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Diversity and Seasonal Activity of Insect Pollinators Visiting Apple Bloom in Relation to Weather Parameters

Tahmina Mushtaq[1*], Sheikh Bilal[2] and Aziz M. A.[3]

[1]PhD Scholar, SKUAST-K (Shalimar, Sgr) J&K-191121

[2]Professor, Division of Entomology, SKUAST-K (Shalimar, Sgr) J&K-191121

[3]Assistant Professor, Division of Soil Science, SKUAST-K (Shalimar, Sgr) J&K-191121

*Corresponding Author E-mail: ttttahmina2@gmail.com

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ABSTRACT

The studies conducted during 2011& 2012 in three major districts of Kashmir to determine diversity and seasonal activity of pollinators visiting apple bloom revealed that a total of 59 insect visitors belonging to 5 orders and 28 families visit apple bloom. Among these insect visitors 12 species Apis mellifera L., Apis cerana indica F, Bombus funerarius Smith, Xylocopa fenestrata F., Lasioglossum moroi (Fabricius), Halictus confuses Smith, Vespa auraria Smith, Syrphus balteatus De Geer, Eristalis tenax (L.), Musca domestica L., Pieris brassicae (L.) and Coccinella septumpunctata L. were frequently present at all the locations Anantnag, Baramulla and Srinagar. Rests of the insects were occasional visitors visiting the bloom at interrupted intervals. The seasonal activity and abundance of the these visitors vary in relation to environmental variables. The correlation coefficient matrix of apple pollinators in relation to weather parameters illustrated that hymenopterans and lepidopterans showed significant and positive correlation with temperature and light intensity and negative correlation with relative humidity and vice versa was observed for dipterans.

Key words: *Apis mellifera L., Apis cerana indica F, Bombus funerarius Smith,*

INTRODUCTION

Weather and blossom time plays an important role in pollination of Apple crop[1]. Process of pollination is complex and is influenced by several environmental factors like temperature, light intensity, wind, etc. Such factors strongly affect the foraging activity of pollinating insects; appear to act by imposing thresholds which limit the duration of activity[4]. Bee species differ in their responses to climatic conditions and are indicative of their different physiological adaptation and partitioning of food resources in sympatric condition[5].Bad weather does have an adverse effect on insect activity and therefore affects cross-pollination[15]. Bee flight is reduced by rain, wind, and cool temperatures, therefore, pollination may fail even though all other factors are favourable[11]. Different pollinators respond differently to diverse climatic conditions.

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The information regarding diversity and seasonal activity of apple pollinators is lacking from Kashmir. The present studies were therefore undertaken in three major districts of Kashmir to determine the diversity and foraging ecology of frequently visiting apple pollinators.

MATERIAL AND METHODS

The Study was conducted during 2011 & 2012 in three major districts of Kashmir valley viz., Anantnag, Baramulla and Srinagar. The observations were after two days of commencement of flowering and continued till 90 per cent flowering was over throughout the day at hourly intervals. The counts of insect visits were taken in one square meter bloom area for fifteen minutes in the beginning of each hour, replicated five times. Atmospheric temperature, relative humidity and light intensity on pollinator activity of released pollinators in the respective locations during the experiment were also recorded. The atmospheric temperature and relative humidity were measured with the help of Aasman type cyclometer (Wet and Dry bulb thermometer) and light intensity was recorded with the help of Luximeter.

RESULTS AND DISCUSSION

Insect visitors of apple orchard ecosystem

Insect visitors collected from bloom of apple during 2011 & 2012 are listed in Table 1. A total of 59 insect visitors belonging to 5 orders and 28 families of class insect were recorded from apple bloom from three districts of Kashmir valley. Out of these, 27 insect visitors belonged to hymenoptera, 24 to diptera, 3 to lepidoptera, 3 to coleopteran and 2 to odonata. Among these insect visitors 12 species *Apis mellifera* L., *Apis cerana indica* F, *Bombus funerarius* Smith, *Xylocopa fenestrata* F., *Lasioglossum moroi* (Fabricius), *Halictus confuses* Smith, *Vespa auraria* Smith, *Syrphus balteatus* De Geer, *Eristalis tenax* (L.), *Musca domestica* L., *Pieris brassicae* (L.) and *Coccinella septumpunctata* L. were frequently present at all the locations Anantnag, Baramulla and Srinagar. Rests of the insects were occasional visitors visiting the bloom at interapted intervals the present findings draw the support from the observations of Raj *et al.*[9] who reported that apple flowers in Solan (H.P) were visited by 46 species of insects belonging to 5 orders and 17 families of class Insecta. Verma and Chauhan[13] reported 44 species of which 16 species belonged to hymenopterans, 11 to dipterans, 9 to lepidopterans, 7 to coleopterans and 1 to Hemiptera. Dashad and Sharma[3] reported a total of 19 insects belonging to 11 genera under 6 families Kumar[6] reported a total of 49 insect species, while as Thakur[12] reported 48 species of insects belonging to 5 orders and 18 families of class insect. Differences in number of species recorded by different workers including the present investigation are attributed to differences in agro climatic conditions of the localities, differential adaptability of a particular native species to its local environmental conditions or due to orientation of other insect visitors to apple during bloom.

