between 1000h-1200h followed by 1400h-1600h (16.10 flowers/min), 1200h-1400h (15.76 flowers/min), 0800h-1000h (15.72 flowers/min) and

1600h-1800h (13.00 flowers/min). Minimum foraging rate was recorded at 0600h-0800h (12.56 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *H. armigera*ranged between 12.20 to 26.70 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *H. armigera* varied between 14.81 to 16.80 flowers/min corresponding to 2nd and 1stweek of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *H. armigera* was observed during 1stweek (16.80 flowers/min), followed by 3rdweek (14.93 flowers/min) and 2ndweek (14.81 flowers/min). Irrespective of weeks, mean foraging rate of *H. armigera* recorded during different times of a day revealed it to be significantly the maximum foraging rate (18.80 flowers/min) was recorded between 1200h-1400h followed by 1000h-1200h (16.76 flowers/min), 1400h-1600h (16.16 flowers/min), 0800h-1000h (15.53 flowers/min), 1600h-1800h (13.20 flowers/min) and 0600h-0800h (12.63 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *H. armigera* observed during 1stweek (16.05 flowers/min), followed by 3rdweek (14.99 flowers/min) and 2ndweek (14.88 flowers/min). Time wise, the foraging rate was significantly the maximum (17.28 flowers/min) at 1200h-1400h followed by 1000h-1200h (17.16 flowers/min), 1400h-1600h (16.13 flowers/min), 0800h-1000h (15.61 flowers/min), 1600h-1800h (13.10 flowers/min) and 0600h-0800h (12.60 flowers/min).

**4.2.26. Foraging speed of *Helicoverpa armigera* on Karonda during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Helicoverpa armigera* on Karonda flowers during 2014 have been narrated in Table 47. Foraging speed of *H. armigera*on Karonda recorded during different weeks over the times revealed that the foraging speed ranged between 1.19 to 3.73 seconds/flower. The mean weekly foraging speed ranged between 2.37 to 2.69 seconds/flower during the crop flowering, respectively (Table 47). It was found that maximum foraging speed recorded during 1st week (2.69 seconds/flower) followed by 3rd week (2.49 seconds/flower) and 2ndweek (2.37 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (3.22 seconds/flower) was recorded at 0600h-0800h followed at 1000h-1200h (2.93 seconds/flower), 1400h-1600h (2.45 seconds/flower), 0800h-1000h and 1600h-1800h (2.18 seconds/flower). Minimum foraging speed was recorded at 1200h-1400h (2.14 seconds/flower).

During 2015, the foraging speed of *H. armigera* ranged between 1.20 to 3.69 seconds/flower. Mean weekly foraging speed of *H. armigera* varied between 2.38 and 2.72 seconds/flower corresponding to 2ndand 1st week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *H. armigera*was observed during 1st week (2.72 seconds/ flower) followed by 3rd week (2.47 seconds/flower) and minimum foraging speed was observed at 2nd week (2.38 seconds/flower).The foraging speed

of *H. armigera* recorded during different times of a day revealed it to be significantly the maximum (3.23 seconds/ flower) between 0600h-0800h, followed by 1000h-1200h (3.13 seconds/flower), 1400h-1600h (2.42 seconds/flower), 1600h-1800h (2.31 seconds/flower) and 1200h-1400h (2.13 seconds/flower). Lowest foraging speed was recorded at 0800h-1000h (1.90 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*H. armigera* observed during 1st week (2.69 seconds/flower), followed by 3rdweek (2.49 seconds/flower) and 2nd week (2.37 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.22 seconds/flower) at 0600h-0800h followed by 1000h-1200h (3.03 seconds/flower), 1400h-1600h (2.43 seconds/flower), 1600h-1800h (2.25 seconds/flower) and 1200h-1400h (2.14 seconds/flower). Minimum foraging speed was recorded at 0800h-1000h (2.04 seconds/flower).

**Table 47 : Foraging speed of *Helicoverpa armigera* in Karonda during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 21/4/14 | 28/4/14 | 5/5/14 | Mean | 17/4/15 | 24/4/15 | 1/5/15 | Mean | Pooled mean |
| 0600-0800 | 3.25 (2.06) | 2.69 (1.92) | 3.73 (2.17) | 3.22 (2.05) | 3.00 (2.00) | 2.99 (1.99) | 3.69 (2.16) | 3.23 (2.05) | 3.22 (2.05) |
| 0800-1000 | 2.17 (1.77) | 2.01 (1.73) | 2.36 (1.83) | 2.18 (1.78) | 1.63 (1.62) | 2.02 (1.73) | 2.04 (1.74) | 1.90 (1.70) | 2.04 (1.74) |
| 1000-1200 | 3.03 (2.00) | 2.74 (1.93) | 3.03 (2.00) | 2.93 (1.97) | 3.70 (2.16) | 2.61 (1.89) | 3.08 (2.01) | 3.13 (2.02) | 3.03 (2.00) |
| 1200-1400 | 2.19 (1.78) | 1.94 (1.71) | 2.31 (1.82) | 2.14 (1.77) | 2.14 (1.77) | 1.92 (1.71) | 2.32 (1.82) | 2.13 (1.76) | 2.14 (1.77) |
| 1400-1600 | 2.33 (1.82) | 2.56 (1.88) | 2.46 (1.86) | 2.45 (1.85) | 2.29 (1.81) | 2.50 (1.87) | 2.47 (1.86) | 2.42 (1.84) | 2.43 (1.85) |
| 1600-1800 | 3.08 (2.02) | 2.26 (1.80) | 1.19 (1.48) | 2.18 (1.77) | 3.53 (2.12) | 2.20 (1.79) | 1.20 (1.48) | 2.31 (1.80) | 2.25 (1.78) |
| Mean | 2.67 (1.91) | 2.37 (1.83) | 2.51 (1.86) | 2.52 (1.86) | 2.72 (1.91) | 2.38 (1.83) | 2.47 (1.85) | 2.52 (1.86) | 15.31 (4.01) |
| Pooled mean | 2.69 (1.91) | 2.37 (1.83) | 2.49 (1.85) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.02 | N.S. |
| Week | 0.03 | 0.02 |
| Time | 0.04 | N.S. |
| Year x Week | 0.04 | 0.03 |
| Year X Time | 0.06 | 0.04 |
| Week x Time | 0.08 | 0.05 |
| Year x Week x Time | 0.11 | 0.07 |

**4. 2.27. Foraging rate of *Apis florea* on Karonda during 2014 and 2015**

Foraging rate (number of flowers of visited/min) of *Apis florea* on Karonda during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 48). Irrespective of different times of the day and weeks, the foraging rate ranged between 0.00 to 9.90 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 5.45 to 5.88 flowers/min corresponding to 2nd and 1stweek of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 1stweek (5.88 flowers/min) followed by 3rdweek (5.68 flowers/min) and 2ndweek (5.45 flowers/min). Irrespective of weeks, mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.23 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (7.36 flowers/min), 1400h-1600h (5.90 flowers/min), 1200h-1400h (5.60 flowers/min) and 0600h-0800h (4.36 flowers/min). Minimum foraging rate was recorded at 1600h-1800h (2.56 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *A. florea* ranged between 0.00 to 9.30 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *A. florea* varied between 4.08 to 5.58 flowers/min corresponding to 3rd and 1stweek of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *A. florea* was observed during 1stweek (5.58 flowers/min), followed by 2ndweek (5.40 flowers/min) and 3rd week (4.08 flowers/min). Irrespective of weeks, mean foraging rate of *A. florea* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.86 flowers/min) was recorded between 1000h-1200h followed by 1400h-1600h (5.83 flowers/min), 1200h-1400h (5.63 flowers/min), 0800h-1000h (4.43 flowers/min), 1600h-1800h (3.90 flowers/min) and 0600h-0800h (1.46 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. florea* observed during 1stweek (5.73 flowers/min), followed by 2ndweek (5.42 flowers/min) and 3rd week (4.88 flowers/min). Time wise, the foraging rate was significantly the maximum (8.55 flowers/min) at 1000h-1200h followed by 0800h-1000h (5.90 flowers/min), 1400h-1600h (5.86 flowers/min), 1200h-1400h (5.61 flowers/min), 1600h-1800h (3.23 flowers/min) and 0600h-0800h (2.91 flowers/min).

**4.2.28. Foraging speed of *Apis florae* on Karonda during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Apis florea* on Karonda flowers during 2014 have been narrated in Table 49. Foraging speed of *A. florea* on Karonda recorded during different weeks over the times revealed that the foraging speed ranged between 1.86 to 3.79 seconds/flower. The mean weekly foraging speed ranged between 2.44 to 2.88 seconds/flower

during the crop flowering, respectively (Table 49). It was found that maximum foraging speed recorded during 2nd week (2.88 seconds/flower) followed by 1st week (2.71 seconds/flower) and 3rd week (2.44 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (3.50 seconds/flower) was recorded at 1000h-1200h followed at 1200h-1400h (2.91 seconds/flower), 0800h-1000h (2.80 seconds/flower), 1600h-1800h (2.67 seconds/flower) and 1400h-1600h (2.11 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (2.09 seconds/flower).

During 2015, the foraging speed of *A. florea* ranged between 0.00 to 3.84 seconds/flower. Mean weekly foraging speed of *A. florea* varied between 1.75 and 2.90 seconds/flower corresponding to 3rd and 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *A. florea* was observed during 2nd week (2.90 seconds/ flower) followed by 1st week (2.28 seconds/flower) and minimum foraging speed was observed at 3rd week (1.75 seconds/flower). The foraging speed of *A. florea* recorded during different times of a day revealed it to be significantly the maximum (3.54 seconds/ flower) between 1000h-1200h, followed by 1200h-1400h (2.89 seconds/flower),1600h-1800h (2.53 seconds/flower), 0800h-1000h (2.12 seconds/flower) and 1400h-1600h (2.10 seconds/flower). Lowest foraging speed was recorded at 0600h-0800h (1.39 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *A. florea* observed during 1st week (1.40 seconds/flower), followed by 2nd week (0.88 seconds/flower) and 3rd week (1.29 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.06 seconds/flower) at 0600h-0800h followed by 0800h-1000h (1.47 seconds/flower), 1200h-1400h (1.33 seconds/flower), 1000h-1200h (1.13 seconds/flower) and 1600h-1800h (1.08 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (1.01 seconds/flower).

**Table 48 : Foraging rate of *Apis florea* in Karonda during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 21/4/14 | 28/4/14 | 5/5/14 | Mean | 17/4/15 | 24/4/15 | 1/5/15 | Mean | Pooled mean |
| 0600-0800 | 4.70 (2.38) | 3.80 (2.18) | 4.60 (2.35) | 4.36 (2.30) | 0.00 (1.00) | 4.40 (2.32) | 0.00 (1.00) | 1.46 (1.44) | 2.91 (1.87) |
| 0800-1000 | 7.90 (2.97) | 6.60 (2.75) | 7.60 (2.93) | 7.36 (2.88) | 7.20 (2.85) | 6.10 (2.66) | 0.00 (1.00) | 4.43 (2.17) | 5.90 (2.53) |
| 1000-1200 | 9.90 (3.29) | 8.60 (3.09) | 6.20 (2.67) | 8.23 (3.02) | 9.30 (3.20) | 8.30 (3.04) | 9.00 (3.16) | 8.86 (3.13) | 8.55 (3.08) |
| 1200-1400 | 6.00 (2.64) | 5.20 (2.48) | 5.60 (2.56) | 5.60 (2.56) | 6.40 (2.71) | 5.10 (2.46) | 5.40 (2.52) | 5.63 (2.57) | 5.61 (2.56) |
| 1400-1600 | 6.80 (2.78) | 4.90 (2.42) | 6.00 (2.64) | 5.90 (2.61) | 6.10 (2.66) | 5.10 (2.46) | 6.30 (2.69) | 5.83 (2.60) | 5.86 (2.61) |
| 1600-1800 | 0.00 (1.00) | 3.60 (2.13) | 4.10 (2.25) | 2.56 (1.79) | 4.50 (2.34) | 3.40 (2.09) | 3.80 (2.18) | 3.90 (2.20) | 3.23 (2.00) |
| Mean | 5.88 (2.51) | 5.45 (2.51) | 5.68 (2.57) | 5.67 (2.53) | 5.58 (2.46) | 5.40 (2.50) | 4.08 (2.09) | 5.02 (2.35) | 5.34 (2.44) |
| Pooled mean | 5.73 (2.49) | 5.42 (2.51) | 4.88 (2.33) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.02 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.05 |
| Year x Week | 0.01 | 0.05 |
| Year X Time | 0.02 | 0.07 |
| Week x Time | 0.03 | 0.08 |
| Year x Week x Time | 0.04 | 0.12 |

**Table 49 : Foraging speed of *Apis florea* in Karonda during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 21/4/14 | 28/4/14 | 5/5/14 | Mean | 17/4/15 | 24/4/15 | 1/5/15 | Mean | Pooled mean |
| 0600-0800 | 2.32 (1.82) | 2.08 (1.75) | 1.86 (1.68) | 2.09 (1.75) | 0.00 (1.00) | 2.06 (1.75) | 0.00 (1.00) | 0.68 (1.25) | 1.39 (1.50) |
| 0800-1000 | 3.09 (2.01) | 3.02 (2.00) | 2.29 (1.81) | 2.80 (1.94) | 3.22 (2.04) | 3.14 (2.03) | 0.00 (1.00) | 2.12 (1.69) | 2.46 (1.82) |
| 1000-1200 | 3.70 (2.16) | 3.79 (2.19) | 3.01 (2.00) | 3.50 (2.11) | 3.70 (2.16) | 3.84 (2.20) | 3.07 (2.01) | 3.54 (2.12) | 3.52 (2.12) |
| 1200-1400 | 2.73 (1.93) | 3.08 (2.01) | 2.90 (1.97) | 2.91 (1.97) | 2.73 (1.93) | 3.02 (2.00) | 2.91 (1.97) | 2.89 (1.97) | 2.90 (1.97) |
| 1400-1600 | 2.18 (1.78) | 2.17 (2.78) | 1.97 (1.72) | 2.11 (1.76) | 2.19 (1.78) | 2.18 (1.78) | 1.93 (1.71) | 2.10 (1.76) | 2.10 (1.76) |
| 1600-1800 | 2.26 (1.80) | 3.15 (2.03) | 2.60 (1.89) | 2.67 (1.91) | 1.82 (1.67) | 3.16 (2.03) | 2.61 (1.89) | 2.53 (1.87) | 2.60 (1.89) |
| Mean | 2.71 (1.92) | 2.88 (1.96) | 2.44 (1.85) | 2.68 (1.91) | 2.28 (1.76) | 2.90 (1.96) | 1.75 (1.60) | 2.31 (1.77) | 2.49 (1.84) |
| Pooled mean | 2.50 (1.84) | 2.89 (1.96) | 2.10 (1.72) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0..01 |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | 0.03 |
| Year X Time | 0.01 | 0.04 |
| Week x Time | 0.01 | 0.05 |
| Year x Week x Time | 0.02 | 0.07 |

### 4.2.29. Foraging rate of *Catopsilia pyranthe* on Bael during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Catopsilia pyranthe* on Bael during 2014 atdifferent times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager has been recorded (Table 50). Irrespective of different times of the day and weeks, the foraging rate ranged between 1.50 to 10.00 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 4.06 to 4.90 flowers/min corresponding to 1$^{st}$and 2$^{nd}$week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2$^{nd}$ week (4.90 flowers/min) followed by 3$^{rd}$week (4.25 flowers/min) and 1$^{st}$week (4.06 flowers/min). Irrespective of weeks, mean foraging rate of *C. pyranthe* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.13 flowers/min) was recorded between 1000h-1200h followed by 1200h-1400h

(5.63flowers/min), 0800h-1000h (4.26 flowers/min), 1400h-1600h (3.96 flowers/min), 0600h-0800h (2.60 flowers/min) and 1600h-1800h (1.70 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *C. pyranthe* ranged between 1.40 to 6.30 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *C. pyranthe* varied between 2.88 to 3.93 flowers/min corresponding to 1st and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *C. pyranthe* was observed during 2nd week (3.93 flowers/min), followed by 3rd week (3.90 flowers/min) and 1st week (2.88 flowers/min). Irrespective of weeks, mean foraging rate of *C. pyranthe* recorded during different times of a day revealed it to be significantly the maximum foraging rate (4.96 flowers/min) was recorded between 0800h-1000h and 1400h-1600h followed by 1000h-1200h (4.00 flowers/min), 0600-0800h (2.80 flowers/min), 1200h-1400h (2.76 flowers/min)and 1600h-1800h (1.93 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *C. pyranthe* observed during 2nd week (4.41 flowers/min), followed by 3rd week (4.07 flowers/min) and 1st week (3.47 flowers/min). Time wise, the foraging rate was significantly the maximum (6.06 flowers/min) at 1000h-1200h followed by 0800h-1000h (4.61 flowers/min), 1400h-1600h (4.46 flowers/min), 1200h-1400h (4.20 flowers/min), 0600h-0800h (2.70 flowers/min) and 1600h-1800h (1.88 flowers/min).

**4.2.30. Foraging speed of *Catopsilia pyranthe*on Bael during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Catopsilia pyranthe* on Bael flowers during 2014 have been narrated in Table 51. Foraging speed of *C. pyranthe*on Bael recorded during different weeks over the times revealed that the foraging speed ranged between 3.30 to 19.58 seconds/flower. The mean weekly foraging speed ranged between 8.77 to 9.48 seconds/flower during the crop flowering, respectively (Table 51). It was found that maximum foraging speed recorded during 3rd week (9.48 seconds/flower) followed by 1st week (9.06 seconds/flower) and 2nd week (8.77 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (16.78 seconds/flower) was recorded at 1600h-1800h followed at 0800h-1000h (10.34 seconds/flower), 1000h-1200h (9.61 seconds/flower), 1400h-1600h (9.38 seconds/flower) and 1200h-1400h (4.27 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (4.24 seconds/flower).

During 2015, the foraging speed of *C. pyranthe* ranged between 3.76 to 17.56 seconds/flower. Mean weekly foraging speed of *C. pyranthe* varied between 8.35 and 8.95 seconds/flower corresponding to 1st and 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *C. pyranthe*was observed during 2nd week (8.95 seconds/ flower) followed by 3rd week (8.37 seconds/flower) and minimum foraging speed was observed at 1st week (8.35 seconds/flower). The foraging speed

of *C. pyranthe* recorded during different times of a day revealed it to be significantly the maximum (15.04 seconds/ flower) between 1600h-1800h, followed

by 0800h-1000h (10.37 seconds/flower), 1400h-1600h (9.36 seconds/flower, 1000h-1200h (8.39 seconds/flower) and 1200h-1400h (4.20 seconds/flower). Lowest forging speed was recorded at 0600h -0800h (3.99 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*C. pyranthe* observed during 1st week (8.71 seconds/flower), followed by 2nd week (8.86 seconds/flower). Minimum foraging speed was observed during 1st week (8.71 seconds/flower). Time wise, the foraging speed was significantly the maximum (15.91 seconds/flower) at 1600h-1800h followed by 0800h-1000h (10.36 seconds/flower), 1400h-1600h (9.37 seconds/flower),1000h-1200h (9.00 seconds/flower) and 1200h-1400h (4.23 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (4.11 seconds/flower).

**Table 50: Foraging rate of *Catopsilia pyranthe* in Bael during May 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 2.50 (1.86) | 3.10 (2.01) | 2.20 (1.78) | 2.60 (1.88) | 1.40 (1.54) | 2.80 (1.93) | 4.20 (2.27) | 2.80 (1.91) | 2.70 (1.90) |
| 0800-1000 | 3.80 (2.18) | 3.90 (2.20) | 5.10 (2.46) | 4.26 (2.28) | 3.30 (2.06) | 6.30 (2.69) | 5.30 (2.50) | 4.96 (2.42) | 4.61 (2.35) |
| 1000-1200 | 10.00 (3.31) | 5.90 (2.62) | 8.50 (3.07) | 8.13 (3.00) | 4.10 (2.25) | 4.00 (2.23) | 3.90 (2.20) | 4.00 (2.22) | 6.06 (2.61) |
| 1200-1400 | 4.00 (2.23) | 9.40 (3.22) | 3.50 (2.11) | 5.63 (2.52) | 2.90 (1.96) | 2.80 (1.94) | 2.60 (1.89) | 2.76 (1.93) | 4.20 (2.22) |
| 1400-1600 | 2.60 (1.89) | 4.80 (2.40) | 4.50 (2.34) | 3.96 (2.21) | 3.70 (2.16) | 5.20 (2.48) | 6.00 (2.64) | 4.96 (2.43) | 4.46 (2.32) |
| 1600-1800 | 1.50 (1.57) | 2.30 (1.80) | 1.70 (1.63) | 1.83 (1.67) | 1.90 (1.69) | 2.50 (1.86) | 1.40 (1.54) | 1.93 (1.69) | 1.88 (1.68) |
| Mean | 4.06 (2.17) | 4.90 (2.37) | 4.25 (2.23) | 4.40 (2.26) | 2.88 (1.94) | 3.93 (2.19) | 3.90 (2.17) | 3.57 (2.10) | 3.98 (2.18) |
| Pooled mean | 3.47 (2.06) | 4.41 (2.28) | 4.07 (2.20) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SE(m) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | 0.06 |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.15 |

**4. 2.31. Foraging rate of *Apis dorsata* on Bael during 2014 and 2015**

Foraging rate (number of flowers of visited/min) of *Apisdorsata* on Bael during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 52). Irrespective of different times of the day and weeks, the foraging rate ranged between 4.20 to 12.80 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 7.01 to 8.95 flowers/min corresponding to 3rdand 2nd week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2ndweek (8.95 flowers/min) followed by 1stweek (8.60 flowers/min) and 3rdweek (7.01 flowers/min). Irrespective of weeks, mean foraging rate of *A. dorsata* recorded during different times of a day revealed it to be significantly the maximum foraging rate (10.86 flowers/min) was recorded between 0800h-1000hfollowed by 1400h-1600h (10.70 flowers/min), 1000h-1200h (9.23 flowers/min), 1200h-1400h (6.63 flowers/min), 1600h-1800h (6.36 flowers/min) and 0600h-0800h (5.33 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *A.dorsata* ranged between 2.90 to 10.00 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *A. dorsata* varied between 5.56 to 6.78 flowers/min corresponding to 1st and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *A. dorsata* was observed during 2nd week (6.78 flowers/min), followed by 3rd week (5.71 flowers/min) and 1st week (5.56 flowers/min). Irrespective of weeks, mean foraging rate of *A. dorsata* recorded during different times of a day revealed it to be significantly the maximum foraging rate (9.00 flowers/min) was recorded between 0800h-1000h followed by 1400h-1600h (6.93 flowers/min), 1000-1200h (6.86 flowers/min), 0600h-0800h (5.00 flowers/min), 1200h-1400h (4.30 flowers/min) and 1600h-1800h (4.03 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. dorsata* observed during 2nd week (7.86 flowers/min), followed by 1stweek (7.08 flowers/min) and 3rdweek (6.36 flowers/min). Time wise, the foraging rate was significantly the maximum (9.93 flowers/min) at 0800h-1000h followed by 1400h-1600h (8.81 flowers/min), 1000h-1200h (8.05 flowers/min), 1200h-1400h (5.46 flowers/min), 1600h-1800h (5.20 flowers/min) and 0600h-0800h (5.16 flowers/min).

**4.2.32. Foraging speed of *Apis dorsata* on Bael during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Apis dorsata*on Bael flowers during 2014 have been narrated in Table 53. Foraging speed of *A. dorsata*on Bael recorded during different weeks over the times revealed that the foraging speed ranged between 2.95 to 14.39 seconds/flower. The mean weekly foraging speed ranged between 5.05 to 5.63 seconds/flower during the crop flowering, respectively (Table 53). It was found that maximum foraging speed

recorded during 3rd week (5.63 seconds/flower) followed by 2nd week (5.58 seconds/flower) and 1st week (5.05 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (9.89 seconds/flower) was recorded at 1600h-1800h followed at 1000h-1200h (6.01 seconds/flower), 1200h-1400h (5.54 seconds/flower), 0800h-1000h (3.75 seconds/flower) and 0600h-0800h (3.68 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (3.63 seconds/flower).

During 2015, the foraging speed of *A. dorsata* ranged between 2.74 to 7.92 seconds/flower. Mean weekly foraging speed of *A. dorsata* varied between 4.30 and 5.03 seconds/flower corresponding to 3rdand 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *A. dorsata*was observed during 2nd week (5.03 seconds/ flower) followed by 1st week (4.93 seconds/flower) and minimum foraging speed was observed at 3rd week (4.30 seconds/flower). The foraging speed of *A. dorsata* recorded during different times of a day revealed it to be significantly the maximum (6.91 seconds/ flower) between 1600h-1800h, followed by 1000h-1200h (5.94 seconds/flower), 1200h-1400h (5.00 seconds/flower), 0800h-1000h (3.82 seconds/flower) and 1400h-1600h (3.75 seconds/flower). Lowest forging speed was recorded at 0600h -0800h (3.09 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*A. dorsata* observed during 2ndweek (5.31 seconds/flower), followed by 1stweek (4.99 seconds/flower). Minimum foraging speed was observed during 3rdweek (4.96 seconds/flower). Time wise, the foraging speed was significantly the maximum (8.40 seconds/flower) at 1600h-1800h followed by 1000h-1200h (5.98 seconds/flower), 1200h-1400h (5.27 seconds/flower), 0800h-1000h (3.78 seconds/flower) and 1400h-1600h (3.69 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (3.39 seconds/flower).

**Table 51 : Foraging speed of *Catopsilia pyranthe* in Bael during May 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 4.69 (2.38) | 3.30 (2.07) | 4.71 (2.38) | 4.24 (2.28) | 3.96 (2.22) | 3.76 (2.15) | 4.24 (2.25) | 3.99 (2.21) | 4.11 (2.24) |
| 0800-1000 | 10.94 (3.45) | 13.02 (3.73) | 7.07 (2.84) | 10.34 (3.34) | 11.25 (3.49) | 13.09 (3.74) | 6.76 (2.76) | 10.37 (3.33) | 10.36 (3.33) |
| 1000-1200 | 5.95 (2.62) | 10.26 (3.34) | 12.63 (3.69) | 9.61 (3.21) | 4.81 (2.40) | 9.92 (3.27) | 10.45 (3.34) | 8.39 (3.01) | 9.00 (3.11) |
| 1200-1400 | 4.29 (2.29) | 3.73 (2.16) | 4.80 (2.40) | 4.27 (2.29) | 4.11 (2.22) | 4.50 (2.30) | 3.97 (2.22) | 4.20 (2.25) | 4.23 (2.27) |
| 1400-1600 | 8.93 (3.14) | 9.49 (3.23) | 9.71 (3.25) | 9.38 (3.21) | 8.41 (3.06) | 9.87 (3.29) | 9.81 (3.28) | 9.36 (3.21) | 9.37 (3.21) |
| 1600-1800 | 19.58 (4.52) | 12.83 (3.71) | 17.93 (4.34) | 16.78 (4.19) | 17.56 (4.24) | 12.56 (3.65) | 15.00 (3.96) | 15.04 (3.95) | 15.91 (4.07) |
| Mean | 9.06 (3.07) | 8.77 (3.04) | 9.48 (3.15) | 9.10 (3.09) | 8.35 (2.94) | 8.95 (3.07) | 8.37 (2.97) | 8.56 (2.99) | 8.83 (3.04) |
| Pooled mean | 8.71 (3.00) | 8.86 (3.05) | 8.93 (3.06) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.02 | 0.06 |
| Week | 0.02 | N.S. |
| Time | 0.04 | 0.11 |
| Year x Week | 0.04 | 0.11 |
| Year X Time | 0.05 | N.S. |
| Week x Time | 0.07 | 0.19 |
| Year x Week x Time | 0.10 | N.S. |

**Table 52 : Foraging rate of *Apis dorsata* in Bael during May 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 5.30 (2.50) | 5.40 (2.52) | 5.30 (2.50) | 5.33 (2.50) | 4.70 (2.37) | 5.50 (2.54) | 4.80 (2.39) | 5.00 (2.44) | 5.16 (2.47) |
| 0800-1000 | 9.50 (3.23) | 12.80 (3.71) | 10.30 (3.35) | 10.86 (3.43) | 7.70 (2.94) | 10.00 (3.31) | 9.30 (3.20) | 9.00 (3.15) | 9.93 (3.29) |
| 1000-1200 | 9.70 (3.25) | 10.20 (3.34) | 7.80 (2.96) | 9.23 (3.18) | 5.90 (2.62) | 6.70 (2.77) | 8.00 (2.99) | 6.86 (2.79) | 8.05 (2.99) |
| 1200-1400 | 6.70 (2.76) | 9.00 (3.16) | 4.20 (2.27) | 6.63 (2.73) | 3.40 (2.09) | 6.00 (2.64) | 3.50 (2.11) | 4.30 (2.28) | 5.46 (2.50) |
| 1400-1600 | 12.20 (3.62) | 10.20 (3.33) | 9.70 (3.26) | 10.70 (3.41) | 7.30 (2.87) | 7.70 (2.94) | 5.80 (2.60) | 6.93 (2.80) | 8.81 (3.11) |
| 1600-1800 | 8.20 (3.02) | 6.10 (2.66) | 4.80 (2.39) | 6.36 (2.69) | 4.40 (2.31) | 4.80 (2.39) | 2.90 (1.94) | 4.03 (2.22) | 5.20 (2.45) |
| Mean | 8.60 (3.07) | 8.95 (3.12) | 7.01 (2.79) | 8.18 (2.99) | 5.56 (2.53) | 6.78 (2.76) | 5.71 (2.54) | 6.02 (2.61) | 7.10 (2.80) |
| Pooled mean | 7.08 (2.80) | 7.86 (2.94) | 6.36 (2.66) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.04 |
| Week | 0.01 | 0.05 |
| Time | 0.02 | 0.07 |
| Year x Week | 0.02 | 0.07 |
| Year X Time | 0.03 | 0.10 |
| Week x Time | 0.04 | 0.12 |
| Year x Week x Time | 0.06 | 0.17 |

**Table 53 : Foraging speed of *Apis dorsata* in Bael during May 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 3.85 (2.19) | 3.96 (2.22) | 3.24 (2.05) | 3.68 (2.16) | 3.39 (2.09) | 2.74 (1.93) | 3.14 (2.03) | 3.09 (2.02) | 3.39 (2.09) |
| 0800-1000 | 4.20 (2.27) | 3.13 (2.03) | 3.92 (2.21) | 3.75 (2.17) | 4.75 (2.39) | 3.33 (2.08) | 3.37 (2.08) | 3.82 (2.18) | 3.78 (2.18) |
| 1000-1200 | 7.55 (2.92) | 7.32 (2.88) | 3.16 (2.04) | 6.01 (2.61) | 7.92 (2.98) | 6.65 (2.76) | 3.26 (2.06) | 5.94 (2.60) | 5.98 (2.60) |
| 1200-1400 | 5.69 (2.58) | 5.92 (2.63) | 5.02 (2.45) | 5.54 (2.55) | 4.85 (2.41) | 5.79 (2.60) | 4.35 (2.30) | 5.00 (2.44) | 5.27 (2.49) |
| 1400-1600 | 2.95 (1.98) | 3.91 (2.21) | 4.03 (2.24) | 3.63 (2.14) | 3.68 (2.16) | 2.80 (1.94) | 4.78 (2.40) | 3.75 (2.17) | 3.69 (2.15) |
| 1600-1800 | 6.04 (2.64) | 9.23 (3.19) | 14.39 (3.43) | 9.89 (3.09) | 4.98 (2.44) | 8.87 (3.14) | 6.90 (2.81) | 6.91 (2.79) | 8.40 (2.94) |
| Mean | 5.05 (2.43) | 5.58 (2.53) | 5.63 (2.40) | 5.42 (2.45) | 4.93 (2.41) | 5.03 (2.41) | 4.30 (2.28) | 4.75 (2.37) | 5.08 (2.41) |
| Pooled mean | 4.99 (2.42) | 5.31 (2.47) | 4.96 (2.34) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.02 | 0.07 |
| Week | 0.03 | 0.09 |
| Time | 0.04 | 0.12 |
| Year x Week | 0.04 | N.S. |
| Year X Time | 0.06 | N.S. |
| Week x Time | 0.07 | 0.22 |
| Year x Week x Time | 0.11 | N.S. |

### 4. 2.33. Foraging rate of *Belenois aurota* on Bael during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Belenois aurota*on Bael during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager has been recorded (Table 54). Irrespective of different times of the day and weeks, the foraging rate ranged between 2.50 to 10.00 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 4.90 to 7.03 flowers/min corresponding to 1$^{st}$and 2$^{nd}$ week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2$^{nd}$ week (7.03 flowers/min) followed by 3$^{rd}$week (6.35 flowers/min) and 1$^{st}$week (4.90 flowers/min). Irrespective of weeks, mean foraging rate of *B. aurota* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.10 flowers/min) was recorded between 0600h-0800h followed by 1000h-1200h (7.36 flowers/min), 0800h-1000h and 1200h-1400h (6.36 flowers/min) and 1400h-1600h (5.53 flowers/min). Minimum foraging rate was recorded at 1600h-1800h (2.83 flowers/min).

During 2015**,** Irrespective of different times of the day and weeks, the forging rate of *B. aurota*ranged between 1.60 to 9.40 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *B. aurota* varied between 4.35 to 5.23 flowers/min corresponding to 1st and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *B. aurota* was observed during 2nd week (5.23 flowers/min), followed by 3rd week (4.63 flowers/min) and 1st week (4.35 flowers/min). Irrespective of weeks, mean foraging rate of *B. aurota* recorded during different times of a day revealed it to be significantly the maximum foraging rate (6.56 flowers/min) was recorded between 0800h-1000h followed by 1000h-1200h (6.53 flowers/min), 0600-0800h (5.86 flowers/min), 1400h-1600h (4.63 flowers/min), 1200h-1400h (3.13 flowers/min) and 1600h-1800h (1.70 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *B. aurota* observed during 2nd week (6.13 flowers/min), followed by 3rdweek (5.49 flowers/min) and 1stweek (4.62 flowers/min). Time wise, the foraging rate was significantly the maximum (6.98 flowers/min) at 0600h-0800h followed by 1000h-1200h (6.95 flowers/min), 0800h-1000h (6.46 flowers/min), 1400h-1600h (5.08 flowers/min), 1200h-1400h (4.75 flowers/min) and 1600h-1800h (2.26 flowers/min).

**4.2.34. Foraging speed of *Belenois aurota* on Bael during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Belenois aurota*on Bael flowers during 2014 have been narrated in Table 55. Foraging speed of *B. aurota*on Bael recorded during different weeks over the times revealed that the foraging speed ranged between 3.00 to 33.46 seconds/flower. The mean weekly foraging speed ranged between 8.69 to 11.89 seconds/flower during the crop flowering, respectively (Table 55). It was found that maximum foraging speed recorded during 2ndweek (11.89 seconds/flower) followed by 3rd week (8.75 seconds/flower) and 1st week (8.69 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (19.55 seconds/flower) was recorded at 1600h-1800h followed at 1400h-1600h (13.10 seconds/flower), 1200h-1400h (8.20 seconds/flower), 1000h-1200h (7.21 seconds/flower) and 0800h-1000h (6.07 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (4.51 seconds/flower).

During 2015, the foraging speed of *B. aurota* ranged between 2.83 to 30.76 seconds/flower. Mean weekly foraging speed of *B. aurota* varied between 8.39 and 11.26 seconds/flower corresponding to 3rd and 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *B. aurota*was observed during 2nd week (11.26 seconds/ flower) followed by 1st week (8.49 seconds/flower) and minimum foraging speed was observed at 3rdweek (8.39 seconds/flower). The foraging speed of *B. aurota* recorded during different times of a day revealed it to be significantly the

maximum (18.83 seconds/ flower) between 1600h-1800h, followed by 1400h-1600h (12.39 seconds/flower), 1200h-1400h (7.43 seconds/flower), 1000h-1200h (6.94 seconds/flower) and 0800h-1000h (6.74 seconds/flower). Lowest foraging speed was recorded at 0600h -0800h (3.94 seconds/flower.

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*B. aurota* observed during 2nd week (11.58 seconds/flower), followed by 1st week (8.59 seconds/flower). Minimum foraging speed was observed during 3rd week (8.57 seconds/flower). Time wise, the foraging speed was significantly the maximum (19.19 seconds/flower) at 1600h-1800h followed by 1400h-1600h (12.74 seconds/flower), 1200h-1400h (7.81 seconds/flower), 1000h-1200h (7.07 seconds/flower) and 0800h-1000h (6.41 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (4.23 seconds/flower).

**Table 54 : Foraging rate of*Belenois aurota* .in Bael during May 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 7.50 (2.91) | 6.80 (2.78) | 10.00 (3.31) | 8.10 (3.00) | 7.40 (2.89) | 3.40 (2.09) | 6.80 (2.79) | 5.86 (2.59) | 6.98 (2.79) |
| 0800-1000 | 4.40 (2.31) | 8.10 (3.00) | 6.60 (2.74) | 6.36 (2.68) | 5.90 (2.62) | 9.40 (3.22) | 4.40 (2.31) | 6.56 (2.72) | 6.46 (2.70) |
| 1000-1200 | 4.40 (2.31) | 9.80 (3.28) | 7.90 (2.96) | 7.36 (2.85) | 3.70 (2.16) | 8.10 (3.01) | 7.80 (2.96) | 6.53 (2.71) | 6.95 (2.78) |
| 1200-1400 | 5.10 (2.46) | 8.30 (3.04) | 5.70 (2.56) | 6.36 (2.69) | 2.70 (1.91) | 3.70 (2.16) | 3.00 (1.99) | 3.13 (2.02) | 4.75 (2.35) |
| 1400-1600 | 5.50 (2.54) | 6.20 (2.66) | 4.90 (2.42) | 5.53 (2.54) | 4.60 (2.36) | 5.10 (2.46) | 4.20 (2.27) | 4.63 (2.36) | 5.08 (2.45) |
| 1600-1800 | 2.50 (1.86) | 3.00 (1.99) | 3.00 (1.98) | 2.83 (1.94) | 1.80 (1.65) | 1.70 (1.63) | 1.60 (1.60) | 1.70 (1.63) | 2.26 (1.78) |
| Mean | 4.90 (2.40) | 7.03 (2.79) | 6.35 (2.66) | 6.09 (2.62) | 4.35 (2.27) | 5.23 (2.43) | 4.63 (2.32) | 4.73 (2.34) | 5.41 (2.48) |
| Pooled mean | 4.62 (2.33) | 6.13 (2.61) | 5.49 (2.49) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed value**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.04 |
| Week | 0.01 | 0.05 |
| Time | 0.02 | 0.07 |
| Year x Week | 0.02 | 0.07 |
| Year X Time | 0.03 | 0.10 |
| Week x Time | 0.04 | 0.12 |
| Year x Week x Time | 0.06 | 0.18 |

**Table 55 : Foraging speed of *Belenois aurota.*in Bael during May 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 5.18 (248) | 3.00 (1.99) | 5.37 (2.52) | 4.51 (2.33) | 4.85 (2.41) | 2.83 (1.95) | 4.14 (2.26) | 3.94 (2.21) | 4.23 (2.27) |
| 0800-1000 | 6.53 (2.73) | 5.33 (2.51) | 6.36 (2.69) | 6.07 (2.65) | 6.91 (2.81) | 5.27 (2.50) | 8.05 (3.00) | 6.74 (2.77) | 6.41 (2.71) |
| 1000-1200 | 4.51 (2.34) | 6.74 (2.77) | 10.38 (3.36) | 7.21 (2.82) | 3.85 (2.20) | 8.08 (3.01) | 8.87 (3.14) | 6.94 (2.78) | 7.07 (2.80) |
| 1200-1400 | 7.97 (2.99) | 8.71 (3.10) | 7.91 (2.98) | 8.20 (3.02) | 7.37 (2.89) | 7.06 (2.83) | 7.85 (2.97) | 7.43 (2.90) | 7.81 (2.96) |
| 1400-1600 | 11.49 (3.51) | 14.11 (3.87) | 13.71 (3.83) | 13.10 (3.73) | 10.58 (3.39) | 13.56 (3.81) | 13.02 (3.74) | 12.39 (3.65) | 12.74 (3.69) |
| 1600-1800 | 16.44 (4.09) | 33.46 (5.83) | 8.76 (3.11) | 19.55 (4.34) | 17.36 (2.24) | 30.76 (5.63) | 8.38 (3.06) | 18.83 (4.31) | 19.19 (4.33) |
| Mean | 8.69 (3.02) | 11.89 (3.34) | 8.75 (3.08) | 9.77 (3.15) | 8.49 (2.99) | 11.26 (3.29) | 8.39 (3.03) | 9.38 (3.10) | 9.57 (3.12) |
| Pooled mean | 8.59 (3.01) | 11.58 (3.32) | 8.57 (3.05) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.02 | N.S. |
| Week | 0.02 | 0.06 |
| Time | 0.03 | 0.09 |
| Year x Week | 0.03 | N.S. |
| Year X Time | 0.05 | N.S. |
| Week x Time | 0.06 | 0.17 |
| Year x Week x Time | 0.08 | 0.24 |

**Table 56 : Foraging rate of *Megachilecephalotes* in Bael during May 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 0.00 (1.00) | 1.50 (1.57) | 1.50 (1.57) | 1.00 (1.38) | 0.00 (1.00) | 1.20 (1.47) | 1.40 (1.54) | 0.86 (1.30) | 0.93 (1.36) |
| 0800-1000 | 7.00 (2.82) | 6.00 (2.64) | 7.70 (2.94) | 6.90 (2.80) | 6.50 (2.73) | 6.30 (2.69) | 7.20 (2.85) | 6.66 (2.76) | 6.78 (2.78) |
| 1000-1200 | 6.20 (2.68) | 8.10 (3.00) | 6.10 (2.66) | 6.80 (2.78) | 5.80 (2.60) | 7.50 (2.90) | 5.80 (2.60) | 6.36 (2.70) | 6.58 (2.74) |
| 1200-1400 | 3.90 (2.20) | 4.20 (2.27) | 3.30 (2.07) | 3.80 (2.18) | 4.30 (2.30) | 4.20 (2.27) | 2.90 (1.97) | 3.80 (2.18) | 3.80 (2.18) |
| 1400-1600 | 3.60 (2.14) | 6.60 (2.73) | 4.70 (2.38) | 4.96 (2.42) | 3.30 (2.07) | 5.70 (2.58) | 4.30 (2.29) | 4.43 (2.31) | 4.70 (2.36) |
| 1600-1800 | 8.90 (3.13) | 10.00 (3.31) | 7.80 (2.96) | 8.90 (3.13) | 8.70 (3.10) | 9.50 (3.23) | 7.70 (2.94) | 8.63 (3.09) | 8.76 (3.11) |
| Mean | 4.93 (2.33) | 6.06 (2.59) | 5.18 (2.43) | 5.39 (2.45) | 4.76 (2.30) | 5.73 (2.53) | 4.88 (2.36) | 5.12 (2.40) | 5.25 (2.35) |
| Pooled mean | 4.85 (2.31) | 5.90 (2.56) | 5.03 (2.40) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.05 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.03 | N.S. |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | N.S. |

### 4. 2.35. Foraging rate of *Megachile cephalotes* on Bael during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Megachile cephalotes* on Bael during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 56). Irrespective of different times of the day and weeks, the foraging rate ranged between 0.00 to 10.00 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 4.93 to 6.06 flowers/min corresponding to 1$^{st}$ and 2$^{nd}$ week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2$^{nd}$ week (6.06 flowers/min) followed by 3$^{rd}$ week (5.18 flowers/min) and 1$^{st}$ week (4.93 flowers/min). Irrespective of weeks, mean foraging rate of *M. cephalotes* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.90 flowers/min) was recorded between 1600h-1800h followed by 0800h-1000h (6.90 flowers/min), 1000h-1200h (6.80 flowers/min), 1400h-1600h (4.96 flowers/min) and 1200h-

1400h (3.80 flowers/min). Minimum foraging rate was recorded at 0600h-0800h (1.00 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *M. cephalotes* ranged between 0.00 to 9.50 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *M. cephalotes* varied between 4.76 to 5.73 flowers/min corresponding to 1st and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *M. cephalotes* was observed during 2nd week (5.73 flowers/min), followed by 3rd week (4.88 flowers/min) and 1st week (4.76 flowers/min). Irrespective of weeks, mean foraging rate of *M. cephalotes* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.63 flowers/min) was recorded between 1600h-1800h followed by 0800h-1000h (6.66 flowers/min), 1000h-1200h (6.36 flowers/min), 1400h-1600h (4.43 flowers/min), 1200h-1400h (3.80 flowers/min) and 0600h-0800h (0.86 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *M. cephalotes* observed during 2nd week (9.69 flowers/min), followed by 3rd week (8.97 flowers/min) and 1st week (6.90 flowers/min). Time wise, the foraging rate was significantly the maximum (15.43 flowers/min) at 0600h-0800h followed by 1200h-1400h (10.79 flowers/min), 1000h-1200h (6.58 flowers/min), 1400h-1600h (4.70 flowers/min), 1200h-1400h (3.80 flowers/min) and 0600h-0800h (0.93 flowers/min).

**Table 57 : Foraging speed of *Megachilecephalotes* in Bael during May 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 4/5/14 | 11/5/14 | 18/5/14 | Mean | 2/5/15 | 9/5/15 | 16/5/15 | Mean | Pooled mean |
| 0600-0800 | 0.00 (1.00) | 25.65 (5.15) | 21.08 (4.69) | 15.57 (3.61) | 0.00 (1.00) | 24.68 (5.06) | 21.20 (4.71) | 15.29 (3.59) | 15.43 (3.60) |
| 0800-1000 | 2.97 (1.99) | 1.98 (1.72) | 3.20 (2.04) | 2.72 (1.92) | 2.83 (1.95) | 2.00 (1.73) | 3.16 (2.04) | 2.67 (1.91) | 2.69 (1.91) |
| 1000-1200 | 3.01 (2.00) | 2.63 (1.89) | 2.82 (1.95) | 2.82 (1.94) | 2.88 (1.96) | 2.88 (1.96) | 2.99 (1.99) | 2.92 (1.97) | 2.87 (1.96) |
| 1200-1400 | 9.99 (3.31) | 11.41 (3.51) | 10.85 (3.44) | 10.75 (3.42) | 9.98 (3.31) | 11.50 (3.53) | 11.00 (3.46) | 10.83 (3.43) | 10.79 (3.43) |
| 1400-1600 | 16.01 (4.11) | 7.69 (2.92) | 6.22 (2.68) | 9.97 (3.24) | 15.67 (4.08) | 8.24 (3.03) | 6.32 (2.70) | 10.08 (3.27) | 10.03 (3.25) |
| 1600-1800 | 9.62 (3.25) | 8.62 (3.10) | 9.33 (3.21) | 9.19 (3.18) | 9.82 (3.28) | 8.65 (3.10) | 9.52 (3.24) | 9.33 (3.21) | 9.26 (3.20) |
| Mean | 6.93 (2.61) | 9.66 (3.05) | 8.92 (3.00) | 8.50 (2.89) | 6.86 (2.60) | 9.66 (3.07) | 9.03 (3.02) | 8.52 (2.90) | 8.51 (2.89) |
| Pooled mean | 6.90 (2.60) | 9.66 (3.06) | 8.97 (3.01) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | N.S. |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.05 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.02 | N.S. |
| Week x Time | 0.03 | 0.09 |
| Year x Week x Time | 0.05 | N.S. |

### 4.2.36. Foraging speed of *Megachile cephalotes* on Bael during 2014 and 2015

The data on foraging speed, i.e., time spent by *Megachile cephalotes* on Bael flowers during 2014 have been narrated in Table 57. Foraging speed of *M. cephalotes* on Bael recorded during different weeks over the times revealed that the foraging speed ranged between 0.00 to 25.65 seconds/flower. The mean weekly foraging speed ranged between 6.93 to 9.66 seconds/flower during the crop flowering, respectively (Table 57). It was found that maximum foraging speed recorded during 2$^{nd}$ week (9.66 seconds/flower) followed by 3$^{rd}$ week (8.92 seconds/flower) and 1$^{st}$ week (6.93 seconds/flower).

As far as time of the day were concerned, significantly the maximum foraging speed (15.57 seconds/flower) was recorded at 0600h-0800h followed at 1200h-1400h (10.75 seconds/flower), 1400h-1600h (9.97 seconds/flower), 1600h-1800h (91.8 seconds/flower) and 1000h-1200h (2.82 seconds/flower). Minimum foraging speed was recorded at 0800h-1000h (2.72 seconds/flower).

During 2015, the foraging speed of *M. cephalotes* ranged between 0.00 to 24.68 seconds/flower. Mean weekly foraging speed of *M. cephalotes* varied between 6.86 and

9.66seconds/flower corresponding to 1st and 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *M. cephalotes* was observed during 2nd week (9.66 seconds/ flower) followed by 3rdweek (9.03 seconds/flower) and minimum foraging speed was observed at 1stweek (6.86 seconds/flower). The foraging speed of *M. cephalotes* recorded during different times of a day revealed it to be significantly the maximum (15.29 seconds/ flower) between 0600h-0800h, followed by 1200h-1400h (10.83 seconds/flower), 1400h-1600h (10.08 seconds/flower), 1600h-1800h (9.33 seconds/flower) and 1000h-1200h (2.92 seconds/flower). Lowest foraging speed was recorded at 0800h - 1000h (2.67 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *M. cephalotes* observed during 2ndweek (9.66 seconds/flower), followed by 3rdweek (8.97 seconds/flower). Minimum foraging speed was observed during 1stweek (6.90 seconds/flower). Time wise, the foraging speed was significantly the maximum (15.43 seconds/flower) at 0600h-0800h followed by 1200h-1400h (10.79 seconds/flower), 1400h-1600h (10.03 seconds/flower), 1600h-1800h (9.26 seconds/flower) and 1000h-1200h (2.87 seconds/flower). Minimum foraging speed was recorded at 0800h-1000h (2.69 seconds/flower).

**4. 2.37. Foraging rate of *Chrysomya megacephala*on Jamun during 2014 and 2015**

Foraging rate (number of flowers of visited/min) of *Chrysomya megacephala* on Jamun during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 58). Irrespective of different times of the day and weeks, the foraging rate ranged between 5.10 to 12.10 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 7.51 to 8.36 flowers/min corresponding to 1stand 2nd, 3rdweek of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2ndand 3rd week (8.36 flowers/min) followed by 1st week (7.51 flowers/min). Irrespective of weeks, mean foraging rate of *C. megacephala* recorded during different times of a day revealed it to be significantly the maximum foraging rate (8.90 flowers/min) was recorded between 0800h-1000h followed by 0600h-0800h (8.83 flowers/min), 1000h-1200h (8.66 flowers/min), 1600h-1800h (8.00 flowers/min), 1600h-1800h (7.76 flowers/min) and 1200h-1400h (6.33 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *C. megacephala*ranged between 4.20 to 13.90 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *C. megacephala* varied between 7.78 to 8.98 flowers/min corresponding to 1st and 3rdweek of crop blooming period, respectively. Significantly the

maximum mean foraginig rate of *C. megacephala* was observed during 3rdweek (8.98 flowers/min), followed by 2ndweek (8.36 flowers/min) and 1st week (7.78 flowers/min). Irrespective of weeks, mean foraging rate of *C. megacephala* recorded during different times of a day revealed it to be significantly the maximum foraging rate (9.93 flowers/min) was recorded between 0600h-0800h followed by 1600h-1800h (9.30 flowers/min), 1000h-1200h (8.53 flowers/min), 0800h-1000h (8.03 flowers/min), 1400h-1600h (7.50 flowers/min) and 1200h-1400h (6.96 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *C. megacephala* observed during 3rdweek (8.67 flowers/min), followed by 2ndweek (8.36 flowers/min) and 1stweek (7.65 flowers/min). Time wise, the foraging rate was significantly the maximum (9.38 flowers/min) at 0600h-0800h followed by 1600h-1800h (8.65 flowers/min), 1000h-1200h (8.60 flowers/min), 0800h-1000h (8.46 flowers/min), 1400h-1600h (7.63 flowers/min) and 1200h-1400h (6.65 flowers/min).

**4.2.38. Foraging speed of *Chrysomya megacephala* on Jamun during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Chrysomya megacephala* on Jamun flowers during 2014 have been narrated in Table 59. Foraging speed of *C. megacephala*on Jamun recorded during different weeks over the times revealed that the foraging speed ranged between 2.36 to 13.63 seconds/flower. The mean weekly foraging speed ranged between 4.33 to 8.97seconds/flower during the crop flowering, respectively (Table 59). It was found that maximum foraging speed recorded during 1stweek (5.63 seconds/flower) followed by 2nd week (6.67 seconds/flower) and 3rdweek (4.33 seconds/flower).As far as time of the day were concerned, significantly the maximum foraging speed (8.17 seconds/flower) was recorded at 0800h-1000h followed at 1600h-1800h (8.14 seconds/flower), 0600h-0800h (7.04 seconds/flower), 1200h-1400h (6.28 seconds/flower) and 1000h-1200h (6.05 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (4.25 seconds/flower).

During 2015, the foraging speed of *C. megacephala* ranged between 2.54 to 11.24 seconds/flower. Mean weekly foraging speed of *C. megacephala* varied between 4.06 and 8.64 seconds/flower corresponding to 3rd and 1stweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *C. megacephala*was observed during 1stweek (8.64 seconds/ flower) followed by 2nd week (6.62 seconds/flower) and minimum foraging speed was observed at 3rdweek (4.06 seconds/flower). The foraging speed of *C. megacephala* recorded during different times of a day revealed it to be significantly the maximum (7.56 seconds/ flower) between 0800h-1000h, followed by 1600h-1800h (7.24 seconds/flower), 1000h-1200h (6.59 seconds/flower), 0600h-0800h (6.56 seconds/flower) and 1200h-1400h (5.84 seconds/flower). Lowest forging speed was recorded at 1400h -1600h (4.85 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*C. megacephala* observed during 1st week (8.80 seconds/flower), followed by 2nd week (6.65 seconds/flower). Minimum foraging speed was observed during 3rd week (4.20 seconds/flower). Time wise, the foraging speed was significantly the maximum (7.86 seconds/flower) at 0800h-1000h followed by 1600h-1800h (7.69 seconds/flower), 0600h-0800h (6.80 seconds/flower), 1000h-1200h (6.32 seconds/flower) and 1200h-1400h (6.06seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (4.55 seconds/flower).