Table 1: Insect visitors of apple bloom with taxonomic status in three districts of Kashmir during 2011 & 2012

Order	Family	Genus/Species	Anantnag	Srinagar	Baramulla
Coleoptera	Coccinellidae	*Coccinella septumpunctata* L.	✓	✓	✓
		Hippodamia variegata (Goeze)	✓	X	✓
	Chrysomelidae	*Altica cyanea* Weber	✓	✓	✓
Hymenoptera	Apidae	*Apis mellifera* L.	✓	✓	✓
		Apis cerana indica F.	✓	✓	✓
		Eucera vernalis (Morawitz)	X	✓	X

		Anthophora sp.	✓	X	✓
		Xylocopa fenestrata F.	✓	✓	✓
		Anthophora confuse Smith	✓	X	✓
		Bombus funerarius Smith	✓	✓	✓
		Thyreus nitidulus (Fabricius)	X	✓	X
		Melissodes bimaculata nulla Laberge	✓	X	✓
	Halictidae	*Lasioglossum morio* (Fabricius)	✓	✓	✓
		Ceratina hieroglyphica Smith	✓	✓	X
		Halictus confuses Smith	✓	✓	✓
		Ceratina calcerata Robt	✓	X	X
		Polistes maculipennis Saussure	X	✓	X
	Vespidae	*Polistes* sp.	X	✓	X
		Odynerus sp.	✓	✓	X
		Vespa auraria Smith	✓	✓	✓
Order	Family	*Genus/Species*	Anantnag	Srinagar	Baramulla
	Andrenidae	*Andrena gravida Imhoff*	X	✓	✓
	Ichneumonidae	*Pimpla sp.*	✓	X	✓
	Megachilidae	*Megachile sp.*	X	✓	✓
		Osmia sp.	✓	✓	X
	Sphecidae	*Pison punctifrons Shuckard*	✓	✓	X
	Sapygidae	*Eusaphyga verticalis (Cresson)*	X	X	✓
	Pompilidae	*Pepsis sp*	X	✓	✓
	Tenthredinidae	*Athalia proxima Klug*	✓	X	✓
	Scoliidae	*Megascolia haemorrhoidalis F.*	X	X	✓
	Eumenidae	*Rhychium sp*	✓	✓	X
Diptera	Syrphidae	*Eristalis soliatus Walker*	✓	✓	✓
		Eristalinus sp.indet.	✓	✓	X
		Didea fasciata Macquart	X	✓	✓
		Scaeva pyrastri L	X	✓	✓
		Syrphus balteatus De Geer	✓	✓	✓
		Syritta sp.indet	✓	X	X

		Sphaerophoria sp.	X	✓	✓
		Syritta orientalis (L.)	X	✓	X
		Eristalis tenax (L.)	✓	✓	✓
		Eristalis arbustorum (L.)	✓	X	X
		Eristalis sp.	X	✓	✓
Order	Family	*Genus/Species*	Anantnag	Srinagar	Baramulla
		Sphaerophoria scripta (L.)	✓	✓	X
		Helophilus trivittatus (F.)	X	X	✓
	Bombylidae	*Bombylus major L.*	X	✓	X
		Bombylidae sp.	X	✓	X
	Bibionidae	*Bibio sp.*	X	✓	✓
	Stratiomyiidae	*Hermetia illucens L.*	X	✓	X
	Calliphoridae	*Chrysomyia sp.*	X	✓	✓
		Pseudopyrellia sp.	X	✓	✓
	Asilidae	*Machinus sp.*	X	✓	✓
	Fannidae	*Fanna sp.*	✓	✓	X
	Muscidae	*Musca domestica L.*	✓	✓	✓
	Sarcophagidae	*Sarcophaga sp.*	X	✓	X
	Dryomyzidae	*Dryomyza flaveola (Fabricius)*	✓	✓	X
Lepidopteran	Brassicae	*Pieris brassicae L.*	✓	✓	✓
	Pieridae	*Cynthia cordui (Linn)*	✓	✓	X
	Pieridae	*Colias romonovi Gr. Gosh*	✓	X	X
Odonata	Coenagrionidae	*Ischnura pumilio (Charpentier)*	✓	✓	X
	Libellulidae	*Libellula quadrimaculata L.*	✓	X	✓