**Table 58 : Foraging rate of *Chrysomya megacephala* in Jamun during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 20/4/14 | 28/4/14 | 5/5/14 | Mean | 23/4/15 | 29/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 7.90 (2.97) | 11.70 (3.55) | 6.90 (2.80) | 8.83 (3.11) | 6.00 (2.64) | 9.90 (3.29) | 13.90 (3.85) | 9.93 (3.26) | 9.38 (3.19) |
| 0800-1000 | 9.00 (3.15) | 7.60 (2.92) | 10.10 (3.32) | 8.90 (3.13) | 9.80 (3.28) | 4.20 (2.27) | 10.10 (3.32) | 8.03 (2.96) | 8.46 (3.04) |
| 1000-1200 | 7.20 (2.86) | 11.80 (3.57) | 7.00 (2.82) | 8.66 (3.08) | 7.20 (2.86) | 11.90 (3.59) | 6.50 (2.73) | 8.53 (3.06) | 8.60 (3.07) |
| 1200-1400 | 6.90 (2.80) | 6.20 (2.67) | 5.90 (2.62) | 6.33 (2.70) | 8.20 (3.02) | 7.30 (2.87) | 5.40 (2.52) | 6.96 (2.81) | 6.65 (2.75) |
| 1400-1600 | 5.10 (2.46) | 6.10 (2.65) | 12.10 (3.61) | 7.76 (2.91) | 5.90 (2.62) | 8.50 (3.07) | 8.10 (3.01) | 7.50 (2.90) | 7.63 (2.90) |
| 1600-1800 | 9.00 (3.15) | 6.80 (2.78) | 8.20 (3.03) | 8.00 (2.99) | 9.60 (3.25) | 8.40 (3.06) | 9.90 (3.29) | 9.30 (3.20) | 8.65 (3.09) |
| Mean | 7.51 (2.90) | 8.36 (3.03) | 8.36 (3.03) | 8.08 (2.99) | 7.78 (2.94) | 8.36 (3.03) | 8.98 (3.12) | 8.37 (3.03) | 8.22 (3.01) |
| Pooled mean | 7.65 (2.92) | 8.36 (3.03) | 8.67 (3.08) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.14 |

**Table 59 : Foraging speed of *Chrysomya megacephala* in Jamun during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 20/4/14 | 28/4/14 | 5/5/14 | Mean | 23/4/15 | 29/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 8.32 (3.05) | 6.88 (2.80) | 5.93 (2.63) | 7.04 (2.82) | 8.66 (3.10) | 7.89 (2.98) | 3.13 (2.03) | 6.56 (2.70) | 6.80 (2.76) |
| 0800-1000 | 9.88 (3.28) | 9.98 (3.30) | 4.65 (2.37) | 8.17 (2.98) | 8.35 (3.05) | 9.93 (3.29) | 4.40 (2.31) | 7.56 (2.89) | 7.86 (2.93) |
| 1000-1200 | 9.96 (3.31) | 5.83 (2.61) | 2.36 (1.82) | 6.05 (2.58) | 9.10 (3.17) | 8.14 (3.01) | 2.54 (1.87) | 6.59 (2.68) | 6.32 (2.63) |
| 1200-1400 | 6.97 (2.82) | 7.11 (2.84) | 4.77 (2.40) | 6.28 (2.69) | 6.56 (2.74) | 6.63 (2.76) | 4.33 (2.30) | 5.84 (2.60) | 6.06 (2.64) |
| 1400-1600 | 5.04 (2.45) | 5.02 (2.45) | 2.69 (1.91) | 4.25 (2.27) | 7.91 (2.98) | 2.74 (1.92) | 3.81 (2.21) | 4.85 (2.37) | 4.55 (2.32) |
| 1600-1800 | 13.63 (3.81) | 5.19 (2.48) | 5.59 (2.56) | 8.14 (2.95) | 11.24 (3.49) | 4.42 (2.32) | 6.07 (2.65) | 7.24 2.82) | 7.69 (2.89) |
| Mean | 8.97 (3.12) | 6.67 (2.75) | 4.33 (2.28) | 6.65 (2.72) | 8.64 (3.09) | 6.62 (2.71) | 4.06 (2.23) | 6.44 (2.68) | 6.54 (2.70) |
| Pooled mean | 8.80 (3.10) | 6.65 (2.73) | 4.20 (2.25) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.05 |
| Year x Week | 0.02 | N.S. |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.14 |

**4. 2.39. Foraging rate of *Eristalinus obliquus*on Jamun during 2014 and 2015**

Foraging rate (number of flowers of visited/min) of *Eristalinus obliquus* on Jamun during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 60). Irrespective of different times of the day and weeks, the foraging rate ranged between 4.20 to 14.20 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 7.96 to 8.85 flowers/min corresponding to 1$^{st}$and 3$^{rd}$week of the crop flowering, respectively.It was found that maximum foraging rate was recorded during 3$^{rd}$ week (8.85 flowers/min) followed by 2$^{nd}$week (8.83 flowers/min) and 1$^{st}$week (7.96 flowers/min).Irrespective of weeks, mean foraging rate of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum foraging rate (12.63 flowers/min) recorded between 1400h-1600h followed by 1000h-1200h (11.50 flowers/min), 1600h-1800h (8.03 flowers/min), 0800h-1000h (7.63 flowers/min), 1200h-1400h (6.60 flowers/min) and 0600h-0800h (4.90 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *E. obliquus*ranged between 4.50 to 14.20 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *E. obliquus* varied between 7.13 to 9.35 flowers/min corresponding to 2nd and 1stweek of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *E. obliquus* was observed during 1stweek (9.35 flowers/min), followed by 3rd week (8.76 flowers/min) and 1st week (7.13 flowers/min). Irrespective of weeks, mean foraging rate of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum foraging rate (10.60 flowers/min) was recorded between 1400h-1600h followed by 1000h-1200h (10.06 flowers/min), 1200h-1400h (8.90 flowers/min), 1600h-1800h (8.00 flowers/min).Minimum foraging rate (6.46 flowers/min) was observed at 0600h-0800h and 1600h-1800h.

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *E. obliquus* observed during 3rdweek (8.80 flowers/min), followed by 1st week (8.65 flowers/min) and 2ndweek (7.98 flowers/min). Time wise, the foraging rate was significantly the maximum (11.61 flowers/min) at 1400h-1600h followed by 1000h-1200h (10.78 flowers/min), 1600h-1800h (8.01 flowers/min), 1200h-1400h (7.75 flowers/min), 0800h-1000h (7.05 flowers/min) and 0600h-0800h (5.68 flowers/min).

**4.2.40. Foraging speed of *Eristalinus obliquus* on Jamun during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Eristalinus obliquus* on Jamun flowers during 2014 have been narrated in Table 61. Foraging speed of *E. obliquus*on Jamun recorded during different weeks over the times revealed that the foraging speed ranged between 2.99 to 14.76 seconds/flower. The mean weekly foraging speed ranged between 5.85 to 10.15 seconds/flower during the crop flowering, respectively (Table 61). It was found that maximum foraging speed recorded during 1stweek (10.15 seconds/flower) followed by 2nd week (6.88 seconds/flower) and 3rdweek (5.85 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (9.76 seconds/flower) was recorded at 1000h-1200h followed at 1200h-1400h (9.65 seconds/flower), 1600h-1800h (9.32 seconds/flower), 0800h-1000h (7.23 seconds/flower) and 1400h-1600h (5.33 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (4.46 seconds/flower).

During 2015, the foraging speed of *E. obliquus* ranged between 3.10 to 12.92 seconds/flower. Mean weekly foraging speed of *E. obliquus* varied between 5.72 and 9.43 seconds/flower corresponding to 2nd and 3rdweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *E. obliquus*was observed during 1stweek (9.43 seconds/ flower) followed by 3rd week (5.81 seconds/flower) and minimum foraging speed was observed at 2ndweek (5.72 seconds/flower).

The foraging speed of *E. obliquus* recorded during different times of a day revealed it to be significantly the maximum (9.32 seconds/ flower) between 1200h-1400h, followed by

1600h-1800h (8.59 seconds/flower), 0800h-1000h (7.28 seconds/flower), 1000h-1200h (6.05 seconds/flower) and 1400h-1600h (6.03 seconds/flower). Lowest forging speed was recorded at 0600h -0800h (4.64 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of*E. obliquus* observed during 1st week (9.79 seconds/flower), followed by 2nd week (6.30 seconds/flower). Minimum foraging speed was observed during 3rd week (5.83 seconds/flower). Time wise, the foraging speed was significantly the maximum (9.48 seconds/flower) at 1200h-1400h followed by 1600h-1800h (8.96 seconds/flower), 1000h-1200h (7.91 seconds/flower), 0800h-1000h (7.26 seconds/flower) and 1400h-1600h (5.68 seconds/flower). Minimum foraging speed was recorded at 0600h-0800h (4.55 seconds/flower).

**Table 60 : Foraging rate of *Eristalinus obliquus* in Jamun during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 20/4/14 | 28/4/14 | 5/5/14 | Mean | 23/4/15 | 29/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 4.20 (2.27) | 4.80 (2.40) | 5.70 (2.58) | 4.90 (2.42) | 4.50 (2.34) | 4.50 (2.34) | 10.40 (3.37) | 6.46 (2.68) | 5.68 (2.55) |
| 0800-1000 | 8.20 (3.03) | 6.80 (2.78) | 7.90 (2.97) | 7.63 (2.93) | 7.90 (2.97) | 6.60 (2.75) | 4.90 (2.41) | 6.46 (2.71) | 7.05 (2.82) |
| 1000-1200 | 10.90 (3.44) | 12.40 (3.65) | 11.20 (3.48) | 11.50 (3.53) | 11.20 (3.48) | 6.80 (2.78) | 12.20 (3.62) | 10.06 (3.29) | 10.78 (3.41) |
| 1200-1400 | 5.50 (2.54) | 8.50 (3.07) | 5.80 (2.60) | 6.60 (2.74) | 10.00 (3.31) | 9.30 (3.19) | 7.40 (2.89) | 8.90 (3.13) | 7.75 (2.93) |
| 1400-1600 | 11.80 (3.57) | 11.90 (3.58) | 14.20 (3.89) | 12.63 (3.68) | 14.20 (3.89) | 8.20 (3.03) | 9.40 (3.22) | 10.60 (3.38) | 11.61 (3.53) |
| 1600-1800 | 7.20 (2.85) | 8.60 (3.09) | 8.30 (3.04) | 8.03 (3.00) | 8.30 (3.04) | 7.40 (2.89) | 8.30 (3.04) | 8.00 (2.99) | 8.01 (2.99) |
| Mean | 7.96 (2.95) | 8.83 (3.10) | 8.85 (3.09) | 8.55 (3.05) | 9.35 (3.17) | 7.13 (2.83) | 8.76 (3.09) | 8.41 (3.03) | 8.48 (3.04) |
| Pooled mean | 8.65 (3.06) | 7.98 (2.96) | 8.80 (3.09) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | N.S. |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | 0.06 |
| Year X Time | 0.03 | 0.09 |
| Week x Time | 0.04 | 0.11 |
| Year x Week x Time | 0.05 | 0.15 |

**Table 61 : Foraging speed of *Eristalinus obliquus* in Jamun during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 20/4/14 | 28/4/14 | 5/5/14 | Mean | 23/4/15 | 29/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 3.85 (2.19) | 3.83 (2.19) | 5.70 (2.58) | 4.46 (2.32) | 4.07 (2.24) | 4.70 (2.38) | 5.16 (2.47) | 4.64 (2.36) | 4.55 (2.34) |
| 0800-1000 | 9.88 (3.28) | 6.73 (2.77) | 5.09 (2.46) | 7.23 (2.84) | 10.16 (3.34) | 8.06 (3.01) | 3.62 (2.14) | 7.28 (2.83) | 7.26 (2.83) |
| 1000-1200 | 14.76 (3.96) | 11.45 (3.52) | 3.07 (2.01) | 9.76 (3.16) | 11.15 (3.48) | 3.91 (2.21) | 3.10 (2.02) | 6.05 (2.57) | 7.91 (2.87) |
| 1200-1400 | 13.38 (3.79) | 3.89 (2.21) | 11.68 (3.55) | 9.65 (3.18) | 12.40 (3.64) | 3.33 (2.07) | 12.23 (3.63) | 9.32 (3.12) | 9.48 (3.15) |
| 1400-1600 | 5.71 (2.59) | 7.30 (2.88) | 2.99 (1.99) | 5.33 (2.48) | 5.90 (2.62) | 7.61 (2.93) | 4.58 (2.36) | 6.03 (2.63) | 5.68 (2.56) |
| 1600-1800 | 13.33 (3.78) | 8.09 (3.00) | 6.55 (2.74) | 9.32 (3.17) | 12.92 (3.73) | 6.72 (2.77) | 6.13 (2.66) | 8.59 (3.05) | 8.96 (3.11s) |
| Mean | 10.15 (3.26) | 6.88 (2.76) | 5.85 (2.56) | 7.63 (2.86) | 9.43 (3.17) | 5.72 (2.56) | 5.81 (2.55) | 6.99 (2.76) | 7.31 (2.81) |
| Pooled mean | 9.79 (3.22) | 6.30 (2.66) | 5.83 (2.55) | | | | | | |

**Each value represents mean of 10 observations**

***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | 0.06 |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.14 |

### 4. 2.41. Foraging rate of *Musca* sp.on Jamun during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Musca* sp. on Jamun during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 62). Irrespective of different times of the day and weeks, the foraging rate ranged between 2.60 to 11.00 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 4.33 to 6.70 flowers/min corresponding to 1$^{st}$and 3$^{rd}$week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 3$^{rd}$week (6.70 flowers/min) followed by 2$^{nd}$week (4.36 flowers/min) and 1$^{st}$week (4.33 flowers/min). Irrespective of weeks, mean foraging rate of *Musca* sp. recorded during different times of a day revealed it to be significantly the maximum foraging rate (9.33 flowers/min) was recorded between 1400h-1600h followed by 0800h-1000h (6.20 flowers/min), 1600h-1800h (5.06 flowers/min), 1000h-1200h (3.90flowers/min), 1200h-1400h (3.23 flowers/min) and 0600h-0800h (3.06 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *Musca* sp. ranged between 2.40 to 9.50 flowers/min. Irrespective of times of the day, mean

weekly foraging rate of*Musca* sp. varied between 3.98 to 6.10 flowers/min corresponding to 2nd and 3rd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *Musca* sp. was observed during 3rd week (6.10 flowers/min), followed by 1st week (4.78 flowers/min) and 2nd week (3.98 flowers/min). Irrespective of weeks, mean foraging rate of *Musca* sp. recorded during different times of a day revealed it to be significantly the maximum foraging rate (9.06 flowers/min) was recorded between 1400h-1600h followed by 0800h-1000h (4.76 flowers/min), 1600-1800h (4.73 flowers/min), 1000h-1200h (4.03 flowers/min), 1200h-1400h (3.73 flowers/min) and 0600h-0800h (3.40 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *Musca* sp.was observed during 3rd week (6.40 flowers/min), followed by 1st week (4.55 flowers/min) and 2nd week (4.17 flowers/min). Time wise, the foraging rate was significantly the maximum (9.20 flowers/min) at 1400h-1600h followed by 0800h-1000h (5.48 flowers/min), 1600h-1800h (4.90 flowers/min), 1000h-1200h (3.96 flowers/min), 1200h-1400h (3.48 flowers/min) and 0600h-0800h (3.23 flowers/min).

**4.2.42. Foraging speed of *Musca* sp. on Jamun during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Musca* sp. on Jamun flowers during 2014 have been narrated in Table 63. Foraging speed of *Musca* sp. on Jamun recorded during different weeks over the times revealed that the foraging speed ranged between 4.70 to 14.57 seconds/flower. The mean weekly foraging speed ranged between 8.67 to 10.55 seconds/flower during the crop flowering (Table 63). It was found that maximum foraging speed recorded during 2nd week (10.55 seconds/flower) followed by 1st week (10.07 seconds/flower) and 3rd week (8.67 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (13.33 seconds/flower) was recorded at 0600h-0800h followed at 0800h-1000h (11.27 seconds/flower), 1000h-1200h (10.03 seconds/flower), 1600h-1800h (9.96 seconds/flower) and 1200h-1400h (7.80 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (6.21 seconds/flower).

During 2015, the foraging speed of *Musca* sp. ranged between 4.78 to 13.66 seconds/flower. Mean weekly foraging speed of *Musca* sp. varied between 8.34 and 10.06 seconds/flower corresponding to 3rd and 2nd week of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *Musca* sp. was observed during 2nd week (10.06 seconds/ flower) followed by 1st week (9.60 seconds/flower) and minimum foraging speed was observed at 3rd week (8.34 seconds/flower).The foraging speed of *Musca* sp. recorded during different times of a day revealed it to be significantly the maximum (12.39 seconds/ flower) between 0600h-0800h, followed by 0800h-1000h (10.89 seconds/flower), 1000h-1200h (9.46 seconds/flower), 1600h-1800h (9.30 seconds/flower) and

1200h-1400h (8.09 seconds/flower). Lowest forging speed was recorded at 1400h -1600h (5.87 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *Musca* sp. observed during 2nd week (10.34 seconds/flower), followed by 1st week (9.84 seconds/flower). Minimum foraging speed was observed during 3rd week (8.51 seconds/flower). Time wise, the foraging speed was significantly the maximum (12.86 seconds/flower) at 0600h-0800h followed by 0800h-1000h (11.08 seconds/flower), 1000h-1200h (9.75 seconds/flower), 1600h-1800h (9.63 seconds/flower) and 1200h-1400h (7.95 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (6.04 seconds/flower).

**Table 62 : Foraging rate of *Musca* sp. in Jamun during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 20/4/14 | 28/4/14 | 5/5/14 | Mean | 23/4/15 | 29/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 2.60 (1.89) | 3.00 (1.99) | 3.60 (2.14) | 3.06 (2.00) | 3.40 (2.09) | 2.70 (1.91) | 4.10 (2.25) | 3.40 (2.08) | 3.23 (2.04) |
| 0800-1000 | 4.20 (2.27) | 3.40 (2.09) | 11.00 (3.02) | 6.20 (2.46) | 5.40 (2.52) | 3.40 (2.09) | 5.50 (2.54) | 4.76 (2.38) | 5.48 (2.42) |
| 1000-1200 | 3.60 (2.14) | 3.20 (2.04) | 4.90 (2.42) | 3.90 (2.20) | 4.20 (2.27) | 2.40 (1.83) | 5.50 (2.54) | 4.03 (2.22) | 3.96 (2.21) |
| 1200-1400 | 2.60 (1.89) | 3.60 (2.14) | 3.50 (2.11) | 3.23 (2.05) | 2.70 (1.92) | 4.50 (2.34) | 4.00 (2.23) | 3.73 (2.16) | 3.48 (2.10) |
| 1400-1600 | 9.00 (3.16) | 9.20 (3.19) | 9.80 (3.28) | 9.33 (3.21) | 9.50 (3.23) | 8.40 (3.06) | 9.30 (3.20) | 9.06 (3.17) | 9.20 (3.19) |
| 1600-1800 | 4.00 (2.22) | 3.80 (2.18) | 7.40 (2.89) | 5.06 (2.43) | 3.50 (2.11) | 2.50 (1.86) | 8.20 (3.03) | 4.73 (2.33) | 4.90 (2.38) |
| Mean | 4.33 (2.26) | 4.36 (2.27) | 6.70 (2.64) | 5.13 (2.39) | 4.78 (2.36) | 3.98 (2.18) | 6.10 (2.63) | 4.95 (2.39) | 5.04 (2.39) |
| Pooled mean | 4.55 (2.31) | 4.17 (2.23) | 6.40 (2.64) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.02 | N.S. |
| Week | 0.03 | 0.08 |
| Time | 0.04 | 0.11 |
| Year x Week | 0.04 | N.S. |
| Year X Time | 0.06 | N.S. |
| Week x Time | 0.07 | 0.20 |
| Year x Week x Time | 0.10 | 0.28 |

**Table 63 : Foraging speed of *Musca* sp. in Jamun during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 20/4/14 | 28/4/14 | 5/5/14 | Mean | 23/4/15 | 29/4/15 | 6/5/15 | Mean | Pooled mean |
| 0600-0800 | 14.07 (3.88) | 12.41 (3.66) | 13.50 (3.80) | 13.33 (3.78) | 13.04 (3.74) | 11.73 (3.56) | 12.41 (3.66) | 12.39 (3.65) | 12.86 (3.72) |
| 0800-1000 | 12.67 (3.69) | 10.88 (3.44) | 10.27 (3.35) | 11.27 (3.50) | 12.83 (3.71) | 10.10 (3.33) | 9.72 (3.27) | 10.89 (3.44) | 11.08 (3.47) |
| 1000-1200 | 10.75 (3.42) | 10.26 (3.35) | 9.08 (3.17) | 10.03 (3.31) | 9.89 (3.29) | 9.47 (3.23) | 9.03 (3.16) | 9.46 (3.23) | 9.75 (3.27) |
| 1200-1400 | 8.49 (3.08) | 6.83 (2.79) | 8.07 (3.01) | 7.80 (2.96) | 8.76 (3.12) | 7.68 (2.94) | 7.84 (2.97) | 8.09 (3.01) | 7.95 (2.98) |
| 1400-1600 | 5.55 (2.55) | 8.37 (3.05) | 4.70 (2.38) | 6.21 (2.66) | 5.11 (2.46) | 7.71 (2.94) | 4.78 (2.40) | 5.87 (2.60) | 6.04 (2.63) |
| 1600-1800 | 8.91 (3.14) | 14.57 (3.94) | 6.40 (2.71) | 9.96 (3.27) | 7.98 (2.99) | 13.66 (3.82) | 6.27 (2.69) | 9.30 (3.17) | 9.63 (3.22) |
| Mean | 10.07 (3.29) | 10.55 (3.27) | 8.67 (3.07) | 9.77 (3.25) | 9.60 (3.22) | 10.06 (3.30) | 8.34 (3.02) | 9.33 (3.18) | 9.55 (3.21) |
| Pooled mean | 9.84 (3.26) | 10.30 (3.34) | 8.51 (3.05) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.02 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.02 | 0.06 |
| Week x Time | 0.02 | 0.07 |
| Year x Week x Time | 0.03 | N.S. |

### 4. 2.43. Foraging rate of *Papilio demoleus* on Sarpagandha during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Papilio demoleus* on Sarpagandha during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 64). Irrespective of different times of the day and weeks, the foraging rate ranged between 19.30 to 32.10 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 22.78 to 25.28 flowers/min corresponding to 1$^{st}$ and 2$^{nd}$ week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2$^{nd}$week (25.28 flowers/min) followed by 3$^{rd}$ week (23.90 flowers/min) and 1$^{st}$ week (22.78 flowers/min). Irrespective of weeks, mean foraging rate of *P. demoleus* recorded during

different times of a day revealed it to be significantly the maximum foraging rate (28.03 flowers/min) was recorded between 0800h-1000h followed by 1200h-1400h (25.43 flowers/min), 1400h-1600h (25.03 flowers/min), 1000h-1200h (24.40 flowers/min) and 1600h-1800h (21.23 flowers/min). Minimum foraging rate was recorded at 0600h-0800h (19.80 flowers/min).During 2015, Irrespective of different times of the day and weeks, the forging rate of *P. demoleus* ranged between 12.00 to 29.50 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *P. demoleus* varied between 20.61 to 24.90 flowers/min corresponding to 1st and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *P. demoleus* was observed during 2nd week (24.90 flowers/min), followed by 3rd week (22.01 flowers/min) and 1st week (20.61 flowers/min). Irrespective of weeks, mean foraging rate of *P. demoleus* recorded during different times of a day revealed it to be significantly the maximum foraging rate (26.60 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (25.86 flowers/min), 1200h-1400h (24.63 flowers/min), 1400h-1600h (21.80 flowers/min), 1600h-1800h (18.66 flowers/min) and 0600h-0800h (17.50 flowers/min).The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *P. demoleus* observed during 2nd week (25.09 flowers/min), followed by 3rd week (22.95 flowers/min) and 1st week (21.70 flowers/min). Time wise, the foraging rate was significantly the maximum (26.95 flowers/min) at 0800h-1000h followed by 1000h-1200h (25.50 flowers/min), 1200h-1400h (25.03 flowers/min), 1400h-1600h (23.41 flowers/min), 1600h-1800h (19.95 flowers/min) and 0600h-0800h (18.65 flowers/min).

**4.2.44. Foraging speed of *Papilio demoleus* on Sarpagandha during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Papilio demoleus* on Sarpagandha flowers during 2014 have been narrated in Table 65. Foraging speed of *P. demoleus* on Sarpagandha recorded during different weeks over the times revealed that the foraging speed ranged between 1.02 to 2.62 seconds/flower. The mean weekly foraging speed ranged between 1.54 to 1.61 seconds/flower during the crop flowering, respectively (Table 65). It was found that maximum foraging speed recorded during 3rdweek (1.61 seconds/flower) followed by 2ndweek (1.60 seconds/flower) and 1st week (1.54 seconds/flower).As far as time of the day were concerned, significantly the maximum foraging speed (2.10 seconds/flower) was recorded at 1400h-1600h followed at 1600h-1800h (1.94 seconds/flower), 0600h-0800h (1.78 seconds/flower), 1200h-1400h (1.26 seconds/flower) and 0800h-1000h (1.25 seconds/flower). Minimum foraging speed was recorded at 1000h-1200h (1.17 seconds/flower).

During 2015, the foraging speed of *P. demoleus* ranged between 1.05 to 2.91 seconds/flower. Mean weekly foraging speed of *P. demoleus* varied between 1.57 and 1.72 seconds/flower corresponding to 1st and 3rdweek of crop blooming period, respectively. Week

wise, significantly the maximum mean foraginig speed of *P. demoleus* was observed during 3rdweek (1.72 seconds/ flower) followed by 2ndweek (1.58 seconds/flower) and minimum foraging speed was observed at 1st week (1.57 seconds/flower). The foraging speed of *P. demoleus* recorded during different times of a day revealed it to be significantly the maximum (2.14 seconds/ flower) between 1400h-1600h, followed by 1600h-1800h (1.94 seconds/flower), 0600h-0800h (1.76 seconds/flower), 1200h-1400h (1.35 seconds/flower) and 0800h-1000h (1.30 seconds/flower). Lowest foraging speed was recorded at 1000h -1200h (1.25 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *P. demoleus* observed during 3rdweek (1.67 seconds/flower), followed by 2ndweek (1.59 seconds/flower). Minimum foraging speed was observed during 1st week (1.55 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.12 seconds/flower) at 1400h-1600h followed by 1600h-1800h (1.94 seconds/flower), 0600h-0800h (1.77 seconds/flower), 1200h-1400h (1.31 seconds/flower) and 0800h-1000h (1.28 seconds/flower). Minimum foraging speed was recorded at 1000h-1200h (1.21 seconds/flower).

**Table 64: Foraging rate of *Papilio demoleus* in Sarpagandha during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 28/4/14 | 5/5/14 | 12/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 15.50 (4.05) | 22.70 (4.86) | 21.20 (4.70) | 19.80 (4.54) | 12.00 (3.60) | 21.60 (4.75) | 18.90 (4.45) | 17.50 (4.27) | 18.65 (4.40) |
| 0800-1000 | 24.40 (5.03) | 31.70 (5.71) | 28.00 (5.38) | 28.03 (5.37) | 22.80 (4.87) | 29.50 (5.52) | 25.30 (5.12) | 25.86 (5.17) | 26.95 (5.27) |
| 1000-1200 | 21.10 (4.69) | 25.50 (5.14) | 26.60 (5.25) | 24.40 (5.03) | 24.90 (5.08) | 29.30 (5.50) | 25.60 (5.15) | 26.60 (5.24) | 25.50 (5.14) |
| 1200-1400 | 24.30 (5.02) | 24.70 (5.06) | 27.30 (5.31) | 25.43 (5.13) | 23.50 (4.94) | 25.70 (5.16) | 24.70 (5.06) | 24.63 (5.05) | 25.03 (5.09) |
| 1400-1600 | 32.10 (5.75) | 23.00 (4.89) | 20.00 (4.58) | 25.03 (5.07) | 25.80 (5.17) | 21.00 (4.68) | 18.60 (4.42) | 21.80 (4.76) | 23.41 (4.91) |
| 1600-1800 | 19.30 (4.50) | 24.10 (5.00) | 20.30 (4.60) | 21.23 (4.70) | 14.70 (3.96) | 22.30 (4.81) | 19.00 (4.46) | 18.66 (4.41) | 19.95 (4.56) |
| Mean | 22.78 (4.84) | 25.28 (5.11) | 23.90 (4.97) | 23.98 (4.97) | 20.61 (4.60) | 24.90 (5.07) | 22.01 (4.78) | 22.51 (4.82) | 23.24 (4.89) |
| Pooled mean | 21.70 (4.72) | 25.09 (5.09) | 22.95 (4.88) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.03 |
| Week | 0.01 | 0.04 |
| Time | 0.02 | 0.06 |
| Year x Week | 0.02 | 0.06 |
| Year X Time | 0.03 | 0.08 |
| Week x Time | 0.03 | 0.10 |
| Year x Week x Time | 0.05 | 0.15 |

**Table 65: Foraging speed of *Papilio demoleus* in Sarpagandha during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 28/4/14 | 5/5/14 | 12/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 2.03 (1.73) | 2.03 (1.73) | 1.28 (1.51) | 1.78 (1.66) | 2.13 (1.76) | 2.06 (1.74) | 1.09 (1.44) | 1.76 (1.65) | 1.77 (1.65) |
| 0800-1000 | 1.02 (1.42) | 1.38 (1.54) | 1.35 (1.53) | 1.25 (1.49) | 1.10 (1.45) | 1.43 (1.55) | 1.38 (1.54) | 1.30 (1.51) | 1.28 (1.50) |
| 1000-1200 | 1.37 (1.54) | 1.03 (1.42) | 1.10 (1.45) | 1.17 (1.47) | 1.36 (1.53) | 0.98 (1.40) | 1.40 (1.54) | 1.25 (1.49) | 1.21 (1.48) |
| 1200-1400 | 1.25 (1.50) | 1.26 (1.50) | 1.29 (1.51) | 1.26 (1.50) | 1.38 (1.54) | 1.28 (1.51) | 1.39 (1.54) | 1.35 (1.53) | 1.31 (1.51) |
| 1400-1600 | 1.08 (1.44) | 2.62 (1.90) | 2.60 (1.89) | 2.10 (1.74) | 1.05 (1.43) | 2.46 (1.86) | 2.91 (1.97) | 2.14 (1.75) | 2.12 (1.75) |
| 1600-1800 | 2.47 (1.86) | 1.29 (1.51) | 2.06 (1.75) | 1.94 (1.70) | 2.41 (1.84) | 1.26 (1.50) | 2.15 (1.77) | 1.94 (1.70) | 1.94 (1.70) |
| Mean | 1.54 (1.58) | 1.60 (1.60) | 1.61 (1.60) | 1.58 (1.59) | 1.57 (1.59) | 1.58 (1.59) | 1.72 (1.63) | 1.62 (1.61) | 1.60 (1.60) |
| Pooled mean | 1.55 (1.58) | 1.59 (1.60) | 1.67 (1.62) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SE m (±) | C.D. |
|---|---|---|
| Year | 0.00 | N.S. |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.01 | N.S. |
| Week x Time | 0.02 | 0.05 |
| Year x Week x Time | 0.03 | N.S. |

### 4. 2.45. Foraging rate of *Amegilla zonata* on Sarpagandha during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Amegilla zonata* on Sarpagandha during 2014 atdifferent times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 66). Irrespective of different times of the day and weeks, the foraging rate ranged between 3.80 to 15.40 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 6.51 to 11.06 flowers/min corresponding to 1$^{st}$ and 2$^{nd}$ week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2$^{nd}$ week (11.06 flowers/min) followed by 3$^{rd}$ week (7.28 flowers/min) and 1$^{st}$ week (6.51 flowers/min). Irrespective of weeks, mean foraging rate of *A. zonata* recorded during different times of a day revealed it to be significantly the maximum foraging rate (11.26 flowers/min) was recorded between 1600h-1800h followed by 1200h-1400h (9.53 flowers/min), 0800h-

1000h (7.86 flowers/min), 1000h-1200h (7.33 flowers/min) and 1400h-1600h (6.93 flowers/min). Minimum foraging rate was recorded at 0600h-0800h (6.80 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *A. zonata* ranged between 4.10 to 13.50 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *A. zonata* varied between 6.38 to 10.35 flowers/min corresponding to 1st and 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *A. zonata* was observed during 2nd week (10.35 flowers/min), followed by 3rd week (6.78 flowers/min) and 1st week (6.38 flowers/min). Irrespective of weeks, mean foraging rate of *A. zonata* recorded during different times of a day revealed it to be significantly the maximum foraging rate (10.10 flowers/min) was recorded between 1600h-1800h followed by 1200h-1400h (8.80 flowers/min), 1000h-1200h (7.60 flowers/min), 1400h-1600h (7.06flowers/min), 0800h-1000h (6.83 flowers/min) and 0600h-0800h (6.63 flowers/min). The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. zonata* observed during 2nd week (10.70 flowers/min), followed by 3rd week (7.03 flowers/min) and 1st week (6.45 flowers/min). Time wise, the foraging rate was significantly the maximum (10.68 flowers/min) at 1600h-1800h followed by 1200h-1400h (9.16 flowers/min), 1000h-1200h (7.46 flowers/min), 0800h-1000h (7.35 flowers/min), 1400h-1600h (7.00 flowers/min) and 0600h-0800h (6.71 flowers/min).

**4.2.46. Foraging speed of *Amegilla zonata* on Sarpagandha during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Amegilla zonata* on Sarpagandha flowers during 2014 have been narrated in Table 67. Foraging speed of *A. zonata* on Sarpagandha recorded during different weeks over the times revealed that the foraging speed ranged between 0.54 to 5.84 seconds/flower. The mean weekly foraging speed ranged between 1.94 to 2.51 seconds/flower during the crop flowering, respectively (Table 67). It was found that maximum foraging speed recorded during 3rdweek (2.51 seconds/flower) followed by 1stweek (2.21 seconds/flower) and 2ndweek (1.94 seconds/flower).As far as time of the day were concerned, significantly the maximum foraging speed (4.53 seconds/flower) was recorded at 0600h-0800h followed at 0800h-1000h (3.01 seconds/flower), 1000h-1200h (2.95 seconds/flower), 1600h-1800h (1.18 seconds/flower) and 1400h-1600h (0.94 seconds/flower). Minimum foraging speed was recorded at 1200h-1400h (0.73 seconds/flower).

During 2015, the foraging speed of *A. zonata* ranged between 0.58 to 5.99 seconds/flower. Mean weekly foraging speed of *A. zonata* varied between 2.03 and 2.65 seconds/flower corresponding to 2ndand 3rdweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *A. zonata* was observed during 3rdweek (2.65 seconds/ flower) followed by 1stweek (2.14 seconds/flower) and minimum foraging speed was observed at 2ndweek (2.03 seconds/flower). The foraging speed of *A.*

*zonata* recorded during different times of a day revealed it to be significantly the maximum (4.57 seconds/ flower) between 0600h-0800h, followed by 0800h-1000h (3.20 seconds/flower), 1000h-1200h (2.94 seconds/flower), 1600h-1800h (1.18 seconds/flower) and 1400h-1600h (0.94 seconds/flower). Lowest foraging speed was recorded at 1200h-1400h (0.79 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *A. zonata* observed during 3rdweek (2.58 seconds/flower), followed by 1stweek (2.18 seconds/flower). Minimum foraging speed was observed during 2ndweek (1.98

seconds/flower). Time wise, the foraging speed was significantly the maximum (4.55 seconds/flower) at 0600h-0800h followed by 0800h-1000h (3.10 seconds/flower), 1000h-1200h (2.95 seconds/flower), 1600h-1800h (1.18 seconds/flower) and 1400h-1600h (0.94 seconds/flower). Minimum foraging speed was recorded at 1200h-1400h (0.76 seconds/flower).

**Table 66 : Foraging rate of *Amegilla zonata* in Sarpagandha during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 28/4/14 | 5/5/14 | 12/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 3.80 (2.17) | 8.50 (3.07) | 8.10 (3.01) | 6.80 (2.75) | 4.10 (2.25) | 7.90 (2.97) | 7.90 (2.97) | 6.63 (2.73) | 6.71 (2.74) |
| 0800-1000 | 6.20 (2.67) | 9.50 (3.23) | 7.90 (2.97) | 7.86 (2.96) | 5.00 (2.44) | 9.10 (3.17) | 6.40 (2.71) | 6.83 (2.77) | 7.35 (2.87) |
| 1000-1200 | 7.10 (2..82) | 10.50 (3.38) | 4.40 (2.31) | 7.33 (2.84) | 8.10 (2.99) | 10.10 (3.32) | 4.60 (2.35) | 7.60 (2.89) | 7.46 (2.86) |
| 1200-1400 | 8.10 (3.01) | 12.00 (3.59) | 8.50 (3.07) | 9.53 (3.22) | 7.50 (2.91) | 11.30 (3.49) | 7.60 (2.92) | 8.80 (3.10) | 9.16 (3.16) |
| 1400-1600 | 5.30 (2.49) | 10.50 (3.38) | 5.00 (2.42) | 6.93 (2.76) | 6.20 (2.67) | 10.20 (3.34) | 4.80 (2.39) | 7.06 (2.80) | 7.00 (2.78) |
| 1600-1800 | 8.60 (3.08) | 15.40 (4.04) | 9.80 (3.27) | 11.26 (3.46) | 7.40 (2.89) | 13.50 (3.80) | 9.40 (3.20) | 10.10 (3.30) | 10.68 (3.38) |
| Mean | 6.51 (2.71) | 11.06 (3.45) | 7.28 (2.84) | 8.28 (3.00) | 6.38 (2.69) | 10.35 (3.35) | 6.78 (2.76) | 7.83 (2.93) | 8.05 (2.96) |
| Pooled mean | 6.45 (2.70) | 10.70 (3.40) | 7.03 (2.80) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SE(m) | C.D. |
|---|---|---|
| Year | 0.01 | 0.05 |
| Week | 0.02 | 0.06 |
| Time | 0.03 | 0.08 |
| Year x Week | 0.03 | N.S. |
| Year X Time | 0.04 | 0.12 |
| Week x Time | 0.05 | 0.15 |
| Year x Week x Time | 0.07 | N.S. |

**Table 67: Foraging speed of *Amegilla zonata* in Sarpagandha during April 2014 and 2015**

| Time (hr) | Time spent/flower (Sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 28/4/14 | 5/5/14 | 12/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 4.23 (2.28) | 3.52 (2.11) | 5.84 (2.61) | 4.53 (2.33) | 3.86 (2.20) | 3.85 (2.19) | 5.99 (2.64) | 4.57 (2.34) | 4.55 (2.34) |
| 0800-1000 | 3.10 (2.02) | 2.94 (1.98) | 2.98 (1.99) | 3.01 (1.99) | 3.06 (2.01) | 3.10 (2.02) | 3.45 (2.10) | 3.20 (2.04) | 3.10 (2.02) |
| 1000-1200 | 3.35 (2..08) | 2.31 (1.81) | 3.18 (2.04) | 2.95 (1.98) | 3.16 (2.03) | 2.24 (1.79) | 3.44 (2.10) | 2.94 (1.98) | 2.95 (1.98) |
| 1200-1400 | 0.97 (1.40) | 0.68 (1.29) | 0.54 (1.24) | 0.73 (1.31) | 1.11 (1.45) | 0.67 (1.29) | 0.58 (1.25) | 0.79 (1.33) | 0.76 (1.32) |
| 1400-1600 | 0.58 (1.25) | 0.82 (1.34) | 1.44 (1.56) | 0.94 (1.38) | 0.58 (1.25) | 0.85 (1.35) | 1.39 (1.54) | 0.94 (1.38) | 0.94 (1.38) |
| 1600-1800 | 1.06 (1.43) | 1.37 (1.53) | 1.10 (1.44) | 1.18 (1.47) | 1.06 (1.43) | 1.45 (1.56) | 1.03 (1.42) | 1.18 (1.47) | 1.18 (1.47) |
| Mean | 2.21 (1.74) | 1.94 (1.68) | 2.51 (1.81) | 2.22 (1.74) | 2.14 (1.73) | 2.03 (1.70) | 2.65 (1.84) | 2.27 (1.76) | 2.24 (1.75) |
| Pooled mean | 2.18 (1.74) | 1.98 (1.69) | 2.58 (1.83) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SE m (±) | C.D. |
|---|---|---|
| Year | 0.00 | N.S. |
| Week | 0.01 | 0.02 |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.02 | N.S. |
| Week x Time | 0.02 | 0.06 |
| Year x Week x Time | 0.03 | N.S. |

### 4. 2.47. Foraging rate of *Pieris* sp. on Sarpagandha during 2014 and 2015

Foraging rate (number of flowers of visited/min) of *Pieris* sp.on Sarpagandha during 2014 at different times of the day was studied at weekly interval throughout the flowering period.

The mean number of flowers visited by an individual forager have been recorded (Table 68). Irrespective of different times of the day and weeks, the foraging rate ranged between 3.50 to 11.50 flowers/min. Irrespective of times of the day, mean weekly foraging rate ranged between 6.03 to 7.28 flowers/min corresponding to 3$^{rd}$and 2$^{nd}$ week of the crop flowering, respectively. It was found that maximum foraging rate was recorded during 2$^{nd}$ week (7.28 flowers/min) followed by 1$^{st}$week (6.90 flowers/min) and 3$^{rd}$week (6.03 flowers/min). Irrespective of weeks, mean foraging rate of *Pieris* sp. recorded during different times of a day revealed it to be significantly the maximum foraging rate (10.13 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (7.83 flowers/min), 1400h-

1600h (7.16 flowers/min), 1200h-1400h (6.86 flowers/min) and 0600h-0800h (4.33 flowers/min). Minimum foraging rate was recorded at 1600h-1800h (4.10 flowers/min).

During 2015, Irrespective of different times of the day and weeks, the forging rate of *Pieris* sp. ranged between 0.00 to 10.80 flowers/min. Irrespective of times of the day, mean weekly foraging rate of *Pieris* sp. varied between 5.46 to 6.43 flowers/min corresponding to 3rdand 2nd week of crop blooming period, respectively. Significantly the maximum mean foraginig rate of *Pieris* sp. was observed during 2nd week (6.43 flowers/min), followed by 1stweek (5.95 flowers/min) and 3rdweek (5.46 flowers/min). Irrespective of weeks, mean foraging rate of *Pieris* sp. recorded during different times of a day revealed it to be significantly the maximum foraging rate (9.86 flowers/min) was recorded between 1000h-1200h followed by 0800h-1000h (7.56 flowers/min), 1400h-1600h (7.50 flowers/min), 1200h-1400h (7.23 flowers/min), 1600h-1800h (3.53 flowers/min) and 0600h-0800h (0.00 flowers/min).

The pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *Pieris* sp. observed during 2nd week (6.85 flowers/min), followed by 1stweek (6.42 flowers/min) and 3rdweek (5.75 flowers/min). Time wise, the foraging rate was significantly the maximum (10.00 flowers/min) at 1000h-1200h followed by 0800h-1000h (7.70 flowers/min), 1400h-1600h (7.33 flowers/min), 1200h-1400h (7.05 flowers/min), 1600h-1800h (3.81 flowers/min) and 0600h-0800h (2.16 flowers/min).

**4.2.48. Foraging speed of *Pieris* sp. on Sarpagandha during 2014 and 2015**

The data on foraging speed, i.e., time spent by *Pieris* sp. on Sarpagandha flowers during 2014 have been narrated in Table 69. Foraging speed of *Pieris* sp.on Sarpagandha recorded during different weeks over the times revealed that the foraging speed ranged between 0.18 to 2.82 seconds/flower. The mean weekly foraging speed ranged between 1.11 to 1.29 seconds/flower during the crop flowering, respectively (Table 69). It was found that maximum foraging speed recorded during 1st week (1.29 seconds/flower) followed by 2nd week (1.25 seconds/flower) and 3rdweek (1.11 seconds/flower). As far as time of the day were concerned, significantly the maximum foraging speed (2.65 seconds/flower) was recorded at 0600h-0800h followed at 1000h-1200h (1.89 seconds/flower), 0800h-1000h (1.52 seconds/flower), 1200h-1400h (0.76 seconds/flower) and 1600h-1800h (0.27 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (0.21 seconds/flower).

During 2015, the foraging speed of *Pieris* sp. ranged between 0.00 to 2.21 seconds/flower. Mean weekly foraging speed of *Pieris* sp. varied between 0.65 and 0.81 seconds/flower corresponding to 3rdand 2ndweek of crop blooming period, respectively. Week wise, significantly the maximum mean foraginig speed of *Pieris* sp.was observed during 2ndweek (0.81 seconds/ flower) followed by 1st week (0.77 seconds/flower) and minimum foraging speed was observed at 3rdweek (0.65 seconds/flower). The foraging speed of *Pieris*

sp. recorded during different times of a day revealed it to be significantly the maximum (1.81 seconds/ flower) between 1000h-01200h, followed by 0800h-1000h (1.51 seconds/flower), 1200h-1400h (0.69 seconds/flower), 1600h-1800h (0.26 seconds/flower) and 1400h-1600h (0.19 seconds/flower). Lowest foraging speed was recorded at 0600h-0800h (0.00 seconds/flower).

The pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *Pieris* sp. observed during 1st and 2ndweek (1.03 seconds/flower), followed by 3rdweek (0.88 seconds/flower). Time wise, the foraging speed was significantly the maximum (1.85 seconds/flower) at 1000h-1200h followed by 0800h-1000h (1.51 seconds/flower), 0600h-0800h (1.32 seconds/flower), 1200h-1400h (0.73 seconds/flower) and 1600h-1800h (0.27 seconds/flower). Minimum foraging speed was recorded at 1400h-1600h (0.20 seconds/flower).

**Table 68 : Foraging rate of *Pieris* sp. in Sarpagandha during April 2014 and 2015**

| Time (hr) | Mean number of flowers visited/min | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 28/4/14 | 5/5/14 | 12/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 4.60 (2.36) | 4.90 (2.42) | 3.50 (2.11) | 4.33 (2.30) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 2.16 (1.65) |
| 0800-1000 | 8.30 (3.04) | 9.60 (3.25) | 5.60 (2.56) | 7.83 (2.95) | 7.60 (2.93) | 10.20 (3.34) | 4.90 (2.42) | 7.56 (2.89) | 7.70 (2.92) |
| 1000-1200 | 10.10 (3.32) | 11.50 (3.53) | 8.80 (3.12) | 10.13 (3.33) | 9.70 (3.26) | 10.80 (3.43) | 9.10 (3.17) | 9.86 (3.29) | 10.00 (3.31) |
| 1200-1400 | 6.40 (2.71) | 7.10 (2.84) | 7.10 (2.84) | 6.86 (2.80) | 7.10 (2.84) | 6.80 (2.79) | 7.80 (2.96) | 7.23 (2.86) | 7.05 (2.83) |
| 1400-1600 | 8.10 (3.01) | 6.70 (2.77) | 6.70 (2.77) | 7.16 (2.85) | 8.10 (3.01) | 7.30 (2.87) | 7.10 (2.84) | 7.50 (2.91) | 7.33 (2.88) |
| 1600-1800 | 3.90 (2.20) | 3.90 (2.20) | 4.50 (2.34) | 4.10 (2.25) | 3.20 (2.04) | 3.50 (2.11) | 3.90 (2.20) | 3.53 (2.12) | 3.81 (2.18) |
| Mean | 6.90 (2.78) | 7.28 (2.83) | 6.03 (2.62) | 6.73 (2.74) | 5.95 (2.51) | 6.43 (2.59) | 5.46 (2.43) | 5.95 (2.51) | 6.34 (2.62) |
| Pooled mean | 6.42 (2.64) | 6.85 (2.71) | 5.75 (2.53) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.01 | 0.02 |
| Week | 0.01 | 0.03 |
| Time | 0.01 | 0.04 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.02 | 0.06 |
| Week x Time | 0.03 | 0.08 |
| Year x Week x Time | 0.04 | 0.12 |

**Table 69 : Foraging speed of *Pieris* sp. in Sarpagandha during April 2014 and 2015**

| Time (hr) | Time spent/flower (sec) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | 2015 | | | | |
| | 28/4/14 | 5/5/14 | 12/5/14 | Mean | 23/4/15 | 30/4/15 | 7/5/15 | Mean | Pooled mean |
| 0600-0800 | 2.82 (1.94) | 2.58 (1.89) | 2.56 (1.88) | 2.65 (1.90) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 1.32 (1.45) |
| 0800-1000 | 1.65 (1.62) | 1.50 (1.57) | 1.40 (1.54) | 1.52 (1.58) | 1.68 (1.63) | 1.46 (1.56) | 1.38 (1.54) | 1.51 (1.58) | 1.51 (1.58) |
| 1000-1200 | 1.89 (1.69) | 2.16 (1.77) | 1.61 (1.61) | 1.89 (1.69) | 1.68 (1.63) | 2.21 (1.79) | 1.53 (1.59) | 1.81 (1.67) | 1.85 (1.68) |
| 1200-1400 | 0.75 (1.32) | 0.82 (1.35) | 0.71 (1.30) | 0.76 (1.32) | 0.68 (1.29) | 0.73 (1.31) | 0.67 (1.29) | 0.69 (1.30) | 0.73 (1.31) |
| 1400-1600 | 0.25 (1.11) | 0.18 (1.08) | 0.19 (1.09) | 0.21 (1.10) | 0.22 (1.10) | 0.16 (1.08) | 0.18 (1.08) | 0.19 (1.09) | 0.20 (1.09) |
| 1600-1800 | 0.37 (1.16) | 0.25 (1.11) | 0.18 (1.08) | 0.27 (1.12) | 0.35 (1.15) | 0.27 (1.12) | 0.14 (1.07) | 0.26 (1.11) | 0.26 (1.11) |
| Mean | 1.29 (1.47) | 1.25 (1.46) | 1.11 (1.42) | 1.22 (1.45) | 0.77 (1.30) | 0.81 (1.31) | 0.65 (1.26) | 0.74 (1.29) | 0.98 (1.37) |
| Pooled mean | 1.03 (1.39) | 1.03 (1.39) | 0.88 (1.34) | | | | | | |

**Each value represents mean of 10 observations**
***Figures in parentheses are square root transformed values**

| Factor | SEm (±) | C.D. |
|---|---|---|
| Year | 0.00 | 0.01 |
| Week | 0.00 | 0.02 |
| Time | 0.01 | 0.03 |
| Year x Week | 0.01 | N.S. |
| Year X Time | 0.01 | 0.04 |
| Week x Time | 0.02 | 0.05 |
| Year x Week x Time | 0.02 | N.S. |

### 4. 2. 3. Number of loose pollen grains sticking on the body of insect visitors/pollinators

#### 4. 2. 3. 1. Number of loose pollen grains sticking on the body of insect visitors/pollinators of Aonla flowers during 2014 and 2015

The number of loose pollen grains sticking to the body of insect pollinators while foraging on Aonla during 2014 and 2015 has been presented in Table 70. During 2014, significant differences were found among the number of loose pollen grains sticking to the body of different foragers of three insect species. *Apis florea* had the highest loose pollen grains on their body (5,56,000) followed by *Episyrphus* sp. (2,02,500) and *Sphaerophoria* sp. (1,56,500). During 2015, loose pollen grains data followed a trend similar to that observed in 2014. During this year significantly highest mean number of loose pollen grains were carried by *A. florea* (4,91,000) followed by *Episyrphus* sp. (2,32,000) and *Sphaerophoria* sp. (1,55,000).

The pooled mean over two years (2014 and 2015) revealed that significantly highest number of loose pollen grains were carried by *A. florea* (5,23,500) followed by *Episyrphus* sp. (2,17,250) and *Sphaerohoria* sp. (1,55,750).

**Table 70: Number of loose pollen grains sticking on the body of insect visitors/pollinators on Aonla flowers during 2014 and 2015**

| Insect species | No. of Loose pollen grains ('000) | | |
|---|---|---|---|
| | 2014 | 2015 | Pooled mean |
| ***Apis florea*** | 556.00 | 491.00 | 523.50 |
| ***Episyrphus* sp.** | 202.50 | 232.00 | 217.25 |
| ***Sphaerophoria* sp.** | 156.50 | 155.00 | 155.75 |
| **Mean** | 305.00 | 292.66 | 298.83 |

**Each value represents mean of 10 observations**

| Factors | SE(m) | C.D. |
|---|---|---|
| Insect | 7.63 | 21.69 |
| Year | 6.23 | N.S. |
| Factor (Insect X Year) | 10.79 | 30.68 |

**4. 2. 3. 2. Number of loose pollen grains sticking on the body of insect visitors/pollinators of Baheda flowers during 2014 and 2015**

The number of loose pollen grains sticking to the body of insect pollinators while foraging on Baheda during 2014 and 2015 has been presented in Table 71. During 2014, significant differences were found among the number of loose pollen grains sticking to the body of different foragers of three insect species. *Apis florea* had the highest loose pollen grains on their body (18,000) followed by *Eristalinus obliquus* (16,500) and *Chrysomya rufifacies* (9,500).

During 2015, loose pollen grains data followed a trend similar to that observed in 2014. During this year significantly the highest mean number of loose pollen grains carried by *A. florea* (21,000) followed by *E. obliquus* (15,500) and *C. rufifacies* (9,500).

The pooled mean over two years (2014 and 2015) revealed that significantly highest number of loose pollen grains carried by *A. florea* (19,500) followed by *E. obliquus*(16,000) and *C. rufifacies* (9,500).

**Table 71: Number of loose pollen grains sticking on the body of insect visitors/pollinators on Baheda flowers during 2014 and 2015**

| Insect species | No. of loose pollen grains ('000) | | |
|---|---|---|---|
| | 2014 | 2015 | Pooled mean |
| ***Eristalinusobliquus*** | 16.50 | 15.50 | 16.00 |
| ***Chrysomya rufifacies*** | 9.50 | 9.50 | 9.50 |
| ***Apis florea*** | 18.00 | 21.00 | 19.50 |
| **Mean** | 14.66 | 15.33 | |

Each value represents mean of 10 observations

| Factors | SEm (±) | C.D. |
|---|---|---|
| Insect | 1.14 | 3.26 |
| Year | 0.93 | N.S. |
| Factor (Insect X Year) | 1.62 | N.S. |

**4. 2. 3. 3. Number of loose pollen grains sticking on the body of insect visitors/pollinators of Lasora flowers during 2014 and 2015**

The number of loose pollen grains sticking to the body of insect pollinators while foraging on Lasora during 2014 and 2015 has been presented in Table 72. During 2014,*Apis dorsata* had the highest loose pollen grains on their body (25,500). Both *Apis cerana and Apis florea*(18,500) were significantly at par.

During 2015,significantly highest mean number of loose pollen grains carried by *A. dorsata* (24,500) followed by *A. cerana* (22,500) and *A. florea* (15,000).

The pooled mean over two years (2014 and 2015) revealed that significantly highest number of loose pollen grains were carried by *A. dorsata* (25,000) followed by *A. cerana* (20,500) and*A. florea* (16,750).

**Table 72: Number of loose pollen grains sticking on the body of insect visitors/pollinators on Lasora flowers during 2014 and 2015**

| Insect Species | No. of loose pollen grains ('000) | | |
|---|---|---|---|
| | 2014 | 2015 | Pooled mean |
| ***Apis dorsata*** | 25.50 | 24.50 | 25.00 |
| ***Apis cerana*** | 18.50 | 22.50 | 20.50 |
| ***Apis florea*** | 18.50 | 15.00 | 16.75 |
| **Mean** | 20.83 | 20.66 | |

Each value represents mean of 10 observations

| Factors | SEm (±) | C.D. |
|---|---|---|
| **Insect** | 1.18 | 3.36 |
| **Year** | 0.96 | N.S. |
| **Factor (Insect X Year)** | 1.67 | N.S. |

**4. 2. 3. 3. Number of loose pollen grains sticking on the body of insect visitors/pollinators of Karonda flowers during 2014 and 2015**

The number of loose pollen grains sticking to the body of insect pollinators while foraging on Karonda during 2014 and 2015 has been presented in Table 73. During 2014, significant differences were found among the number of loose pollen grains sticking to the body of different forages of three insect species. *Apis florea*and *Papilio demoleus*had the highest loose pollen grains on their body (26,500) followed by *Helicoverpa armigera* (20,500). During 2015 significantly the highest mean number of loose pollen grains carried by*P. demoleus* (31,500) followed by *A. florea* (27,500) and *H. armigera* (24,500).

The pooled mean over two years (2014 and 2015) revealed that significantly highest number of loose pollen grains carried by *P. demoleus* (29,000) followed by *A. florea* (27,000) and *H. armigera* (22,500).

**Table 73: Number of loose pollen grains sticking on the body of insect visitors/pollinators on Karonda flowers during 2014 and 2015**

| Insect species | No. of loose pollen grains ('000) | | |
|---|---|---|---|
| | **2014** | **2015** | **Pooled mean** |
| ***Apis florea*** | 26.50 | 27.50 | 27.00 |
| ***Papilio demoleus*** | 26.50 | 31.50 | 29.00 |
| ***Helicoverpa armigera*** | 20.50 | 24.50 | 22.50 |
| **Mean** | 24.50 | 27.83 | |

Each value represents mean of 10 observations

| **Factors** | **SEm (±)** | **C.D.** |
|---|---|---|
| Insect | 1.57 | 4.46 |
| Year | 1.28 | N.S. |
| Factor (Insect X Year) | 2.22 | N.S. |

**4. 2. 3. 5. Number of loose pollen grains sticking on the body of insect visitors/pollinators of Baelflowers during 2014 and 2015**

The number of loose pollen grains sticking to the body of insect pollinators while foraging on Bael during 2014 and 2015 has been presented in Table 74. During 2014, significant differences were found among the number of loose pollen grains sticking to the body of different forages of three insect species. *Apis dorsata*(1,08,000) had the highest loose pollen grains on their body followed by *Megachile cephalotes* (79,000), *Belenois aurota* (31,000) and *Catopsilia pyranthe* (12,000). During 2015, loose pollen grains data followed a trend similar to that observed in 2014. During this year significantly the highest mean number of loose pollen grains carried by*A. dorsata*(1,27,000) had the highest loose pollen grains on their body followed by *M. cephalotes* (66,000), *B. aurota* (39,500) and *C. pyranthe* (12,500).

The pooled mean over two years (2014 and 2015) revealed that significantly highest number of loose pollen grains carried by *A. dorsata* (1,17,500) had the highest loose pollen grains on their body followed by *M. cephalotes* (72,500), *B. aurota* (35,250) and *C. pyranthe* (12,500).

**Table 74: Number of loose pollen grains ('000) sticking on the body of insect visitors/pollinators on Bael flowers during 2014 and 2015**

| **Insect species** | **2014** | **2015** | **Pooled mean** |
|---|---|---|---|
| ***Apis dorsata*** | 108.00 | 127.00 | 117.50 |
| ***Megachile cephalotes*** | 79.00 | 66.00 | 72.50 |
| ***Belenois aurota*** | 31.00 | 39.50 | 35.25 |
| ***Catopsilia pyranthe*** | 12.00 | 12.50 | 12.25 |
| **Mean** | 57.50 | 61.25 | |

Each value represents mean of 10 observations

| Factors | SEm (±) | C.D. |
|---|---|---|
| Insect | 2.95 | 8.33 |
| Year | 2.08 | N.S. |
| Factor(Insect X Year) | 4.17 | 11.78 |

**4. 2. 3. 6. Number of loose pollen grains sticking on the body of insect visitors/pollinators of Jamun flowers during 2014 and 2015**

The number of loose pollen grains sticking to the body of insect pollinators while foraging on Jamun during 2014 and 2015 has been presented in Table 75. During 2014, significant differences were found among the number of loose pollen grains sticking to the body of different forages of three insect species. *Eristalinus obliquus*had the highest loose pollen grains on their body (51,000) followed by *Chrysomya megacephala* (27,500) and *Musca* sp. (14,000). During 2015, loose pollen grains data followed a trend similar to that observed in 2014. During this year significantly the highest mean number of loose pollen grains carried by*E. obliquus* had the highest loose pollen grains on their body (52,000) followed by *C. megacephala* (35,500) and *Musca* sp. (11,000).The pooled mean over two years (2014 and 2015) revealed that significantly highest number of loose pollen grains carried by *E. obliquus*(51,500) followed by *C. megacephala* (31,500) and *Musca* sp. (12,500).

**Table 75: Number of loose pollen grains ('000) sticking on the body of insect visitors/pollinators on Jamun flowers during 2014 and 2015**

| Insect species | 2014 | 2015 | Pooled mean |
|---|---|---|---|
| ***Eristalinus obliquus*** + | 51.00 | 52.00 | 51.50 |
| ***Chrysomya megacephala*** | 27.50 | 35.50 | 31.50 |
| ***Musca* sp.** | 14.00 | 11.00 | 12.50 |
| **Mean** | 30.83 | 32.83 | |

Each value represents mean of 10 observations

| Factors | SEm (±) | C.D. |
|---|---|---|
| Insect | 1.47 | 4.20 |
| Year | 1.20 | N.S. |
| Factor (Insect X Year) | 2.09 | 5.95 |

**4. 2. 3. 7. Number of loose pollen grains sticking on the body of insect visitors/pollinators of Sarpagandha flowers during 2014 and 2015**

The number of loose pollen grains sticking to the body of insect pollinators while foraging on Sarpagandha during 2014 and 2015 has been presented in Table 76. During 2014, significant differences were found among the number of loose pollen grains sticking to the body of different forages of three insect species. *Amegilla zonata* (21,500) had the highest loose pollen grains on their body followed by *Papilio demoleus and Pieris* sp.(12,500).

During 2015, significantly the highest mean number of loose pollen grains carried by *A. zonata*(23,500) followed by *P. demoleus* (15,500) and *Pieris*sp. (10,500).

The pooled mean over two years (2014 and 2015) revealed that significantly highest number of loose pollen grains carried by *A. zonata* (22,500) followed by *P. demoleus*(14,000) and *Pieris* sp. (11,500).

**Table 76: Number of loose pollen grains (‘000) sticking on the body of insect visitors/pollinators on Sarpagandha flowers during 2014 and 2015**

| Insect species | 2014 | 2015 | Pooled mean |
|---|---|---|---|
| ***Papilio demoleus*** | 12.50 | 15.50 | 14.00 |
| ***Amegilla zonata*** | 21.50 | 23.50 | 22.50 |
| ***Pieris* sp.** | 12.50 | 10.50 | 11.50 |
| **Mean** | 15.50 | 16.50 | |

Each value represents mean of 10 observations

| Factors | SEm (±) | C.D. |
|---|---|---|
| Insect | 1.12 | 3.20 |
| Year | 0.92 | N.S. |
| Factor(Insect X Year) | 1.59 | N.S. |

**4.2. 4. Pollination efficiency ofmajor insect pollinators**

**4.2. 4. 1. Pollination efficiency of major insect pollinators on Aonla**

The data on pollination efficiency of different insect visitors/pollinators foraging on Aonla flowers presented in Table 77 revealed that *A. florea*entrapped the maximum number of pollen grains (‘000) (523.50) followed by *Episyrphus* sp. (217.25) and *Sphaerophoria* sp. (155.75).

The abundance of *Episyrphus* sp. (8.67) was highest followed by *A. florea*(5.55), while the abundance of *Sphaerophoria* sp. was least (3.58) and the foraging rate of *Episyrphus* (14.64) was highest followed by *A.florea* (13.61), while foraging rate of *Sphaerophoria* sp. was least (10.04) but the pollination index of *A. florea*(39,542.83) was highest followed by *Episyrphus* sp. (27575.28) and S*phaerphoria* sp. (5589.15). Hence,it was observed that *A. florea* came out to be most efficient pollinator of Aonla. Other pollinators with relatively lower ranking in pollination efficiency were *Episyrphus* sp. and *Sphaerophoria* sp. in descending order (Table 77).

**Table 77: Pollination efficiency of major insect pollinators on Aonla**

| Insect Species | Abundance | Foraging Rate | Loose pollen grains sticking on the body of insect species (‘000) | Pollination index (abundance x foraging rate x loose pollen grains) | Pollination efficiency (Rank) |
|---|---|---|---|---|---|
| *Apis florea* | 5.55 | 13.61 | 523.50 | 39,542.83 | 1st |
| *Episyrphus* sp. | 8.67 | 14.64 | 217.25 | 27,575.28 | 2nd |
| *Sphaerophoria* sp. | 3.58 | 10.04 | 155.75 | 5598. 15 | 3rd |

**4.2. 4. 2. Pollination efficiency of major insect pollinators on Baheda**

The data on pollination efficiency of different insect visitors/pollinators foraging on Baheda flowers presented in Table 78 revealed that *Apis florea* entrapped the maximum number of pollen grains (‘000) (19.50) followed by *Eristalinus obliquus* (16.00) and *Chrysomya rufifacies* (9.50).

The abundance of*C. rufifacies* (3.95) was highest followed by *E. obliquus*(3.78), while the abundance of *A. florea* was least (2.67) and the foraging rate of *E. obliquus* (6.45) was highest followed by *A.florea* (5.35), while foraging rate of *C. rufifacies* was least (5.05) but the pollination index of *E. obliquus* (390.09) was highest followed by *A. florea* (278.54) and *C. rufifacies* (189.50). Hence, it was observed that *E. obliquus* (3,90,096)came out to be most efficient pollinator of Baheda. Other pollinators with relatively lower ranking in pollination efficiency were *A. florea*(2,78,547)and *C. rufifacies*(1,89,501)in descending order.

**Table 78: Pollination efficiency ofmajor insect pollinators on Baheda**

| Insect Species | Abundance | Foraging Rate | Loose pollen grains sticking on the body of insect species (‘000) | Pollination index (abundance x foraging rate x loose pollen grains) | Pollination efficiency (Rank) |
|---|---|---|---|---|---|
| ***Eristalinus obliquus*** | 3.78 | 6.45 | 16.00 | 390.09 | 1st |
| ***Chrysomya rufifacies*** | 3.95 | 5.05 | 9.50 | 189.50 | 3rd |
| ***Apis florea*** | 2.67 | 5.35 | 19.50 | 278.54 | 2nd |

**4.2. 4. 3. Pollination efficiency of major insect pollinators on Lasora**

The data on pollination efficiency of different insect visitors/pollinators foraging on Lasora flowers presented in Table 79 revealed that *Apis dorsata* entrapped the maximum number of pollen grains (‘000) (25.00) followed by *A. cerana* (20.50) and*A. florea*(16.75).

The abundance of *A. dorsata* (4.49) was highest followed by *A. florea* (2.95), while the abundance of *A. cerana* was least (0.49) and the foraging rate of *A. dorsata* (13.15) was highest followed by *A.cerana* (8.37), while foraging rate of *A. florea* was least (3.68) and the pollination index of *A. dorsata* (1476.08) was highest followed by *A. florea* (182.14) and*A. cerana.* (84.93). Hence,it was observed that *A. dorsata*(1476.08) came out to be most efficient pollinator of Lasora. Other pollinators with relatively lower ranking in pollination efficiency were*A. florea*(182.14) and *A. cerana*(84.93) in descending order.

**Table 79: Pollination efficiency ofmajor insect pollinators on Lasora**

| Insect Species | Abundance | Foraging Rate | Loose pollen grains sticking on the body of insect species (‘000) | Pollination index (abundance x foraging rate x loose pollen grains) | Pollination efficiency (Rank) |
|---|---|---|---|---|---|
| ***Apis dorsata*** | 4.49 | 13.15 | 25.00 | 1476.08 | 1st |
| ***Apis cerana*** | 0.49 | 8.37 | 20.50 | 84.93 | 3rd |
| ***Apis florea*** | 2.95 | 3.68 | 16.75 | 182.14 | 2nd |

**4.2. 4. 4. Pollination efficiency of major insect pollinators on Karonda**

The data on pollination efficiency of different insect visitors/pollinators foraging on Karonda flowers presented in Table 80 revealed that *P. demoleus* entrapped the maximum number of pollen grains (‘000) (29.00) followed by *Apis florea* (27.00) and *Helicoverpa armigera* (22.50).

The abundance of *P. demoleus* (3.47) was highest followed by *H. armigera* (2.32) *A. florea* (1.45). Foraging rate of*P.demoleus*(30.98) was highest followed by *H. armigera*(15.31) and *A.florea* (8.18). Pollination index of *P. demoleus* (3,117,517.4) was highest followed by *H. armigera* (799,182) and *A. florea* (320.247). Hence,it was observed that *P. demoleus* came out to be most efficient pollinator of Karonda followed by *H. armigera* and *A. florea*.

**Table 80: Pollination efficiency of major insect pollinators on Karonda**

| Insect Species | Abundance | Foraging Rate | Loose pollen grains sticking on the body of insect species (‘000) | Pollination index (abundance x foraging rate x loose pollen grains) | Pollination efficiency (Rank) |
|---|---|---|---|---|---|
| *Apis florea* | 1.45 | 8.18 | 27.00 | 320.247 | 3rd |
| *Papilio demoleus* | 3.47 | 30.98 | 29.00 | 3,117,517.4 | 1st |
| *Helicoverpa armigera* | 2.32 | 15.31 | 22.50 | 799,182 | 2nd |

**4.2. 4. 5. Pollination efficiency of major insect pollinators on Bael**

**Table 81: Pollination efficiency of major insect pollinators on Bael**

| Insect Species | Abundance | Foraging Rate | Loose pollen grains sticking on the body of insect species (‘000) | Pollination index (abundance x foraging rate x loose pollen grains) | Pollination efficiency (Rank) |
|---|---|---|---|---|---|
| *Apis dorsata* | 7.79 | 7.10 | 117.50 | 6489.80 | 1st |
| *Megachile cephalotes* | 3.03 | 5.25 | 72.50 | 1153.29 | 2nd |
| *Belenois aurota* | 5.34 | 5.41 | 39.50 | 1141.13 | 3rd |
| *Catopsilia pyranthe* | 4.26 | 3.98 | 12.50 | 211.93 | 4th |

The data on pollination efficiency of different insect visitors/pollinators foraging on Bael flowers presented in Table 81 revealed that *Apis dorsata*(117.50) entrapped the maximum number of pollen grains followed by *Megachile cephalotes* (72.50), *Belenois aurota* (39.50) and *Catopsilia pyranthe* (12.50).

The abundance of *A. dorsata* (7.79) was highest followed by *B. aurota* (5.34), *C. pyranthe* (4.26), while the abundance of *M. cephalotes* (3.03) was least and the foraging rate of *A. dorsata* (7.10) was highest followed by *B. aurota* (5.41), *M. cephalotes* (5.25), while foraging rate of*C. pyranthe* was least (3.98) but the pollination index of *A. dorsata* (6489.80) was highest followed by *M. cephalotes* (1153.29), *B. aurota* (1141.13) and *C. pyranthe*(211.93). Hence,it was observed that *A. dorsata* came out to be most efficient pollinator of Bael. Other pollinators with relatively lower ranking in pollination efficiency were *M. cephalotes, B. aurota* and *C. pyranthe* in descending order.

**4.2. 4. 6. Pollination efficiency of major insect pollinators on Jamun**

The data on pollination efficiency of different insect visitors/pollinators foraging on Jamun flowers presented in Table 82 revealed that *Eristalinus obliquus*(51.50) entrapped the maximum number of pollen grains followed by *Chrysomya megacephala* (31.50) and *Musca* sp. (11.00).

The abundance of *E. obliquus* (13.80) was highest followed by *C. megacephala* (10.62), while the abundance of *Musca* sp.was least (3.64) and the foraging rate of *E. obliquus* (8.48) was highest followed by *C. megacephala* (8.22), while foraging rate of *Musca* sp.was least (5.04) but the pollination index of *E. obliquus* (6026.73) was highest followed by *C. megacephala* (2749.83) and *Musca* sp. (201.80). Hence,it was observed that *E. obliquus*

came out to be most efficient pollinator of Jamun. Other pollinators with relatively lower ranking in pollination efficiency were *C. megacephala* and *Musca* sp. in descending order.

**Table 82: Pollination efficiency of major insect pollinators on Jamun**

| Insect Species | Abundance | Foraging Rate | Loose pollen grains sticking on the body of insect species (‘000) | Pollination index (abundance x foraging rate x loose pollen grains) | Pollination efficiency (Rank) |
|---|---|---|---|---|---|
| *Eristalinus obliquus* | 13.80 | 8.48 | 51.50 | 6026.73 | 1st |
| *Chrysomya megacephala* | 10.62 | 8.22 | 31.50 | 2749.83 | 2nd |
| *Musca* sp. | 3.64 | 5.04 | 11.00 | 201.80 | 3rd |

**4.2. 4. 7. Pollination efficiency of major insect pollinators on Sarpagandha**

The data on pollination efficiency of different insect visitors/pollinators foraging on Sarpagandha flowers presented in Table 83 revealed that *Amegilla zonata* (22.50)entrapped the maximum number of pollen grains followed by*Papilio demoleus*(14.00) and *Pieris* sp. (11.50).

The abundance of *P. demoleus* (3.58) was highest followed by *A. zonata*(1.84), while the abundance of *Pieris* sp. was least (1.38) and the foraging rate of *P. demoleus* (23.24) was highest followed by *A.zonata* (8.05), while foraging rate of*Pieris* sp. was least (6.34) but the pollination index of *P. demoleus* (1164.78) was highest followed by *A. zonata* (333.27) and *Pieris*sp. (100.61). Hence,it was observed that *P. demoleus* came out to be most efficient pollinator of Sarpagandha. Other pollinators with relatively lower ranking in pollination efficiency were *A. zonata* and *Pieris* sp. in descending order.

**Table 83: Pollination efficiency of major insect pollinators on Sarpagndha**

| Insect Species | Abundance | Foraging Rate | Loose pollen grains sticking on the body of insect species (‘000) | Pollination index (abundance x foraging rate x loose pollen grains) | Pollination efficiency (Rank) |
|---|---|---|---|---|---|
| *Papilio demoleus* | 3.58 | 23.24 | 14.00 | 1164.78 | 1st |
| *Amegilla zonata* | 1.84 | 8.05 | 22.50 | 333.27 | 2nd |
| *Pieris* sp. | 1.38 | 6.34 | 11.50 | 100.61 | 3rd |

**4.3. Dry nectar sugars in flowers of different plants**

Estimation of dry nectar sugars in flowers of different plants revealed that during 2014 maximum dry nectar sugar was present in Lasora (0.874), followed by Bael (0.599), Karonda (0.423), Baheda (0.231), Aonla (0.227), Sarpagandha (0.162) and Jamun (0.153).

Similar trend followed in the year 2015 i.e., Lasora (0.896), followed by Bael (0.555), Karonda (0.450), Baheda (0.266), Aonla (0.231), Sarpagandha (0.159) and Jamun (0.158).The pooled mean of 2014 and 2015 revealed that maximum dry nectar sugars found in Lasora (0.885), followed by Bael (0.577), Karonda (0.436), Baheda (0.248), Aonla (0.229), Sarpagandha (0.160) and Jamun (0.155) (Table 84).

**Table 84: Dry nectar sugars in flowers of different plants**

| Plant/Tree | Dry Nectar Sugars produced (mg) per flower | | |
|---|---|---|---|
| | 2014 | 2015 | Pooled mean |
| **Aonla (*P. emblica*)** | 0.227 | 0.231 | 0.229 |
| **Baheda (*T. bellirica*)** | 0.231 | 0.266 | 0.248 |
| **Lasora (*C. myxa*)** | 0.874 | 0.896 | 0.885 |
| **Karonda (*C. carandas*)** | 0.423 | 0.450 | 0.436 |
| **Bael (*A. marmelos*)** | 0.599 | 0.555 | 0.577 |
| **Jamun (*S. cumini*)** | 0.153 | 0.158 | 0.155 |
| **Sarpagandha (*R. serpentina*)** | 0.162 | 0.159 | 0.160 |

**Each value is mean of 7 observations**

### 4.4. Effects of different modes of pollination on yield parameters during 2014 and 2015

#### 4.4. 1. Effects of different modes of pollination on yield parameters of Aonla during 2014 and 2015

The data on yield parameters of Aonla during 2014 have been presented in the Table 85. Number of fruits/branch (27.10), fruit length (22.93 mm) and fruit weight (41.51 g) were significantly higher incase of open pollination as compared to without insect pollination (4.10, 20.49 mm and 34.25 g, respectively). Under open pollination, stone weight (0.55g) was non - significant when compared to without insect pollination (0.50 g). Similar trend followed during 2015 i.e., number of fruits/branch (26.20), fruit length (22.12 mm), fruit weight (40.39 g) and stone weight (0.46 g) were significantly higher incase of open pollination as compared to without insect pollination (4.10, 19.89 mm, 35.57 g and 0.42 g, respectively) (Table 86). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 560.97 and 539.02 respectively.

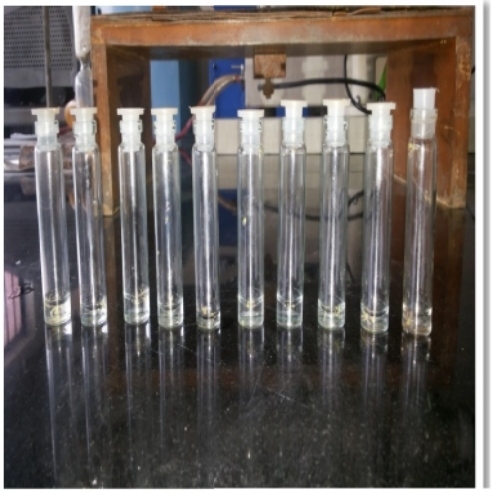

**Plate 94: Estimation of dry nectar sugars**

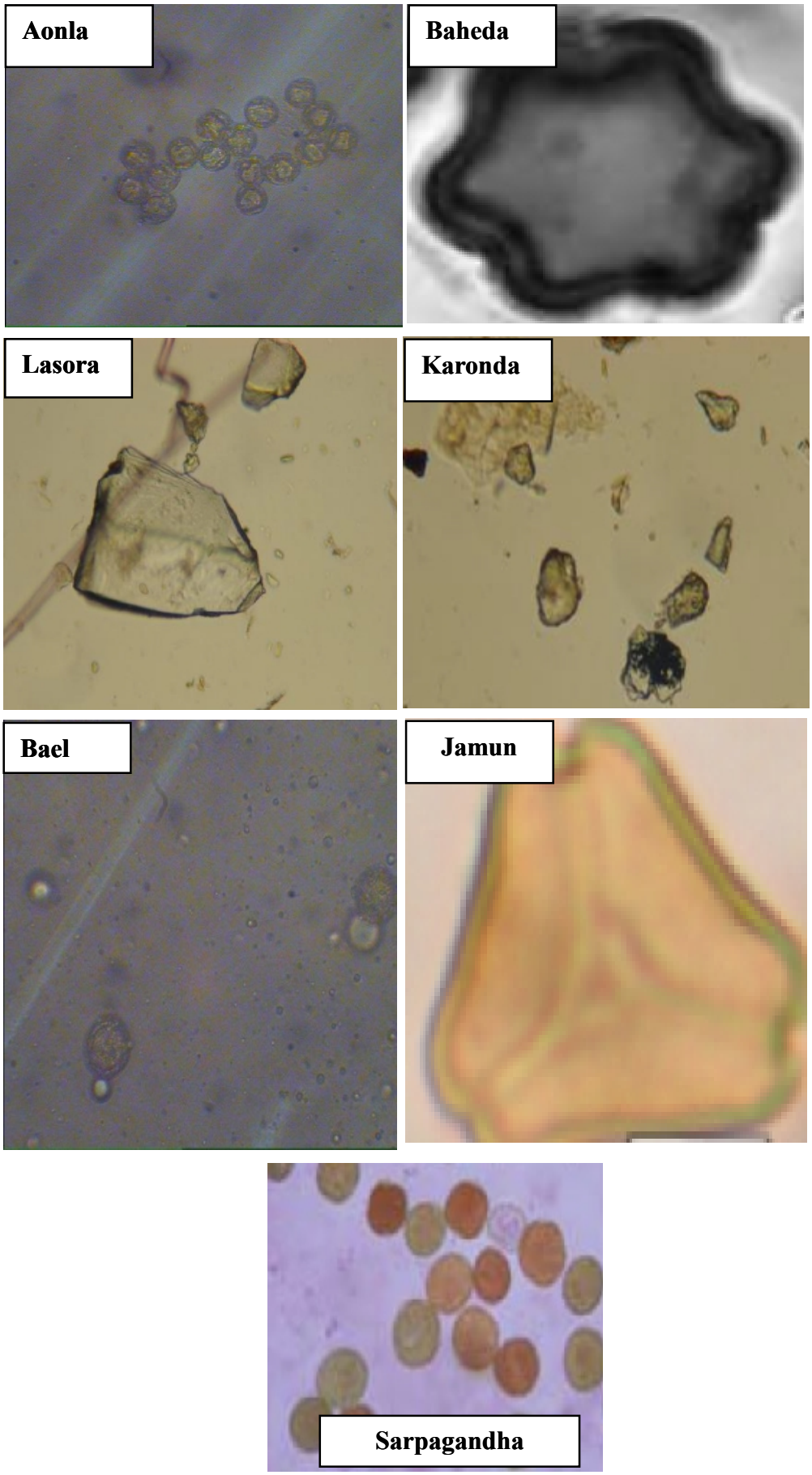


**Plate 95: Pollen grains of research plants**

**Table 85: Effects of different modes of pollination on yield parameters of Aonla (*P.emblica*) during 2014**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Stone weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 27.10 (5.29) | 560.97 | 22.93 (4.89) | 41.51 (6.49) | 0.55 (1.24) |
| **Without Insect Pollination (Muslin cloth bagged)** | 4.10 (2.25) | - | 20.49 (4.63) | 34.25 (5.93) | 0.50 (1.22) |
| **SEm (±)** | 0.08 | - | 0.01 | 0.06 | 0.00 |
| **C.D.** | 0.27 | - | 0.05 | 0.19 | N.S. |
| **C.V.** | 6.97 | - | 1.20 | 3.06 | 1.86 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**Table 86:Effects of different modes of pollination on yield parameters of Aonla (*P.emblica*) during 2015**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Stone weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 26.20 (5.21) | 539.02 | 22.12 (4.80) | 40.39 (6.43) | 0.46 (1.21) |
| **Without Insect Pollination (Muslin cloth bagged)** | 4.10 (2.25) | - | 19.89 (4.57) | 35.57 (6.04) | 0.42 (1.19) |
| **SEm (±)** | 0.04 | - | 0.02 | 0.01 | 0.00 |
| **C.D.** | 0.15 | - | 0.06 | 0.06 | 0.01 |
| **C.V.** | 3.94 | - | 1.41 | 0.93 | 1.22 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

### 4.4. 2. Effects of different modes of pollination on yield parameters of Baheda during 2014 and 2015

The data on yield parameters of Baheda during 2014 have been presented in the Table 87. Number of fruits/branch (15.60), fruit length (23.59 mm), fruit weight (3.87 g) and stone weight (0.79 g) were significantly higher in case of open pollination as compared to without insect pollination (2.40, 20.56 mm, 3.27 g and 0.57 g, respectively). Similar trend followed during 2015 i.e., Number of fruits/branch (14.50), fruit length (22.07 mm), fruit weight (3.75 g) and stone weight (0.78 g) were significantly higher in case of open pollination as compared to without insect pollination (3.30, 20.94 mm, 2.87 g and 0.63 g, respectively) (Table 88). Percent increase in number of fruits due to open pollination during 2014 and 2015 were 550.00 and 339.39,respectively.

**Table 87: Effects of different modes of pollination on yield parameters of Baheda (*T.bellirica*) during 2014**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Stone weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 15.60 (4.06) | 550.00 | 23.59 (4.95) | 3.87 (2.20) | 0.79 (1.34) |
| **Without Insect Pollination(Muslin cloth bagged)** | 2.40 (1.82) | - | 20.56 (4.64) | 3.27 (2.06) | 0.57 (1.25) |
| **SEm (±)** | 0.07 | - | 0.03 | 0.03 | 0.01 |
| **C.D.** | 0.25 | - | 0.12 | 0.11 | 0.03 |
| **C.V.** | 8.51 | - | 2.50 | 5.23 | 2.66 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**Table 88: Effects of different modes of pollination on yield parameters of Baheda (*T. bellirica*) during 2015**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Stone weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 14.50 (3.93) | 339.39 | 22.07 (4.80) | 3.75 (2.17) | 0.78 (1.33) |
| **Without Insect Pollination (Muslin cloth bagged)** | 3.30 (2.06) | - | 20.94 (4.68) | 2.87 (1.96) | 0.63 (1.27) |
| **SEm (±)** | 0.05 | - | 0.03 | 0.03 | 0.00 |
| **C.D.** | 0.16 | - | 0.10 | 0.11 | 0.02 |
| **C.V.** | 5.31 | - | 2.20 | 5.59 | 1.89 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

### 4.4. 3. Effects of different modes of pollination on yield parameters of Lasora during 2014 and 2015

The data on yield parameters of Lasora during 2014 have been presented in the Table 89. Number of fruits/branch (164.90), fruit length (14.83 mm)and stone weight (0.39 g) were significantly higher in case of open pollination as compared to without insect pollination (5.20, 13.36 mm, 1.67 g and 0.30 g, respectively). Under open pollination, fruit weight (1.88 g) was non - significant when compared to without insect pollination (1.67 g). Similar trend followed during 2015 i.e., Number of fruits/branch (144.60), fruit length (13.88 mm) and stone weight (0.39 g) were significantly higher in case of open pollination as compared to without insect pollination (6.70, 13.12mm, 1.60 g and 0.27 g, respectively) (Table 90). Per

cent increase in number of fruits due to open pollination during 2014 and 2015 were 3071.15 and2058.20, respectively.

**Table 89: Effects of different modes of pollination on yield parameters of Lasora (*C. myxa*) during 2014**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Stone weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 164.90 (12.86) | 3071.15 | 14.83 (3.97) | 1.88 (1.69) | 0.39 (1.18) |
| **Without Insect Pollination(Muslin cloth bagged)** | 5.20 (2.48) | - | 13.36 (3.79) | 1.67 (1.63) | 0.30 (1.14) |
| **SEm (±)** | 0.16 | - | 0.03 | 0.01 | 0.00 |
| **C.D.** | 0.53 | - | 0.10 | N.S. | 0.02 |
| **C.V.** | 6.83 | - | 2.49 | 3.60 | 1.75 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**Table 90: Effects of different modes of pollination on yield parameters of Lasora (*C. myxa*) during 2015**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Stone weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 144.60 (12.06) | 2058.20 | 13.88 (3.85) | 1.77 (1.66) | 0.39 (1.18) |
| **Without Insect Pollination (Muslin cloth bagged)** | 6.70 (2.76) | - | 13.12 (3.75) | 1.60 (1.61) | 0.27 (1.13) |
| **SEm (±)** | 0.06 | - | 0.01 | 0.01 | 0.00 |
| **C.D.** | 0.22 | - | 0.05 | 0.03 | 0.01 |
| **C.V.** | 2.95 | - | 1.50 | 1.88 | 1.64 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

### 4.4. 4. Effects of different modes of pollination on yield parameters of Karonda during 2014 and2015

The data on yield parameters of Karonda during 2014 have been presented in the Table 91. Number of fruits/branch (55.90), fruit length (17.92 mm) and fruit weight (2.07 g) were significantly higher in case of open pollination as compared to without insect pollination (3.90, 14.78 mm and 1.32 g respectively). Under open pollination, seed weight (0.19g) was non - significant when compared to without insect pollination (0.16 g).Similar trend followed during 2015 i.e., Number of fruits/branch (56.70), fruit length (18.02 mm) and fruit weight (1.94 g) were significantly higher in case of open pollination as compared to without insect pollination (5.80, 14.79mm and 1.32 g respectively) (Table 92). Under open pollination, seed

weight (0.20 g) was non - significant when compared to without insect pollination (0.17 g). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 1333.33 and877.58, respectively.

**Table 91: Effects of different modes of pollination on yield parameters of Karonda (*C. carandas*) during 2014**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 55.90 (7.42) | 1333.33 | 17.92 (4.35) | 2.07 (1.74) | 0.19 (1.09) |
| **Without Insect Pollination(Muslin cloth bagged)** | 3.90 (2.20) | - | 14.78 (3.97) | 1.32 (1.52) | 0.16 (1.08) |
| **SEm (±)** | 0.30 | - | 0.02 | 0.02 | 0.00 |
| **C.D.** | 0.98 | - | 0.07 | 0.09 | N.S. |
| **C.V.** | 20.02 | - | 1.84 | 5.65 | 1.74 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**Table 92: Effects of different modes of pollination on yield parameters of Karonda (*C. carandas* during 2015**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 56.70 (7.58) | 877.58 | 18.02 (4.36) | 1.94 (1.71) | 0.20 (1.09) |
| **Without Insect Pollination (Muslin cloth bagged)** | 5.80 (2.60) | - | 14.79 (3.97) | 1.32 (1.52) | 0.17 (1.08) |
| **SEm (±)** | 0.11 | - | 0.01 | 0.00 | 0.00 |
| **C.D.** | 0.35 | - | 0.05 | 0.02 | N.S. |
| **C.V.** | 6.84 | - | 1.37 | 1.76 | 1.63 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**4.4. 5. Effects of different modes of pollination on yield parameters of Bael during 2014 and2015**

The data on yield parameters of Bael during 2014 have been presented in the Table 93. Number of fruits/branch (3.70), fruit length (99.40 mm), fruit weight (529.60 g) and Seed weight (0.04) were significantly higher in case of open pollination as compared to without insect pollination (1.50, 80.00 mm,369.80 g and 0.02 g respectively). During 2015 i.e., Number of fruits/branch (3.00), fruit length (87.40 mm) and fruit weight (462.00g) were significantly higher in case of open pollination as compared to without insect pollination (1.80, 76.30 mm and 393.00 g respectively) (Table 94). Under open pollination, seed weight

(0.05g) was non - significant when compared to without insect pollination (0.04 g).Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 146.66 and 66.66 respectively.

**Table 93: Effects of different modes of pollination on yield parameters of Bael (*A. marmelos*) during 2014**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 3.70 (2.15) | 146.66 | 99.40 (10.00) | 529.60 (22.99) | 0.04 (1.02) |
| **Without Insect Pollination (Muslin cloth bagged)** | 1.50 (1.57) | - | 80.00 (8.99) | 369.80 (19.21) | 0.02 (1.01) |
| **SEm (±)** | 0.06 | - | 0.18 | 0.35 | 0.00 |
| **C.D.** | 0.22 | - | 0.61 | 1.15 | 0.00 |
| **C.V.** | 11.56 | - | 6.25 | 5.32 | 0.65 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**Table 94: Effects of different modes of pollination on yield parameters of Bael (*A. marmelos*) during 2015**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 3.00 (1.99) | 66.66 | 87.40 (9.40) | 462.00 (21.50) | 0.05 (1.02) |
| **Without Insect Pollination (Muslin loth bagged)** | 1.80 (1.66) | - | 76.30 (8.79) | 393.00 (19.83) | 0.04 (1.02) |
| **SEm (±)** | 0.06 | - | 0.07 | 0.21 | 0.00 |
| **C.D.** | 0.20 | - | 0.25 | 0.70 | N.S. |
| **C.V.** | 11.09 | - | 2.75 | 3.30 | 0.50 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

### 4.4. 6. Effects of different modes of pollination on yield parameters of Jamun during 2014 and 2015

The data on yield parameters of Jamun during 2014 have been presented in the Table 95. Number of fruits/branch (33.10), fruit length (22.91 mm), fruit weight (4.11 g) and Seed weight (1.96 g) were significantly higher in case of open pollination as compared to without insect pollination (5.00, 18.95 mm, 2.76 g and 1.59 g respectively). During 2015 i.e., Number of fruits/branch (32.60), fruit length (22.55 mm), fruit weight (3.94 g) and seed weight (1.83

g) were significantly higher in case of open pollination as compared to without insect pollination (4.00, 18.62 mm, 2.62 g, 1.36 g respectively) (Table 96). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 562.00 and 715.00 respectively.

**Table 95: Effects of different modes of pollination on yield parameters of Jamun (*S. cumini*) during 2014**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 33.10 (5.83) | 562.00 | 22.91 (4.88) | 4.11 (2.25) | 1.96 (1.72) |
| **Without Insect Pollination (Muslin cloth bagged)** | 5.00 (2.44) | - | 18.95 (4.46) | 2.76 (1.93) | 1.59 (1.60) |
| **SEm (±)** | 0.08 | - | 0.04 | 0.03 | 0.03 |
| **C.D.** | 0.27 | - | 0.15 | 0.11 | 0.09 |
| **C.V.** | 6.48 | - | 3.11 | 5.39 | 5.81 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**Table 96: Effects of different modes of pollination on yield parameters of Jamun (*S. cumini*) during 2015**

| Treatments | Number of fruits/branch | Per cent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 32.60 (5.79) | 715.00 | 22.55 (4.85) | 3.94 (2.22) | 1.83 (1.68) |
| **Without Insect Pollination (Muslin cloth bagged)** | 4.00 (2.22) | - | 18.62 (4.43) | 2.62 (1.90) | 1.36 (1.53) |
| **SEm (±)** | 0.04 | - | 0.03 | 0.02 | 0.01 |
| **C.D.** | 0.16 | - | 0.10 | 0.09 | 0.04 |
| **C.V.** | 3.88 | - | 2.09 | 4.27 | 2.86 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

### 4.4. 7. Effects of different modes of pollination on yield parameters of Sarpagandha during 2014 and 2015

The data on yield parameters of Sarpagandha during 2014 have been presented in the Table 97. Number of fruits/branch (32.80) and fruit length (5.83 mm) were significantly higher in case of open pollination as compared to without insect pollination (6.60 and 4.97 mm respectively). During 2015 i.e., Number of fruits/branch (30.30) and fruit length (5.04 mm) were significantly higher in case of open pollination as compared to without insect

pollination (8.30 and 5.40 mm respectively) (Table 98). Under open pollination, fruit weight (0.13g) and Seed weight (0.08 g) were non - significant when compared to without insect pollination (0.04 g and 0.03 g respectively).Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 396.96 and 265.06, respectively.

**Table 97: Effects of different modes of pollination on yield parameters of Sarpagandha (*R. serpentina*) during 2014**

| Treatments | Number of fruits/branch | Percent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 32.80 (5.80) | 396.96 | 5.83 (2.61) | 0.10 (1.05) | 0.04 (1.02) |
| **Without Insect Pollination (Muslin cloth bagged)** | 6.60 (2.74) | - | 4.97 (2.44) | 0.10 (1.05) | 0.02 (1.01) |
| **SEm (±)** | 0.10 | - | 0.03 | 0.00 | 0.00 |
| **C.D.** | 0.32 | - | 0.12 | N.S. | 0.00 |
| **C.V.** | 7.48 | - | 4.66 | 0.85 | 0.62 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

**Table 98: Effects of different modes of pollination on yield parameters of Sarpagandha (*R. serpentina*) during 2015**

| Treatments | Number of fruits/branch | Percent increase in yield | Fruit length (mm) | Fruit weight (g) | Seed weight (g) |
|---|---|---|---|---|---|
| **Open Pollination** | 30.30 (5.58) | 265.06 | 5.04 (2.45) | 0.13 (1.06) | 0.04 (1.02) |
| **Without Insect Pollination (Muslin cloth bagged)** | 8.30 (3.04) | - | 5.40 (2.52) | 0.08 (1.04) | 0.03 (1.01) |
| **SEm (±)** | 0.08 | - | 0.02 | 0.00 | 0.00 |
| **C.D.** | 0.28 | - | 0.06 | 0.01 | N.S. |
| **C.V.** | 6.38 | - | 2.48 | 0.93 | 0.50 |

Each value is mean of 10 observations
*Figures in parentheses are square root transformed values

# CHAPTER - V

# DISCUSSION

The results of the present investigation entitled "Evaluation of some underutilized fruit and medicinal plants as bee forage" are discussed under the following headings:

5. 1. Diversity and Abundance of insect visitors/pollinators

5. 2. Foraging behavior

5. 2. 1. Foraging rate

5. 2. 2. Foraging speed

5. 2. 3. Number of loose pollen grains sticking on the body of insect visitors

5. 2. 4. Pollination efficiency of major insect pollinators

5. 3. Dry nectar sugars in flowers of different plants

5. 4. Effect of different modes of pollination on fruit set/yield

In an agro-ecosystem, pollination is accomplished by a large number of pollinator species. However, only a few of them largely control the pollination process and are said to be the dominant pollinators. Removal of the dominant pollinator species would adversely affect the pollination process in the crop.

Though the removal of a non dominant species would produce much less change on the pollination process, yet it will affect the species diversity. Populations of the entire organisms in the ecosystem are extremely important to regulate and stabilize the ecosystem (Odum, 1971). Since scanty literature/meager work has been done by various workers on different aspects of present study. Therefore results are discussed in the light of available literature on some of the related crops.

## 5.1. Diversity and Abundanceof insect visitors/pollinators

Diversity can help to reduce the risk that may arise due to lack of pollination during critical period of crop flowering. These pollination attributes can help in determining the efficient pollinators which aid in the characterization of best and supplementary pollinators of a crop.

Abundance of the pollinators presents the full spectrum of different species that visit the flowers of a crop during the whole span of its flowering period. Higher the abundance more are the chances of a flower to be visited repeatedly by a species. That should results into more pollination in the flowers and will contribute towards the reproductive success of the plant. The abundance of insect pollinators on flowering crops depends on several factors such as anthesis, weather components, competing flora, nests of wild bees near flowering crops, nectar concentration and its volume. At peak flowering, the availability of flowers is more

than initiation and cessation of flowering, and the maximum number of insects would visit the crop during this period to increase the pollination process. Therefore, the number of flowers clearly influences the pollinator abundance, and inturn, the level of pollination. Plants with many flowers often attract more floral visitors than those with fewer flowers (Free, 1993).

The results pertaining to the diversity of insect visitors/pollinators on aonla during March -April 2014 and 2015 revealed that total of 12 insect species belonging to 7 families of 5 orders were recorded. Among them Dipterans were the major floral visitors comprising of 4 species from 3 families viz., Syrphidae (*Episyrphus* sp. and *Sphaerophoria* sp.), Sarcophagidae (*Sarcophaga* sp.) and Muscidae (*Musca domestica*). They were followed in order of diversity by Hymenopterans (four species from one family) viz., Apidae (*Apis florea*, *A. dorsata*, *A. cerana* and *A. mellifera*). They were followed in order of diversity by Coleopterans (two species from one family) Coccinellidae (*Coccinella septempunctata* and *Chiomenes sexmaculata*), Hemipterans (one species from one family) viz., Scutellaridae (*Chrysocoris stolli*) and Lepidoptera (one species from one family) viz., Arctiidae (*Amata* sp.). Similar findings were reported in amla by Saini (2011) and stated that majority of insect visitors belonged toDiptera (*Sarcophaga* sp., *Chrysoma bezziana*, *Eristalinus*, *Episyrphus*, *Syrphus* and *Syritta*), followed by Hymenoptera (*Apis dorsata*, *A. mellifera*, *A. florea* and *Polisteshebraeus*) and Lepidoptera(*Psichotoe duvauceli*).

Present pollination studyrevealed that Dipteran insect species were most abundant insect pollinators on aonla flowers. Irrespective of different day hours, significantly maximum number of *Episyrphus* sp. was recorded from aonla flowers followed by *Sphaerophora sp.* and *A. florea.* Peakabundance of *Episyrphus* sp. wasrecorded between 1000h-1200h during full bloom of crop. Maximum abundance of *A. florea* was recorded at 1000h-1200h and minimum abundance was recorded at 0600h-0800h irrespective of weeks. During 2014 and 2015, highest pooled mean of abundance (8.79 and 8.56 flies/$m^2$ branch/5min) was recorded in *Episyrphus* sp. followed by *A. florea* (5.40 and 5.70 bees/$m^2$ branch/5min), while lowest pooled mean of abundance was recorded in *Sphaerophoria* sp.(3.62 and 3.54 flies/$m^2$ branch/5min). In contrast, a studyconducted by Saini (2011) foundthat abundance of *Apis dorsata* was in lead followed by *A. mellifera*, *A. florea*, *Sarcophaga* and others which included few hymenoptrans and dipterans in amla.

Diversity of insect visitors/pollinators on Baheda during April 2014 and 2015 revealed that total of 10 insect species belonging to 7 families of 5 orders were recorded. Among them, Dipterans were the major floral visitors comprising of 4 species from 2 families viz., Syrphidae (*Eristalinus obliquus, Eristalis* sp. *and Eristalinus obscuritarsus*) and Calliophoridae (*Chrysomya rufifacies*). They were followed in order of diversity by Hymenopterans (2 species from 2 families) viz., Apidae (*Apis florea*) and Vespidae (*Allorhynchium metallicum*), Coleopterans (two species from one family) viz., Coccinellidae

(*Coccinella septempunctata* and *Chiomenes sexmaculata*), Hemipterans (one species from one family) viz., Scutellaridae (*Chrysocoris stolli*) and Lepidoptera (one species from one family) viz., Pieridae (*Pieris* sp.).

Present findings are in agreement with those of Srivastava (1993),who reported the pollination mechanisms of four species of genus *Terminalia*(*T. arjuna*, *T. chebula*, *T. tomentosa* and *T. paniculata*) and revealed that pollination is entomophilous. Out of 22 insect pollinators collected maximum number belonged to Lepidoptera (6), Diptera (6) and Hymenoptera (6). Among them, *Apis dorsata* and *Apisflorea* play an important role in pollination. Similarly Raju *et al*. (2012) observed that *Terminaliapallida* flowers were foraged during daytime by 33 species of insects representing bees, wasps, bugs, flies, butterflies and beetles.

Abundance of major insect pollinators on Baheda flowers at different day hours during April 2014 and 2015 revealed that the abundance of major insect pollinators at different weeks during day hours it differed significantly with insect pollinators.Among Dipterans, maximum pooled mean population was of *Chrysomya rufifacies* (3.82 and 4.08 flies/$m^2$ branch/5min) followed by that of *E. obliquus* (3.66 and 3.91 flies/$m^2$ branch/5min) and *E. obscuritarsus* (2.20 and 2.17 flies/$m^2$ branch/5min). In Hymenoptera, *A. florea* was recorded with the pooled mean population of 2.57 and 2.77 bees/$m^2$branch/5 min.From the present pollination study, it is evident that Dipterans were most abundant insect pollinators on baheda flowers. Irrespective of different day hours, significantly maximum number of *C. rufifacies* was recorded from baheda flowers followed by *E.obliquus, A. florea* and *E.obscuritarsus.* Minimum activity of all dipterans (*E.obliquus, E. obscuritarsus* and *C. rufifacies*) was recorded between 0600h - 0800h and peak activity was recorded at 1000h – 1200h irrespective of weeks.Peak abundance of *A. florea* was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h irrespective of weeks.Raju *et. al.* (2012) also reported that bee forager in *Terminaliapallida* with maximum foraging visits at 0900–1000 h in the forenoon and at 1700 h in the afternoon. They also stated that flies were very slow in their flower-to-flower movements mainly during 0900–1100h, these findings were in confirmity with present study.

Diversity of insect visitors/pollinators on Lasora during April 2014 and 2015 revealed that total of 15 insect species belonging to 8 families of 4 orders were recorded. The Hymenopterans were the major floral visitors comprising of 6 species from 3 families viz., Apidae (*A. florea, A. dorsata, A. mellifera* and *A. cerana*), Megachilidae (*Megachile* sp.) and Vespidae (*Polistes* sp.). They were followed in order of diversity by Dipterans (4 species from 3 families) viz., Syrphidae (*Eristalinusobliquus*and *Eristalis* sp.), Tephritidae (*Bactrocera nigrofemoralis*) and Calliophoridae (*Chrysomya rufifacies*), Lepidopterans (3 species from one family) viz., Noctuidae (*Mythimna separata, Plusia* sp. and *Thysanoplusia*

*orichalcea*) and Coleoptera (2 species from one family) viz., Coccinellidae (*Coccinella septempunctata* and *Chilomenes sexmaculata*). Similar findings were reported by Bhattacharya *et al*. (2005) who reported that out of all the flower visitors of *Jatropha curcas*, honey bees (*A. florea, A. dorsata, A. mellifera* and *A. cerana*) were the effective pollinators. Qing *et al*. (2007) also reported similar findings in *Jatropha curcas* and stated that *Apis dorsata*, *A. mellifera, A. florea* and *Vespa* sp. were the effective pollinators. Reddi and Reddi (1983) also reported that *Jatropha gossypiifolia* visited by total 18 species of insects i.e., bees (*Trigona* sp., *Apis florea* and*A. cerana*), wasps, flies and butterflies promoted both geitonogamous and xenogamous pollination.

Abundance of major insect pollinators on Lasora flowers at different day hours of the day during April 2014 and 2015 revealed that the abundance of major insect pollinators at different weeks and day hours differed significantly with insect pollinators. Highest pooled mean of abundance (4.18 and 4.81 bees/$m^2$ branch/5min) was recorded in *A. dorsata* followed by *C. rufifacies* (3.48 and 3.82 flies/$m^2$ branch/5min), *A. florea* (2.78 and 3.13 bees/$m^2$ branch/5min), *A. mellifera* (1.67 and 2.54 bees/$m^2$ branch/5min), *E. obliquus* (0.96 flies/$m^2$ branch/5min) and *Polistes* sp. (0.90 and 1.07 wasps/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *A. cerana* (0.46 and 0.53 bee/$m^2$ branch/5min). Similarly, Saini (2013) reported that relative abundance of *Polistes hebraeus*( 0.6 ± 0.89) and *Rhynchium* sp. (0.6 ± 1.34) on *Zizyphus maurtiana* and stated that relative abundance was greater during 1200 – 1400h.

From the present pollination study, it is evident that Hymenopterans were most abundant insect pollinators on lasora flowers. Irrespective of different day hours, significantly maximum number of *Apis dorsata* was recorded from lasora flowers followed by *C. rufifacies, A. florea*, *A. mellifera, E. obliquus, Polistes sp.* and *A. cerana.* Peak abundance of all honey bee species was recorded at 1000h-1200h and minimum abundance was recorded at 0600h -0800h and 1600h-1800h irrespective of weeks. Minimum activity of *Polistes* sp.was recorded between 0600h to0800h and peak activity was observed at 1000h -1200h and 1200h -1400h irrespective of weeks. Low abundance of dipterans (*C. rufifacies* and *E. obliquus*) wasrecordedat 0600h-0800h and 1600h - 1800h and peak abundance was recorded at 0800h - 1200h irrespective of weeks. These findings are in close agreement with Bajpai(1968), Pushpakumara (2004) and Saini (2011) who reported that the visitation of hymenopterans and other pollinators on aonla flowers was maximum in the morning and evening hours. Similarly Atluri and Rao (2000)who reported that insect pollinators were more active between 09.00h and 11.30h on*Terminalia tomentosa.* Maximum activity was between 09.00h and 11.30h, and then there was a sudden decline in the number of insect visitors from 12.00h to 16.30h.

Diversity of insect visitors/pollinators on Karonda during April 2014 and 2015 revealed that total of 15 insect species belonging to 8 families of 4 orders were recorded. The

Hymenopterans were the major floral visitors comprising of 8 species from 2 families viz., Apidae (*Apis florea, A. dorsata, A. cerana, A. dorsata* and*Xylocopa fenestrata*)and Vespidae (*Allorhynchium metallicum, Delta esuriens* and *Polistes olivaceus*). They were followed in order of diversity by Lepidopterans (four species from four families) viz., Papilionidae (*Papilio demoleus*), Noctuidae (*Helicoverpa armigera*), Pieridae (*Eurema hecabe*) and Hesperiidae (*Pelopidas* sp.),Dipterans (two species from one family) viz., Syrphidae (*Sphaerphoria* sp.and *Episyrphus* sp.) and Coleoptera (one species from one family) viz., Coccinellidae (*Coccinella septempunctata*).Kumar and Bharti (2015) studied diversity of insect visitors on *Butea monosperma* and reported that out of nine insect species, majority belonged to Hymenoptera (6), followed by Lepidoptera (2), while one belonged to Coleoptera. Similarly, Manzoor-ul-haq and Inayatullah(1979) also found 27 species of Hymenoptera, Lepdoptera and Diptera visiting phalsa flowers. *Apis florea* and several species of *Halictus* (Halictidae) and *Andrena* (Andrenidae) were the most common visitors.

Abundance of major insect pollinators on Karonda flowers at different day hours of the day during April 2014 and 2015 revealed that the abundance at different weeks and day hours differed significantly with insect pollinators. During 2014 and 2015, highest pooled mean abundance (3.35 and 3.60 insects/$m^2$ branch/5min) was recorded in *P.demoleus* followed by *H. armigera* (2.23 and 2.41 insects/$m^2$ branch/5min), *A. florea* (1.45 and 1.45 bees/$m^2$ branch/5min), *P. olivaceus* (1.40 and 1.61 insects/$m^2$ branch/5min) and *E. hecabe* (0.92 and 0.87 insects/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *D. esuriens* (0.87 and 1.10 insects/$m^2$ branch/5min).From the present pollination study, it is evident that Hymenopteran and Lepidopteran insects were more abundant insect pollinators on karonda flowers. Irrespective of different day hours, significantly maximum number of *P. demoleus* was recorded from karonda flowers followedby *H. armigera*, *A. florea, P. olivaceus, E. hecabe* and *D. esuriens*. Peakactivity of *P. demoleus* wasrecorded between 1000h -1200h during full bloom of crop. Peak abundance of all Hymenopterans was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h and 1600h-1800h irrespective of weeks. Minimum abundance of all Lepidopteran species was recorded at 0600h -0800h and 1600h - 1800h. Peak abundance was recorded at 1000h -1400h irrespective of weeks.Parmar (1976) also observed that honey bees were the most abundant visitors, and pollinated the flowers of phalsa.

Diversity of insect visitors/pollinators on Bael during May 2014 and 2015 revealed that total of 24 insect species belonging to 12 families of 4 orders were recorded. The Lepidoterans were the major floral visitors comprising of 11 species from 5 families viz., Nymphalidae (*Danaus chrysippus*, *Junonia alomana*, *Junonia lemonias*, *Venessa cardui* and *Phalantaphalantha*), Pieridae (*Catopsilia pyranthe* and *Pieris* sp.), Arctiidae (*Utetheisa pulchella* and *Amata* sp.), Papilionidae (*Papilio demoleus*) and Lycaenidae (*Lampides*

*boeticus*). They were followed in order of diversity by Hymenopterans (9 species from 4 families) viz., Apidae (*Apis florea*, *A. dorsata*, *A. cerana*, *A. mellifera* and *Xylocopa pubescence*), Vespidae (*Delta esuriens* and *Eumenesdimidatipennis*), Megachilidae (*Megachile cephalotes*) and Formicidae (*Monomorium* sp.). They were followed in order of diversity by Coleopterans (two species from two families) viz., Coccinellidae (*Coccinella septempunctata*) and Meloidae (*Mylabris pustulata*) and Diptera (two species from one family) Syrphidae (*Eristalinus obscuritarsus and Eristalinus obliquus*). Similar findings by Singhal *et al*. (2011) stated that eight insect species were recorded on the flowers of Bael trees growing in Patiala region. Those species were *Apis dorsata*, hover fly, *Amata cyssea*, *Anaphaeisaurota*, *Pieris brassicae*, *Polestis herbreus*, *Solenopsis geminate* and *Xylocopa pubescens*. On the other hand in Kangra region, only six insect species namely, *Apis dorsata*, *Apis* sp., hover fly, *Amata cyssea*, *Solenopsis geminata* and an unidentified weevil were recorded. Studies of Bhattacharya (2004) on pollination of *Anacardium occidentale,* found that bees, flies, butterflies, beetles and ants were the visitors of the flowers.

Abundance of major insect visitors/pollinators on Bael during May 2014 and 2015 revealed that, highest pooled mean abundance (7.40 and 8.18 bees/$m^2$ branch/5min) was recorded in *A. dorsata* followed by *B. aurota* (5.14 and 5.55 bees/$m^2$ branch/5min), *C. pyranthe* (4.10 and 4.43 insects/$m^2$ branch/5min), *M. cephalotes* (3.01 and 3.05 insects/$m^2$ branch/5min), *E. obscuritarsus* (1.55 and 0.87 insects/$m^2$ branch/5min) and *A. florea* (1.17 and 2.26 bees/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *A. mellifera* (0.84 and 0.95 bee/$m^2$ branch/5min). Thus it proves that *A. dorsata* and other wild pollinators are most abundant in bael. So there is need to conserve these pollinators to enhance the pollnation services. From the present pollination study, it is evident that Hymenopteran insects were most abundant and Lepidopterans were more diversified insect pollinators on bael flowers. Irrespective of different day hours, significantly maximum number of *Apis dorsata* was recorded from bael flowers followed by *Belenois aurota*, *Catopsilia pyranthe, Megachile cephalotes*, *Apis florea, Eristalinusobscuritarsis* and *Apis mellifera.* Peakactivity of *A. dorsata* wasrecorded between 0800h -1000h during full bloom of crop. Minimum activity of all honey bee species was recorded between 0600h - 0800h and 1400 - 1600h and peak activity was recorded at 0800h -1000h and 1000h – 1200h irrespective of weeks. Minimum activity of *M. cephalotes* was recorded between 0600h to1000h and peak activity was observed at 1000h -1200h and 1400h -1600h irrespective of weeks. Minimum abundance of both Lepidopteran species was recorded at 0600h -0800h and 1400h - 1600h. Peak abundance was recorded at 1000h -1400h irrespective of weeks. Low abundance of *E.obscuritarsis* recordedat 0600h-0800h and 1400h - 1600h. Peak abundance was recorded at 0800h -1200h irrespective of weeks.Singhal *et al*. (2011) revealed that *Apis dorsata* was the most active and frequent visitor of bael flowers during peak blooming.

Diversity of insect visitors/pollinators on Jamun during April 2014 and 2015 reveals that total of 9 insect species belonging to 5 families of 3 orders were recorded. The Dipterans were the major floral visitors comprising of 7 species from 3 families viz., Syrphidae (*Eristalinusobliquus*, *E. tabanoides*, *E. obscuritarsusE. aeneus*and *Eristalis* sp.), Calliophoridae (*Chrysomya megacephala*) and Muscidae (*Musca*sp.) followed by Hymenopterans (one species from one family) viz., Apidae (*Apis dorsata*) and Lepidoptera (one species from one family) viz., Arctiidae (*Amata* sp.).Rajkumar*et. al*. (2015) reported seven insect spieces belongs to family Apidae (*Apis* sp.), Nymphalidae, Scarabaeidae (*Anomala* sp.), Chrysomelidae (*Altica cyanea*) on flowers of *Eugenia discifera*. Parmar (1976) also observed that honey bees were the most abundant visitors, and pollinated the flowers while collecting nectar and found that 30 bee species visited phalsa flowers

Abundance of major insect visitors/pollinators on Jamun during April 2014 and 2015 revealed that at different weeks and day hours differed significantly among the insect pollinators of flower visiting insects. Highest pooled mean abundance (13.54 and 14.07 flies/$m^2$ branch/5min) was recorded in *E. obliquus,* followed by *C. megacephala* (10.97 and 10.28 flies/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *Musca* sp.(3.62 and 3.67 flies/$m^2$ branch/5min). From the present pollination study, it is evident that Dipteran insects were most abundant insect pollinators on jamun flowers. Irrespective of different day hours, significantly maximum number of *E. obliquus* was recorded from jamun flowers followed by *C. megacephala*and *Musca* sp.Peakactivity of *E. obliquus* wasrecorded between 1000h -1200h during full bloom of crop. Peak abundance of *C. megacephala* was recorded at 1600-1800h and minimum abundance was recorded at 1200h -1400h irrespective of weeks. However, some authors reported that bees are the most common visitors of Myrtaceae in general (Gressler *et.al.,*2006). Djonwangwe *et*. *al*. (2011) also reported that there are 2 peaks of activity of *Apis mellifera* adansonii on flowers of *Syzygium guineense* var. *guineense* and stated that the first peak appears in the morning (6-7h) and second peak during afternoon (14-15h).According to Silva and Pinheiro (2007) flies are also importantfloral visitors of Myrtaceae.

Diversity of insect visitors/pollinators on Sarpagandha during April 2014 and 2015 reveals that total of 17 insect species belonging to 10 families of 4 orders were recorded. The Lepidoterans were the major floral visitors comprising of 9 species from 3 families viz., Pieridae (*Pieris* sp., *Anaphaeis* sp., *Pieris canidia*, *Belenois aurota*, *Pieris brassicae* and *Colotis etrida*), Papilionidae (*Papilio demoleus* and *Papilio polytes*) and Hesperiidae (*Pelopidas sp.*). They were followed in order of diversity by Hymenopterans (3 species from 3 families) viz., Apidae (*Amegilla zonata*), Vespidae (*Polistes olivaceus*) and Formicidae (*Monomorium* sp.), Dipterans (3 species from 2 family) Syrphidae viz., (*Eristalinus obscuritarsus* and *Eristalis* sp.) and Sarcophagidae (*Sarcophaga* sp.). They were followed in

order of diversity by Coleopterans (1 species from 1 family) Coccinellidae (*Coccinella septempunctata*), Hemiptera (one species from one family) and Scutellaridae (*Chrysocoris stolli*).These findings are in agreement with those of Wadhwa and Sihag (2012) recorded 19 insect species visiting the blossoms of sarpagandha. Among the visitors, 11 were hympenopterans ( *Xylocopa fenestrata*, *X. pubescens*, *Xylocopa* sp., *Mellisodes* sp., *Pithitis smargdula*, *Megachile bicolor* and *Megachile* sp., *Apis dorsata*, *A. mellifera*, *A. florea* and *polistes hebreaus*) and 8 were lepidopterous insects (*Papilio demoleus*, *P. polytes*, *Danaus aglea creamer*, *Danaus chrysippus*, *Pieris brassicae,Eurema hecabe*, cabbage butterfly and *Pedis* skipper). Among them lepidopterous butterflies and some of hymenopterous bees were important pollinators.

Abundance of major insect visitors/pollinators on Sarpagandha during April 2014 and 2015 revealed that at different weeks and day hours differed significantly among the insect pollinators of Sarpagandha.During 2014, highest pooled mean abundance (3.70 and 3.47 insects/$m^2$ branch/5min) was recorded in *P. demoleus* followed by *A. zonata* (1.83 and 1.85 bees/$m^2$ branch/5min). Lowest pooled mean abundance was recorded in *Pieris* sp.(1.23 1nd 1.53 insects/$m^2$ branch/5min). From the present pollination study, it is evident that Lepidopteran insects were most abundant insect pollinators on Sarpagandha flowers. Irrespective of different day hours, significantly maximum number of *P. demoleus* was recorded from sarpagandha flowers followed by *A. zonata* and *Pieris* sp. Peak abundance of *P. demoleus*, *A.zonata* and *Pieris* sp. was recorded at 1000h-1200h irrespective of weeks. Minimum abundance was recorded at 0600h -0800h irrespective of weeks. Similarly, Wadhwa and Sihag (2012) also observed abundance of insect visitors/pollinators of sarpagandha and stated that *Papilio demoleus* was most abundant followed by *Mellisodes* sp. *Xylocopa fenestrata*, *Pieris brassicae* and *Megachile* sp. and also stated the abundance of insect visitors of sarpagandha and stated that abundance/ visits were low at the time of commencement and cessation of the flowering but these remained high during mid flowering period. Similar findings were reported by Charnov (1976) and Pyke *etal*. (1977) who stated that during peak flowering more flowers were on the plant and they provide more pollen and nectar simultaneously to attract more pollinators.

**5.2. Foraging behaviour**

Foraging is a trade between the amount of nectar expected from a flower and time required to extract it (Pyke *et al.*, 1977). Inouye (1980) observed that more the nectar is available, more time will be spent per flower however, both the parameters might be affected by the length of proboscis. The number of flowers visited by an insect species also depends upon the type of floralreward (working for nectar and/or pollen), bloom and the density of flowers on a particular cultivar.

Flight activity and visitation rates of pollinators are influenced by anthesis and weather components like relative humidity, temperature, wind and rainfall (Forbes and Cervancia, 1994).

**5. 2. 1. Foraging rate**

On Aonla, mean foraging rate for the year 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. florea* observed during 3rd week (15.43 flowers/min), followed by 1st week (13.79 flowers/min) and 2nd week (12.37 flowers/min). Time wise, the maximum foraging rate was observed at 1000h-1200h (24.21 flowers/min) and minimum was at 1600h-1800h (5.21 flowers/min).

During 2014, no activity of *A. florea* was recorded at 0600-0800h of 1st and 3rd week and 1600-1800h of 1st week of flowering. In case of of *Episyrphus* sp. peak foraging rate observed during 2nd week (15.86 flowers/min) followed by 1st week (15.15 flowers/min) and 3rd week (12.92 flowers/min).

Time wise, the foraging rate was significantly the maximum (18.41 flowers/min) at 0800h-1000h and minimum at 1600h-1800h (9.31 flowers/min), Similarly, Peak foraging rate of *Sphaerophoria* sp. observed during 3rd week (11.06 flowers/min), followed by 2nd week (9.81 flowers/min) and 1st week (9.27 flowers/min). Time wise, the foraging rate was significantly the maximum (11.70 flowers/min) at 0800h-1000h and minimum at 1600h-1800h (8.86 flowers/min). Present findings are in conformity with Saini (2011) who observed that the foraging rates of *Apis dorsata*, *A. mellifera*, *A.florea*, *Sarcophaga* and other pollinators on different varieties of amla and stated that foraging rate of *A. dorasta* were maximum on all the three varieties (NA-7, NA-10 and Chakaiya) and foraging rate of all the insect pollinators at diferent hours of the day was significantly different. Foraging rates were maximum at 0800 hrs and minimum at 1400 hrs. Observations by Priti and Sihag, 1998, is in agreement with present study they recorded, among all insect visitors, *Apis florea* had highest foraging rate. Foraging rates of bees were higher than those of flies

Mean foraging rate on Baheda for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *E. obliquus* observed during 1st week (7.22 flowers/min), followed by 2nd week (6.83 flowers/min) and 3rd week (5.31flowers/min). Time wise, the foraging rate was significantly the maximum (9.61 flowers/min) at 1000h-1200h and minimum at 1600h-1800h (3.33 flowers/min). In case of *C. rufifacies,* irrespective of different times of the day, peak foraging rate observed during 3rd week (5.30 flowers/min), followed by 1st week (5.11 flowers/min) and 2nd week (4.74 flowers/min). Time wise, the foraging rate was significantly the maximum (7.48 flowers/min) at 0800h-1000h and minimum at 0600h-0800h (3.66 flowers/min), where as, *E. obscuritarsus,*irrespective of different times of the day, peak foraging rate observed during 3rd week (6.71 flowers/min), followed by 1st week (5.85 flowers/min) and 3rd week (5.00 flowers/min). Time wise, the

foraging rate was significantly the maximum (7.98 flowers/min) at 0800h-1000h and minimum at 1400h-1600h (4.23 flowers/min). In case of*A. florea,*irrespective of different times of the day, peak foraging rate observed during 1$^{st}$week (6.08 flowers/min), followed by 3$^{rd}$ week (5.43 flowers/min) and 2$^{nd}$ week (4.56 flowers/min). Time wise, the foraging rate was significantly the maximum (11.75 flowers/min) at 1000h-1200h and minimum at 0600h-0800h (2.71 flowers/min).

Data on mean foraging rate on Lasora for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *A. cerana* observed during 1$^{st}$ week (8.85 flowers/min), followed by 2$^{nd}$ week (8.36 flowers/min) and 3$^{rd}$ week (7.90 flowers/min). Time wise, the foraging rate was significantly the maximum (14.65 flowers/min) at 1000h-1200h and minimum at 0600h-0800h (1.40 flowers/min). No activity was observed at 1600h-1800h (0.00 flowers/min). In case of *A. dorsata*, Irrespective of different times of the day, peak foraging rate was observed during 1$^{st}$ week (13.66 flowers/min), followed by 3$^{rd}$week (12.98 flowers/min)and 2$^{nd}$ week (12.81 flowers/min). Time wise, the foraging rate was significantly the maximum (15.35 flowers/min) at 1000h-1200h.Lowest foraging rate was recorded at 1200h-1400h (10.75 flowers/min), where as, irrespective of different times of the day, peak foraging rate of *E. obliquus* observed during 3$^{rd}$ week (9.84 flowers/min), followed by 1$^{st}$ week (9.79 flowers/min) and 2$^{nd}$ week (8.73 flowers/min). Time wise, the foraging rate was significantly the maximum (13.76 flowers/min) at 1600h-1800h. Lowest foraging rate was recorded at 1200h-1400h (5.01flowers/min). In case of *A. florea*, peak foraging rate was observed during 3$^{rd}$ week (8.88 flowers/min), followed by 1$^{st}$ week (8.31 flowers/min) and 2$^{nd}$ week (7.35 flowers/min). Time wise, the foraging rate was significantly the maximum (9.35 flowers/min) at 1000h-1200h and minimum at 1200h-1400h (6.81 flowers/min). No literature on this aspect on lasora is available so present results could not be discussed.

Mean foraging rate for 2014 and 2015 on Karonda revealed that irrespective of different times of the day, peak foraging rate of *P. demoleus* observed during 2$^{nd}$ week (2.47 flowers/min), followed by 1$^{st}$ week (31.93 flowers/min) and 3$^{rd}$ week (28.55 flowers/min). Time wise, the foraging rate was significantly the maximum (39.35 flowers/min) at 0800h-1000h and minimum at 0600h-0800h (20.80 flowers/min). Peak foraging rate of *H. armigera* observed during 1$^{st}$ week (16.05 flowers/min), followed by 3$^{rd}$ week (14.99 flowers/min) and 2$^{nd}$ week (14.88 flowers/min). Time wise, the foraging rate was significantly the maximum (17.28 flowers/min) at 1200h-1400h and minimum at 0600h-0800h (12.60 flowers/min). Peak foraging rate of *A. florea* observed during 1$^{st}$ week (5.73 flowers/min), followed by 2$^{nd}$ week (5.42 flowers/min) and 3$^{rd}$ week (4.88 flowers/min). Time wise, the foraging rate was significantly the maximum (8.55 flowers/min) at 1000h-1200h and minimum at 0600h-0800h (2.91 flowers/min). No literature on this aspect on karoonda is available so present results could not be discussed.

Mean foraging rate or 2014 and 2015 on Bael revealed that irrespective of different times of the day, peak foraging rate of *C. pyranthe* observed during 2nd week (4.41 flowers/min), followed by 3rd week (4.07 flowers/min) and 1st week (3.47 flowers/min). Time wise, the foraging rate was significantly the maximum (6.06 flowers/min) at 1000h-1200h and minimum at 1600h-1800h (1.88 flowers/min). In case of *A. dorsata*, peak foraging rate of *A. dorsata* observed during 2nd week (7.86 flowers/min), followed by 1st week (7.08 flowers/min) and 3rd week (6.36 flowers/min). Time wise, the foraging rate was significantly the maximum (9.93 flowers/min) at 0800h-1000h and minimum at 0600h-0800h (5.16 flowers/min). Whereas, foraging rate of *B. aurota* observed during 2nd week (6.13 flowers/min), followed by 3rd week (5.49 flowers/min) and 1st week (4.62 flowers/min). Time wise, the foraging rate was significantly the maximum (6.98 flowers/min) at 0600h-0800h and minimum at 1600h-1800h (2.26 flowers/min). Peak foraging rate of *M. cephalotes* observed during 2nd week (9.69 flowers/min), followed by 3rd week (8.97 flowers/min) and 1st week (6.90 flowers/min). Time wise, the foraging rate was significantly the maximum (15.43 flowers/min) at 0600h-0800h and minimum at 0600h-0800h (0.93 flowers/min). present findings are in agreement with Singhal *et al.* (2011) who revealed that *Apis dorsata* was the most active and frequent visitor of bael flowers during peak blooming and stated that *A. dorasta* carried 5–8 visits/flower/hour and also approximated that around 240–384 bees visited during the functional life of each flower of Bael and also reported that Hover fly was noticed to be the most sluggish insect in its movement over the flower. Honey bees were most active and carried a complete revolving circle on the anthers.

On Jamun, Pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *C. megacephala* observed during 3rd week (8.67 flowers/min), followed by 2nd week (8.36 flowers/min) and 1st week (7.65 flowers/min). Time wise, the foraging rate was significantly the maximum (9.38 flowers/min) at 0600h-0800h and minimum at 1200h-1400h (6.65 flowers/min). Peak foraging rate of *E. obliquus* observed during 3rd week (8.80 flowers/min), followed by 1st week (8.65 flowers/min) and 2nd week (7.98 flowers/min). Time wise, the foraging rate was significantly the maximum (11.61 flowers/min) at 1400h-1600h and minimum at 0600h-0800h (5.68 flowers/min). Peak foraging rate of *Musca* sp. observed during 3rd week (6.40 flowers/min), followed by 1st week (4.55 flowers/min) and 2nd week (4.17 flowers/min). Time wise, the foraging rate was significantly the maximum (9.20 flowers/min) at 1400h-1600h and minimumat 0600h-0800h (3.23 flowers/min). According to Djonwangwe *et. al*. (2011), mean foraging rate of *Apis mellifera* adansonii, on flowers of *Syzygium guineense* var. *guineense* was 7.10 flowers / min and foraging speed was 7.98 sec /flower.

On Sarpagandha, Pooled mean for 2014 and 2015 revealed that irrespective of different times of the day, peak foraging rate of *P. demoleus* observed during 2nd week (25.09

flowers/min), followed by 3rd week (22.95 flowers/min) and 1st week (21.70 flowers/min). Time wise, the foraging rate was significantly the maximum (26.95 flowers/min) at 0800h-1000h and minimum at 0600h-0800h (18.65 flowers/min). Peak foraging rate of *A. zonata* observed during 2nd week (10.70 flowers/min), followed by 3rd week (7.03 flowers/min) and 1st week (6.45 flowers/min). Time wise, the foraging rate was significantly the maximum (10.68 flowers/min) at 1600h-1800h and minimum at 0600h-0800h (6.71 flowers/min), where as, peak foraging rate of *Pieris sp.* observed during 2nd week (6.85 flowers/min), followed by 1st week (6.42 flowers/min) and 3rd week (5.75 flowers/min). Time wise, the foraging rate was significantly the maximum (10.00 flowers/min) at 1000h-1200h and minimum at 0600h-0800h (2.16 flowers/min). Similarly, Wadhwa and Sihag (2012) stated that lepidopterous insects had higher foraging rates than those of hymenopterous insects visiting *R. serpentina.* Among the lepidopterous insects *Papilio demoleus* had highest foraging rate (20.1flowers/min) as compared to *Pieris brassicae* (17.8). Among the hymenopterous insects *Xylocopa* (13.5) had highest foraging rate followed by *Megachile* sp. (10.4) and *Mellisodes* sp. (9.3).

**5. 2. 2. Foraging speed**

Data on mean foraging speed of different insect visitors/pollinators on aonla for 2014 and 2015 revealed that week wise, peak foraging speed of *A. florea* observed during 2nd week (2.80 seconds/flower), followed by 3rd week (2.11 seconds/flower). Minimum foraging speed was observed during 1st week (1.55 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.96 seconds/flower) at 1200h-1400h. Minimum foraging speed was recorded at 0600h-0800h (1.01 seconds/flower). In case of *Episyrphus* sp.*,* peak foraging speed of observed during 3rd week (3.24 seconds/flower), followed by 1st week (3.21 seconds/flower). Minimum foraging speed was observed during 2nd week (3.19 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.48 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 1400h-1600h (2.84 seconds/flower). In case of *Sphaerophoria* sp.peak foraging speed was observed during 1st week (3.35 seconds/flower), followed by 2nd week (3.01 seconds/flower). Minimum foraging speed was observed during 3rd week (2.78 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.97 seconds/flower) at 0800h-1000h. Minimum foraging speed was recorded at 1200h-1400h (1.87 seconds/flower).No literature on this aspect on karonda is available so present results could not be discussed.

Incase of Baheda, pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *E. obliquus* observed during 3rd week (10.70 seconds/flower), followed by 2nd week (9.07 seconds/flower). Minimum foraging speed was observed during 1st week (8.75 seconds/flower). Time wise, the foraging speed was significantly the maximum (12.48

seconds/flower) at 1200h-1400h Minimum foraging speed was recorded at 1000h-1200h (6.72 seconds/flower).

In case of *C. rufifacies* peak foraging speed was observed during 2nd week (7.74 seconds/ flower), followed by 3rd week (7.56 seconds/flower). Minimum foraging speed was observed during 1st week (7.47 seconds/flower). Time wise, the foraging speed was significantly the maximum (11.82 seconds/flower) at 1400h-1600h Minimum foraging speed was recorded at 1600h-1800h (4.84 seconds/flower). Where as, peak foraging speed of *E. obscuritarsus* was observed during 2nd week (6.36 seconds/flower), followed by 3rd week (6.17 seconds/flower). Minimum foraging speed was observed during 1st week (5.20 seconds/flower). Time wise, the foraging speed was significantly the maximum (9.91 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 1600h-1800h (3.06 seconds/flower). In case of *A. florea*, peak foraging speed wasobserved during 1st week (3.94 seconds/flower), followed by 3rd week (3.78 seconds/flower). Minimum foraging speed was observed during 2nd week (3.35 seconds/flower). Time wise, the foraging speed was significantly the maximum (5.95 seconds/flower) at 1000h-1200h. Minimum foraging speed was recorded at 0600h-0800h (1.81 seconds/flower).

Data on mean foraging speed on Lasora for 2014 and 2015 revealed that week wise, peak foraging speed of *A. cerana* observed during 1st week (1.67 seconds/flower), followed by 2nd week (1.55 seconds/flower). Minimum foraging speed was observed during 3rd week (1.51 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.51 seconds/flower) at 0800h-1000h and minimum at 0600h-0800h (0.20 seconds/flower). No activity of *A. cerana* was recorded at 1600h-1800h (0.00 seconds/flower).Whereas, peak foraging speed of *A. dorsata* observed during 3rd week (2.86 seconds/flower), followed by 1st week (2.85 seconds/flower). Minimum foraging speed was observed during 2nd week (2.57 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.28 seconds/flower) at 1000h-1200h. Minimum foraging speed recorded at 1400h-1600h (2.08 seconds/flower). In case of *E. obliquus,* peak foraging speed wasobserved during 1st week (8.24 seconds/flower), followed by 3rd week (8.13 seconds/flower). Minimum foraging speed was observed during 2nd week (7.75 seconds/flower). Time wise, the foraging speed was significantly the maximum (16.80 seconds/flower) at 1200h-1400h. Minimum foraging speed recorded at 0600h-0800h (3.13 seconds/flower), where as, peak foraging speed of *A. florea* observed during 3rd week (3.19 seconds/flower), followed by 2nd week (3.17 seconds/flower). Minimum foraging speed was observed during 1st week (3.05 seconds/flower). Time wise, the foraging speed was significantly the maximum (4.32 seconds/flower) at 1200h-1400h. Minimum foraging speed was recorded at 0600h-0800h (2.13 seconds/flower).Incase of Karonda, pooled mean for 2014 and 2015 revealed that week wise, peak foraging speed of *P. demoleus* observed during 1st week (1.40 seconds/flower), followed by 2nd week (0.88

seconds/flower) and 3rd week (1.29 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.06 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 1400h-1600h (1.01 seconds/flower). In case of *H. armigera*, peak foraging speed of *H. armigera* observed during 1st week (2.69 seconds/flower), followed by 3rd week (2.49 seconds/flower) and 2nd week (2.37 seconds/flower). Time wise, the foraging speed was significantly the maximum (3.22 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 0800h-1000h (2.04 seconds/flower). Where as, peak foraging speed of *A. florea* observed during 1st week (1.40 seconds/flower), followed by 2nd week (0.88 seconds/flower) and 3rd week (1.29 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.06 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 1400h-1600h (1.01 seconds/flower).No literature on this aspect on karonda is available so present results could not be discussed.

Data on mean foraging speed on bael for the year 2014 and 2015 revealed that week wise, peak foraging speed of *C. pyranthe* observed during 1stweek (8.71 seconds/flower), followed by 2nd week (8.86 seconds/flower). Minimum foraging speed was observed during 1st week (8.71 seconds/flower). Time wise, the foraging speed was significantly the maximum (15.91 seconds/flower) at 1600h-1800h. Minimum foraging speed was recorded at 0600h-0800h (4.11 seconds/flower). Where as, peak foraging speed of *A. dorsata* observed during 2nd week (5.31 seconds/flower), followed by 1st week (4.99 seconds/flower). Minimum foraging speed was observed during 3rd week (4.96 seconds/flower). Time wise, the foraging speed was significantly the maximum (8.40 seconds/flower) at 1600h-1800h. Minimum foraging speed was recorded at 0600h-0800h (3.39 seconds/flower). In case of *B. aurota,*peak foraging speed was observed during 2nd week (11.58 seconds/flower), followed by 1st week (8.59 seconds/flower). Minimum foraging speed was observed during 3rd week (8.57 seconds/flower). Time wise, the foraging speed was significantly the maximum (19.19 seconds/flower) at 1600h-1800h. Minimum foraging speed was recorded at 0600h-0800h (4.23 seconds/flower), where as *M. cephalotes*, peak foraging speed was observed during 2nd week (9.66 seconds/flower), followed by 3rd week (8.97 seconds/flower). Minimum foraging speed was observed during 1st week (6.90 seconds/flower). Time wise, the foraging speed was significantly the maximum (15.43 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 0800h-1000h (2.69 seconds/flower).No literature on this aspect on karoonda is available so present results could not be discussed.

Data on foraging speed on Jamun durig the year 2014 and 2015 revealed that week wise, peak foraging speed of *C. megacephala* observed during 1st week (8.80 seconds/flower), followed by 2nd week (6.65 seconds/flower). Minimum foraging speed was observed during 3rd week (4.20 seconds/flower). Time wise, the foraging speed was significantly the maximum (7.86 seconds/flower) at 0800h-1000h. Minimum foraging speed was recorded at

1400h-1600h (4.55 seconds/flower). Incase of *E. obliquus*. Peak foraging speed was observed during 1st week (9.79 seconds/flower), followed by 2nd week (6.30 seconds/flower). Minimum foraging speed was observed during 3rd week (5.83 seconds/flower). Time wise, the foraging speed was significantly the maximum (9.48 seconds/flower) at 1200h-1400h. Minimum foraging speed was recorded at 0600h-0800h (4.55 seconds/flower). Where as, peak foraging speed of *Musca* sp. was observed during 2nd week (10.34 seconds/flower), followed by 1st week (9.84 seconds/flower). Minimum foraging speed was observed during 3rd week (8.51 seconds/flower). Time wise, the foraging speed was significantly the maximum (12.86 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 1400h-1600h (6.04 seconds/flower).According to Djonwangwe *et. al*. (2011) mean foraging rate of *Apis mellifera adansonii*, on flowers of *Syzygium guineense* var. *guineense* was 7.10 flowers / min and foraging speed was 7.98 sec /flower.

Mean foraging speed of different insect visitors on Sarpagandha for the year 2014 and 2015 revealed that week wise, peak foraging speed of *P. demoleus* observed during 3rd week (1.67 seconds/flower), followed by 2nd week (1.59 seconds/flower). Minimum foraging speed was observed during 1st week (1.55 seconds/flower). Time wise, the foraging speed was significantly the maximum (2.12 seconds/flower) at 1400h-1600h. Minimum foraging speed was recorded at 1000h-1200h (1.21 seconds/flower). In case of *A. zonata*, peak foraging speed was observed during 3rd week (2.58 seconds/flower), followed by 1st week (2.18 seconds/flower). Minimum foraging speed was observed during 2nd week (1.98 seconds/flower). Time wise, the foraging speed was significantly the maximum (4.55 seconds/flower) at 0600h-0800h. Minimum foraging speed was recorded at 1200h-1400h (0.76 seconds/flower). Where as, peak foraging speed of *Pieris* sp. observed during 1st and 2nd week (1.03 seconds/flower), followed by 3rd week (0.88 seconds/flower). Time wise, the foraging speed was significantly the maximum (1.85 seconds/flower) at 1000h-1200h. Minimum foraging speed was recorded at 1400h-1600h (0.20 seconds/flower).Wadhwa and Sihag (2012) observed that foraging rates of different insect species of sarpagandha blossoms were low in the morning and evening (i.e. 0700-0800 and 1600-1700h) and high during mid day (1100-1500h) and also stated that foraging rates of lepidopterous insects visiting sarpagandha flowers were significantly higher than those of the hymenopterous insects. Among them *Papilio demoleus* had highest foraging rate followed by *Pieris brassicae*, *Xylocopa fenestrata*, *Megachile* sp. and *Mellisodes*sp.

**5. 2. 3. Number of loose pollen grains sticking on the body of insect visitors**

Pollination process depends on the transfer of pollen from one flower to another. Incase of entomophily, pollination accomplished by insects. More pollen will be transferred by an insect if insect carries large number of pollengrains and may pollinate several flowers (Crane, 1990; Free, 1993). Bees are adapted better to carry pollen grains. This is because of

their structural features that aid in pollination. These structures may entrap thousands of pollen grains during their flower visits.

Mean pollen carrying capacity of *A. florea* on aonla was recorded with highest number (523.50) of pollen grains (‘000) followed by *Episyrphus* sp. (217.25) and *Sphaerophoria* sp. (155.75).Saini, 2011also reported that average number of loose pollen grains was maximum (6538.80) on body o*f A. dorsata* followed by *A. mellifera* (4608.03), *A. florea* (4320.20), *Sarcophag*a (3247.63) and other insect pollinators (760.26) in amla.

*Apis florea* entrapped the maximum number (19.50) of pollen grains (‘000) followed by *Eristalinus obliquus* (16.00) and *Chrysomya rufifacies* (9.50).Incase of Lasora, *Apis dorsata* entrapped the maximum number of pollen grains (‘000) (25.00) followed by *Apis cerana* (20.50) and *Apis florea* (16.75).No literature on this aspect on karonda is available so present results could not be discussed.

On Karonda, *P. demoleus* entrapped the maximum number of pollen grains (‘000) (29.00) followed by *Apis florea* (27.00) and *Helicoverpa armigera* (22.50). According to Rusta *et al*. (2003) reported that the behaviour of nectar foragers on staminate flowers differed according to body size. The number of loose pollen grains on the body of insect visitors dependsupon the size of insect and the condition, in which the pollen load is carried.

Highest number (117.50) of pollen grains (‘000) were collected by *A. dorsata* on bael flowers. followed by *Megachile cephalotes* (72.50), *Belenois aurota* (39.50) and *Catopsilia pyranthe* (12.50). This leads to the conclusion that large body sized bee pollinators carried more number of loose pollen grains than the small sized bees.On Jamun,*Eristalinus obliquus* entrapped the maximum number (51.50) of pollen grains (‘000) followed by *Chrysomya megacephala* (31.50) and *Musca* sp. (11.00).

*Amegilla zonata* entrapped the maximum number (22.50)of pollen grains (‘000) followed by *Papilio demoleus* (14.00) and *Pieris* sp. (11.50). Similar results reported by Wadhwa and Sihag (2012) in sarpagandha and observed that pollen grains carried by the body of *Mellisodes* sp. were maximum followed by *Megachile* sp., *Xylocopa fenestrata*, *Papilio demoleus* and *Pieris brassicae*and concluded that large body sized bee pollinators carried more than small sized bees.

**5. 2. 4. Pollination efficiency of major insect pollinators**

The pollinator’s efficiency in transferring pollen grains partially determines a species’ reproductive success. An effective pollinator makes sequential visits to the flowers, carries pollen and transfers them to stigma during a visit (Corbet *et al*., 1991). It is not possible to determine the best pollinator of crop without studying the relative pollinating efficiency (Sihag, 1986). Pollination efficiency depends upon large number of factors such as abundance, foraging behaviour, loose pollen grains on the insect body, multiplicity of bee

visits and morphometrical characters i.e., body size, tongue length, pollen collecting apparatus and hairyness (Atwal, 1970; Kapil and Brar, 1971; Free, 1993).

In the present study on Aonla, pollination index of *A. florea* was highest (39,542.83) followed by *Episyrphus* sp. (27575.28) and S*phaerphoria* sp. (5589.15). Hence, it was observed that *A. florea* came out to be most efficient pollinator of Aonla. Other pollinators with relatively lower ranking in pollination efficiency were *Episyrphus* sp. and *Sphaerophoria* sp. in descending order. Studies conducted on ber(*Zizyphus mauritiana* Lamk.) by Singh (1984) on the activity of some insect pollinators showed that honey bees were the more efficient pollinators while frequency of visits of houseflies to receptive flowers was more is in conformity of present study.

Pollination index of *E. obliquus* was highest (390.09) in baheda followed by *A. florea* (278.54) and *C. rufifacies* (189.50). Hence, it was observed that *E. obliquus* (390.09)came out to be most efficient pollinator of Baheda. Other pollinators with relatively lower ranking in pollination efficiency were *A. florea* (278.54)and *C. rufifacies* (189.50)in descending order. Pollination index of *A. dorsata* was highest (1476.08) followed by *A. florea* (182.14) and *A. cerana.* (84.93). Hence, it was observed that *A. dorsata* (1476.08) came out to be most efficient pollinator of Lasora. Other pollinators with relatively lower ranking in pollination efficiency were *A. florea* (182.14) and *A. cerana* (84.93) in descending order. On Karonda, Pollination index of *P. demoleus* (3,117,517.4) was highest followed by *H. armigera* (799,182) and *A. florea* (320.247). Hence, it was observed that *P. demoleus* came out to be most efficient pollinator of Karonda followed by *H. armigera* and *A. florea*.

Whereas, on Bael,Pollination index of *A. dorsata* (6489.80) was highest followed by *M. cephalotes* (1153.29), *B. aurota* (1141.13) and *C. pyranthe* (211.93). Hence it was observed that, *A. dorsata* came out to be most efficient pollinator of Bael. Other pollinators with relatively lower ranking in pollination efficiency were *M. cephalotes, B. aurota* and *C. pyranthe* in descending order. Pollination index of *E. obliquus* was highest (6026.73) followed by *C. megacephala* (2749.83) and *Musca* sp. (201.80) in jamun. Hence, it was observed that *E. obliquus* came out to be most efficient pollinator of Jamun. Other pollinators with relatively lower ranking in pollination efficiency were *C. megacephala* and *Musca* sp. in descending order.Work on this aspect of the above plants mentioned has not been undertaken by earlier workers.

On Sarpagandha, Pollination index of *P. demoleus* (1164.7) was highest followed by *A. zonata* (333.27) and *Pieris* sp. (100.61). Hence it was observed that, *P. demoleus* came out to be most efficient pollinator of Sarpagandha. Other pollinators with relatively lower ranking in pollination efficiency were *A. zonata* and *Pieris* sp. in descending order. These findings are in agreement with those of Wadhwa and Sihag (2012) who reported that *Papilio demoleus*was

the most efficient pollinator of Sarpagandha followed by *Mellisodes* sp., *Xylocopa fenestrata* and *Megachile* sp based on the pollination index.

**5. 3. Dry nectar sugars in flowers of different plants**

Results pertaining to the estimation of dry nectar sugars in flowers of different plants revealed that during 2014 maximum dry nectar sugar was present in Lasora (0.874), followed by Bael (0.599), Karonda (0.423), Baheda (0.231), Aonla (0.227), Sarpagandha (0.162) and Jamun (0.153). Similar trend followed in the year 2015 i.e., Lasora (0.896), followed by Bael (0.555), Karonda (0.450), Baheda (0.266), Aonla (0.231), Sarpagandha (0.160) and Jamun (0.158). The pooled mean of 2014 and 2015 revealed that maximum dry nectar sugars found in Lasora (0.885), followed by Bael (0.577), Karonda (0.436), Baheda (0.248), Aonla (0.229), Sarpagandha (0.160) and Jamun (0.155).Djonwangwe *et al*. (2011) reported that mean concentration in total sugars of the *S. guineense* var. *guineense* nectar was 45.53%. Rama devi*et al*. (1989) reported that on an average *Zizyphus mauritiana* flower secreted 2.5 µl/nectar/flower.Girdher (2008) reported that on the basis of flower density and nectar sugar concentration order of preference among pollinators was *A.florea* >dipterans>*P hebraeus* >*A. mellifera* >*A. dorsata* in ber.

**5. 4. Effect of different modes of pollination on fruit set/yield**

Insects play important role in pollination and in enhancing their seed yield. In many entomophilous crops, all the cultural practices would prove useless to effect fruit or seed set if its pollination is neglected. Insect pollinators set a greater proportion of early flowers of the crop and increase quality and quantity of the seed yield.

The observations on the effect of different modes of pollination on various yield parameters of Aonla during 2014 and 2015 reveal that, Number of fruits/branch (27.10 and 26.20), fruit length (22.93 mm and 22.12 mm) and fruit weight (41.51 g and 40.39 g) were significantly higher in case of open pollination as compared to without insect pollination (4.10 and 4.10, 20.49 mm and 19.89 mm, 34.25 and 35.57 g, respectively). Under open pollination, stone weight (0.55g and 0.46) was non - significant when compared to without insect pollination (0.50 g and 0.42 g). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 560.97 and 539.02 respectively.

Present study is in conformity with Srivastava and Pathak (1993) who observed maximum fruit set in amla under open pollination followed by hand pollination and bagging. Similarly Saini (2011) revealed that per cent fruit set was maximum for hand pollination (95.67), followed by open pollination (83.33) and wind pollination (18.00). Whereas Singh *et al*. (1998 and 2001) reported that open pollination resulted in maximum fruit retention followed by geitonogamy in amla and bagging resulted in no fruit retention is in conformity with Mohammad and Ram (1990) who observed absolutely no fruit set under bagging in aonla but contradict present study.

On Baheda, during 2014 and 2015, Number of fruits/branch (15.60 and 14.50), fruit length (23.59mm and 22.07 mm), fruit weight (3.87 g and 3.75 g) and stone weight (0.79 g and 0.78) were significantly higher in case of open pollination as compared to without insect pollination (2.40 and 3.30, 20.56 mm and 20.94 mm, 3.27 g and 2.87 g,0.57 g and 0.63 g, respectively). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 550.00 and 339.39, respectively.In contrast to the present findings,Raju *et al*. (2012) observed maximum fruit set under xenogamous mode (61.6 ± 10.4%) followed by open-pollinations (5.5 ± 0.78% in) whereas no fruit set was observed in autogamy and geitonogamy on *Terminaliapallida*.Similarly, Atluri and Rao (2000) observed fruit set on *T. tomentosa* and reported that maximum fruit set in hand-pollination (80%), followed by open pollination (2%) and stated that lowest fruit set in open pollination is the result ofpollinator limitation due to precipitation in the flowering season which adversely affects both foraging and nestsites.

On Lasora, during 2014 and 2015, Number of fruits/branch (164.90 and 144.60), fruit length (14.83 mm and 13.88 mm) and stone weight (0.39 g and 0.39 g) were significantly higher in case of open pollination as compared to without insect pollination (5.20 and 6.70, 13.36 mm and 13.12 mm, 0.30 g and 0.27 g, respectively). Under open pollination, fruit weight (1.88 g and 1.77g) was non - significant when compared to without insect pollination (1.67 g and 1.60 g,). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 3071.15 and 2058.20, respectively.Present findings are in agreement with earlier study conducted by Sdraiati (1998) on fruit set of *Erythronium denscanis* (Liliaceae) that were open pollinated was 73.9 per cent. It was 21.3 per cent on flowers isolated from insects. The average number of seeds /fruit was 18.02 for open pollinated plants, 7.62 for isolated plants from insects. Uncovered flower buds produced more fruits than the covered ones in sweet orange (*Citrus sinensis* L. Osbeck) cultivars, as concluded by Souza and Cauto (2002).

On Karonda, Number of fruits/branch (55.90 and 56.70), fruit length (17.92 mm and 18.02 mm) and fruit weight (2.07 g and 1.94 g) were significantly higher in case of open pollination as compared to without insect pollination (3.90 and 5.80, 14.78 mm and 14.79 mm, 1.32 g and 1.32 g respectively). Under open pollination, seed weight (0.19g and 0.20 g) was non - significant when compared to without insect pollination (0.16 g and 0.17 g). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 1333.33 and 877.58, respectively. Badiyala and Garg (1990) found that there was increased fruit set in unbagged condition as compared to bagged conditionin litchi. Similar results have been reported by Rianti *et. al*. 2010 in *Jatrophacurcas* and stated that number of fruits per bunch, seeds / plant and seed weight / plant in uncovered plants were higher than that of covered plants.

On Bael, Number of fruits/branch (3.70), fruit length (99.40 mm), fruit weight (529.60 g) and Seed weight (0.04) were significantly higher in case of open pollination as compared to without insect pollination (1.50, 80.00 mm,369.80 g and 0.02 g respectively). During 2015 i.e., Number of fruits/branch (3.00), fruit length (87.40 mm) and fruit weight (462.00 g) were significantly higher in case of open pollination as compared to without insect pollination (1.80, 76.30 mm and 393.00 g respectively). Under open pollination, seed weight (0.05g) was non - significant when compared to without insect pollination (0.04 g).Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 146.66 and 66.66 respectively.Singhal *et al*. (2011) reported that fruit set initiation in open pollinated flowers was noticed to be high, with wild trees showing slightly higher percentage (70.58 ± 0.96%) compared to the cultivated trees where it varied between 60.00 ± 1.09 and 68.42 ± 1.18%. Percentage fruit set initiation with hand pollination was reduced in both the wild (37.50 ± 0.63%) and cultivated trees (25.00 ± 0.60–30.00 ± 0.89%). No fruits were set in the emasculated and non-emasculated flowers after bagging. However, bagging of whole panicles in cultivated and wild trees resulted into 12.21 ± 0.99–14.10 ± 0.57% and 14.12 ± 0.91% fruit set, respectively. Reciprocal crosses performed among wild and cultivated trees yielded no fruit.

On Jamun, Number of fruits/branch (33.10 and 32.60), fruit length (22.91 mm and 22.55 mm), fruit weight (4.11 g and 3.94 g) and Seed weight (1.96 g and 1.83 g) were significantly higher in case of open pollination as compared to without insect pollination (5.00 and 4.00, 18.95 mm and 18.62 mm, 2.76 g and 2.62 g, 1.59 g and 1.36 g respectively). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 562.00 and 715.00 respectively.Djonwangwe *et al*. (2011) reported that fruiting index of flower clusters in free pollination was high (56.90%) than that of bagged flower clusters of S. *guineense* var. *guineense*. Similarly, Bajpai *et. al*. (2012), concluded that geintonogamy is preferred mode of pollination for isolated trees of jamun, coexisting with insect and wind mediated cross pollination. Rajkumar*et. al*. (2015)also reported highest mean fruit set in geitonogamy followed by genogamy, open pollination and autogamy. However, no fruit set was observed in the emasculated and bagged flower of *Eugenia discifera*.

On Sarpagandha, during 2014 and 2015,Number of fruits/branch (32.80 and 30.30) and fruit length (5.83 mm and 5.04 mm) were significantly higher in case of open pollination as compared to without insect pollination (6.60 and 8.30, 4.97 mm and 5.40 mm, respectively). Under open pollination, fruit weight (0.10 g and 0.13 g) and Seed weight (0.04 and 0.04 g) were non - significant when compared to without insect pollination (0.10 g and 0.08 g, 0.03 g and 0.04 g respectively). Per cent increase in number of fruits due to open pollination during 2014 and 2015 were 396.96 and 265.06, respectively. Similar reports reported by Wadhwa and Sihag (2012) in Sarpagandha and revealed that seed setting was

found to be highest in insect pollination treatments 177.45 seed/inflorescence followed by87.33 seed/inflorescence in open pollination. Seed set was found to be very low in wind and self pollination.

# CHAPTER – VI

## SUMMARY AND CONCLUSION

The present study entitled "Evaluation of some underutilized fruit and medicinal plants as bee forage" was carried out on Aonla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha at Research Farm of the Department of Horticulture and Department of Genetics &Plant Breeding, CCS Haryana Agricultural University, Hisar during 2014 and 2015.

The number of insect visitors was low in the initiation of flowering period, increased during peak flowering and decreased when the cessation of flowering. During 2014 and 2015, twelve insect species belonged to 5 orders, 7 families and 9 genera were recorded in Aonla. The dipterans were the major floral visitors followed by hymenopteran, coleopteran, hemipteran and one lepidopteran. Ten insect species belonging to 5 orders, 7 families and 9 genera were recorded in Baheda. The dipterans were the major floral visitors followed in order of diversity by hymenopteran, coleopteran, hemipteran and lepidopteran.Fifteen insect species belonging to 4 orders, 8 families and 12 genera were recorded in Lasora. The hymenopterans were the major floral visitors followed in order of diversity by dipteran, coleopteranand lepidopteran.Fifteen insect species belonging to 4 orders, 8 families and 12 genera were recorded in Karonda. The lepidopterans were the major floral visitors followed in order of diversity by hymenopteran, coleopteran and dipteran.Twenty four insect species belonging to 4 orders, 8 families and 19 genera were recorded in Bael. The hymenopterans were the major floral visitors followed in order of diversity by lepidopteran, coleopteran and dipteran.Nine insect species belonging to 3 orders, 5 families and 6 genera were recorded in Jamun. The Dipterans were the major floral visitors followed by lepidopteranand hymenopteran.Seventeen insect species belonging to 4 orders, 6 families and 16 genera were recorded in Sarpagandha. The lepidopterans were the major floral visitors followed in order of diversity by dipteran, hymenopteranand coleopteran.

From the present pollination study, it is evident that dipterans were most abundant insect pollinators on aonla flowers. Irrespective of different day hours, significantly maximum number of *Episyrphus* sp. was recorded from aonla flowers followed by *Sphaerophoria* sp.and *A. florea.* Peakabundance of *Episyrphus* sp. wasrecorded between 1000h -1200h during full bloom. Irrespective of weeks, maximum abundance of *A. florea* was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h. Dipterans were most abundant insect pollinators on baheda flowers. Irrespective of different day hours, significantly maximum number of *C. rufifacies* was recorded from baheda flowers followed by *E.obliquus, A. florea* and *E.obscuritarsus.* Peakactivity of *C. rufifacies* wasrecorded between 1000h -1200h during full bloom period. Irrespective of weeks, peak abundance of *A. florea* was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h.

On Lasora, hymenopterans were most abundant insect pollinators.Irrespective of different day hours, significantly maximum number of *Apis dorsata* were recorded and followed by *C. rufifacies, A. florea*, *A. mellifera, E. obliquus, Polistes sp.* and *A. cerana.* Peakactivity of *A. dorsata* wasrecorded between 1000h -1200h during full bloom of plant. Peak abundance of all honey bee species was recorded at 1000-1200h. Irrespective of weeks, minimum abundance was recorded at 0600h -0800h and 1600h-1800h. Hymenopteran and lepidopteran insects were more abundant insect pollinators on karonda flowers. Irrespective of different day hours, significantly maximum number of *P. demoleus* was recorded followedby *H. armigera*, *A. florea, P. olivaceus, E. hecabe* and *D. esuriens.* Peakactivity of *P. demoleus* wasrecorded between 1000h -1200h during full bloom, Peak abundance of all hymenopterans was recorded at 1000-1200h and irrespective of weeks, minimum abundance was recorded at 0600h -0800h and 1600h-1800h. Hymenopteran were the most abundant and lepidopterans were more diversified insect pollinators on bael flowers. Irrespective of different day hours, significantly maximum number of *Apis dorsata* was recorded from bael flowers followed by *Belenois aurota*, *Catopsilia pyranthe, Megachile cephalotes*, *Apis florea, Eristalinusobscuritarsis* and *Apis mellifera.* Peakactivity of *A. dorsata* wasrecorded between 0800h -1000h during full bloom of crop. Irrespective of weeks, peak abundance of all honey bee species was recorded at 1000-1200h and minimum abundance was recorded at 0600h -0800h. Dipterans were most abundant insect pollinators on jamun flowers. Irrespective of different day hours, significantly maximum number of *E. obliquus* was recorded from jamun flowers followed by *C. megacephala* and *Musca* sp.Peakactivity of *E. obliquus* wasrecorded between 1000h -1200h during full bloom of period. Irrespective of weeks, peak abundance of *C. megacephala* was recorded at 1600-1800h and minimum abundance was recorded at 1200h -1400h.On Sarpagandha, lepidopterans were most abundant insect pollinators. Irrespective of different day hours, significantly maximum number of *P. demoleus* was recorded followed by *A. zonata* and *Pieris* sp. Irrespective of weeks, peak abundance of *P. demoleus*, *A.zonata* and *Pieris* sp. was recorded at 1000h-1200h while minimum abundance was recorded at 0600h -0800h.

Maximum foraging rate (Number of flowers visited/min) in Aonla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha by*Episyrphus* sp.(14.64), *Eristalinus obliquus* (6.45), *Apis dorsata (*13.15), *Papilio demoleus* (30.98), *Apis dorsata* (7.10), *Eristalinus obliquus* (8.48) and *Papiliodemoleus* (23.24) respectively.Maximum foraging speed (Time spent/flower) in Aonla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha recorded by *Episyrphus* sp.(3.21), *Eristalinus obliquus* (9.50), *Eristalinus obliquus (*9.45), *Apis florea* (2.49), *Belenois aurota* (9.54), *Musca* sp. (9.55) and *Amegilla zonata* (2.24) respectively.

On Aonla, *Apis florea* entrapped the highest number of average loose pollen grains to its body (5,23,500 pollen grains), *Episyrphus* sp. (2,17,250 pollen grains) and it was lowest

incase of *Sphaerophoria* sp. (1,55,750 pollen grains), respectively, On Baheda, *Apis florea* entrapped the highest number of loose pollen grains to its body (19,500 pollen grains), *Eristalinus obliquus* (16,000 pollen grains) and it was lowest incase of *Chrysomya rufifacies* (9500 pollen grains), respectively, On Lasora, *Apis dorsata* entrapped the highest number of loose pollen grains to its body (25,000 pollen grains), *Apis cerana* (20,500 pollen grains) and it was lowest incase of *Apis florea*(16,750 pollen grains), respectively,where as, on Karonda *Papilio demoleus* had the highesr number of loose pollen grains sticking to its body (29,000 pollen grains) followed by *Apis florea* (27,000 pollen grains) and it was lowest incase of *Helicoverpa armigera* (22,500 pollen grains). In case of Bael, *Apis dorsata* entrapped the highest number of loose pollen grains to its body (1,17,500 pollen grains), *Megachile cephalotes* (72,500 pollen grains), *Belenois aurota* (35,250) and it was lowest incase of *Catopsilia pyranthe* (16,750 pollen grains), respectively. *Eristalinus obliquus* entrapped the highest number of loose pollen grains to its body (avg. 51,500 pollen grains), *Chrysomya rufifacies* (avg. 31,500 pollen grains) and it was lowest incase of *Musca* sp. (12,500 pollen grains), respectively on Jamun. whereas, on Sarpagandha, *Amegilla zonata* had the highest number of loose pollen grains sticking to its body (22,500 pollen grains) followed by *Papilio demoleus* (14,000 pollen grains) and it was lowest incase of *Pieris* sp.(11,500 pollen grains).

Based on the pollination index, on Aonla, *Apis florea* was the most efficient pollinator followed by *Episyrphus* sp. and *Sphaerophoria* sp., where as, on Baheda,*Eristalinus obliquus* was the most efficient pollinator followed by *Apis florea* and *Chrysomya rufifacies.*In case of Lasora, *Apis dorsata* was the most efficient pollinator followed by *Apis florea* and *Apis cerana,* whereas, on Karonda *Papilio demoleus* was the most efficient pollinator followed by *Helicoverpa armigera* and *Apis florea.* In case of Bael, *Apis dorsata* was the most efficient pollinator followed by *Megachile cephalotes, Catopsilia pyranthe* and *Belenois aurota*, whereas, in Jamun, *Eristalinus obliquus* was the most efficient pollinator followed by *Chrysomya megacephala* and *Musca* sp. and on Sarpagandha *Papiliodemoleus* was the most efficient pollinator followed by*Amegilla zonata*and *Pieris* sp.

During 2014 and 2015, Number of fruits/branch, fruit length, fruit weight and seed weight under open pollination were significantly higher than without insect pollination. Number of fruits/branch of Aonla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha under open pollination was 26.20-27.10, 14.50-15.60, 144.10-164.90, 55.90-56.70, 3.00-3.70, 32.60-33.10, 30.30-32.80 whereas, in without insect pollination, Number of fruits/branch was 4.10, 2.40-3.30, 5.20-6.70, 3.90-5.80, 1.50-1.80, 4.00-5.00 and 6.60-8.30. However, the per cent increase in yield of Aonla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha under open pollination was 539.02-560.97, 339.39-550.00, 2058.20-3071.15, 877.58-1333.33, 66.66-146.66, 562-715 and 265.66-396.96, respectively.The fruit length (mm) of Aonla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha under open pollination was 22.12-

22.93, 22.07-23.59, 13.88-14.83, 17.92-18.02, 87.40-99.40, 22.51-22.91 and 5.04-5.83 as, in without insect pollination, fruit length (mm) was 19.89-20.49, 20.56-20.94, 13.12-13.36, 14.78-14.79, 76.30-80.00, 18.62-18.95 and 4.97-5.40, respectively.Fruit weight (g) of Aonla, Baheda, Karonda, Bael and Jamun under open pollination was, 40.39- 41.51, 3.75-3.87, 1.94-2.07, 462.00-529.60 and 3.94-4.11 where as, in without insect pollination, fruit weight was 34.25-35.57, 2.87-3.27, 1.32, 369.80-393.00 and 2.62-2.76. Incase of Lasora and Sarpagandha, under open pollination, fruit weight (1.77-1.88 g and 0.10-0.13 g) was non significant when compared to without insect pollination (1.60-1.67 g and 0.08-0.10 g). However, seed weight (g) was non significant under open pollination (0.46-0.55, 0.19-0.20, 0.04-0.05 and 0.04) when compared to without insect pollination (0.42-0.50, 0.16-0.17, 0.02-0.04 and 0.02-0.03) in case of Aonla, Karonda, Bael and Sarpagandha. But there were significant differences in seed weight (g) between open pollination (0.78-0.79, 0.39 and 0.04) and without insect pollination (0.57-0.63, 0.27-0.30 and 1.36-1.59) in case of Baheda, Lasora and Jamun.

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# ABSTRACT

| | | |
|---|---|---|
| **Title of thesis** | **:** | "Evaluation of some underutilized fruit and medicinal plants as bee forage " |
| **Full name of the degree holder** | **:** | **Vadde Anoosha** |
| **Admission No.** | **:** | 2012A17D |
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| **Major subject** | **:** | Entomology |
| **Total number of pages in thesis** | **:** | 172 + iv |
| **Number of words in the abstract** | **:** | 276 |
| **Key words** | **:** | Diversity, Abundance, Pollination efficiency and Yield Parameters and insect visitors |

Hymenoptera was the most diversified order in amla, Lasora and Karonda. Diptera was the most diversified order in Baheda and Jamun. Lepidoptera was the most diversified order in Bael and Sarpagandha.*Episyrphus* sp., *Chrysomya rufifacies, Apis dorsata, Papilio demoleus, Apis dorsata, Eristalinus obliquus, Papilio demoleus* were the most abumdant insect pollinators inAmla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha respectively. Maximum foraging rate in Amla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha was recorded in *Episyrphus* sp.(14.64), *Eristalinus obliquus* (6.45), *Apis dorsata (*13.15), *Papilio demoleus* (30.98), *Apis dorsata* (7.10), *Eristalinus obliquus* (8.48) and *Papiliodemoleus* (23.24) respectively.Maximum foraging speed in Amla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha was recorded in *Episyrphus* sp.(3.21), *Eristalinus obliquus* (9.50), *Eristalinus obliquus (*9.45), *Apis florea* (2.49), *Belenois aurota* (9.54), *Musca* sp. (9.55) and *Amegilla zonata* (2.24) respectively.Maximum number of loose pollen grains carried by *Apis florea* (avg. 5,23,500), *Apis florea* (avg. 19,500), *Apis dorsata* (avg. 25,000), *Papilio demoleus* (avg. 29,000), *Apis dorsata* (avg. 1, 17,500), *Eristalinus obliquus* (avg. 51,500) and *Amegilla zonata* (avg. 22,500) in Amla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha, respectively. Maximum Pollination efficiency in Amla, Baheda, Lasora, Karonda, Bael, Jamun and Sarpagandha was recorded in *Apis florea* (37087.93), *Eristalinus obliquus* (390.09), *Apis dorsata (*1476.08), *Papilio demoleus* (3117.51), *Apis dorsata* (1476.08), *Eristaliinus obliquus* (6026.73) and *papilio demoleus* (1164.78), respectively. Maximum dry nectar sugar was estimated in Lasora (0.885), followed by Bael (0.577), Karonda (0.436), Baheda (0.248), Amla (0.229), Sarpagandha (0.160) and Jamun (0.155).Percent increase in yield in Amla (539.02 - 560.97), Baheda (339.39 - 550.00), Lasora (2058.20 -3071.15), Karonda (877.58 - 1333.33), Bael (66.66 - 146.66), Jamun (562.00-715.00) and Sarpagandha (265.06 - 386.96) was recorded due to open pollination.

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"I, **VADDE ANOOSHA**, Admission No. **2012A17D**, here by undertake that I give the full copyrights of my thesis entitled "Evaluation of some underutilized fruit and medicinal plants as bee forage" to the Chaudhary Charan Singh Haryana Agricultural University, Hisar.

I also undertake that the patent, if any, arising out of the research work conducted during the programme shall be filed by me only with due permission of the competent authority of Chaudhary Charan Singh Haryana Agricultural University, Hisar.

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