Foraging Activity of Insect pollinators in relation to weather parameters in three different districts of kashmir

1. Anantnag

In Anantnag district, the activity of insect visitors *Apis mellifera* L., *Apis cerana indica* F., *Lasioglossum moroi, Xylocopa fenestrata*, *Halictus confusus*, *Eristalis tenax* (L.), *Syrphus balteatus* De Geer and *Musca domestica* started during the 2nd standard week (15th April) when the mean temperature and relative humidity were 18^{0}C and 77.5 per cent, respectively (Fig. 1). Peak intensity (number of pollinators/15minutes/m^2) of *Apis mellifera* L. (4.883), *Apis cerana indica* F. (4.120), *Lasioglossum moroi* (3.35),Xylocopa fenestrata (1.213), *Halictus confusus*. (1.03), were recorded on 23rd April when temperature and relative humidity was 21.5^{o}C and 62.5 per cent, respectively. However, the peak intensity of *Eristalis tenax* (L.) (2.780), *Syrphus balteatus* De Geer (1.980) and *Musca domestica* (1.358), was recorded on 15th April at a temperature 18^{o}C and relative humidity of 77.5 per cent. The activity of *Bombus funerarius* Smith started from the 4th week of April and its peak population (1.900) was recorded on 28th April when the mean temperature and relative humidity was 20.5^{o}C and 67.5 per cent, respectively. *Coccinella septumpunctata* L., *Vespa auraria* Smith and *Pieris brassicae* started their activity on 3rd week of April and attained their peak population of 1.900, 0.795, 1.350, respectively, on 23rd of April when the mean temperature and relative humidity was 21^{o}C and 62.5 per cent, respectively.The correlation coefficient matrix of apple pollinators in relation to weather parameters presented in Table 2, revealed that the activity of *Apis mellifera* L.(r=+0.95,+0.91,-0.91), *Apis cerana indica* F. (r=+0.95,+0.90,-0.92), *Lasioglossum moroi* (r=+0.91,+0.89,-0.89), *Xylocopa fenestrata* (r=+0.73,+0.86,- 0.78), *Bombus funerarius* (r=+0.89, +0.92, -0.84), *Halictus confusus* (r=+0.90, +0.89, -0.84), *Vespa auraria* Smith (r=+0.97, +0.96, -0.95) and *Pieris brassicae* (r=+0.94, +0.91, -0.92) was significantly and positively correlated with temperature and light intensity and negatively correlated with relative humidity. Whereas, significant and negative correlation was found with respect to activity with temperature and light intensity, and positive correlation with relative humidity was recorded for *Eristalis tenax* (L.) (r=-0.96, -0.99, +0.95), *Syrphus balteatus* De Geer (r=-0.86,-0.91, +0.77) and *Musca domestica* (r=-0.96, -0.96, +0.91). However, the activity of *Coccinella septumpunctata* L. (r=+0.86, +0.86,-0.85) was positively correlated with temperature and light intensity and negatively correlated with relative humidity but the effect was non-significant.

Table 2: Correlation between weather parameters and pollinators during 2011 & 2012 in Anantnag

Weather parameters	Pollinators/15 minutes											
	Am	**Ac**	**L**	**X**	**B**	**V**	**H**	**E**	**S**	**m**	**P**	**c**
Temperature	0.951**	0.950**	0.910**	0.738**	0.898*	0.975**	0.900**	-0.968**	-0.836**	-0.960*	0.944**	0.861
Relative humidity	-0.913**	-0.921**	-0.892**	-0.789*	-0.848*	-0.954**	-0.847*	0.935**	0.774*	0.912**	-0.926**	-0.855
Solar intensity	0.912**	0.900**	0.895**	0.561	0.926**	0.964**	0.894*	-0.991**	-0.919**	-0.961**	0.912**	0.868

**significant at 1% level, *significant at 5% level

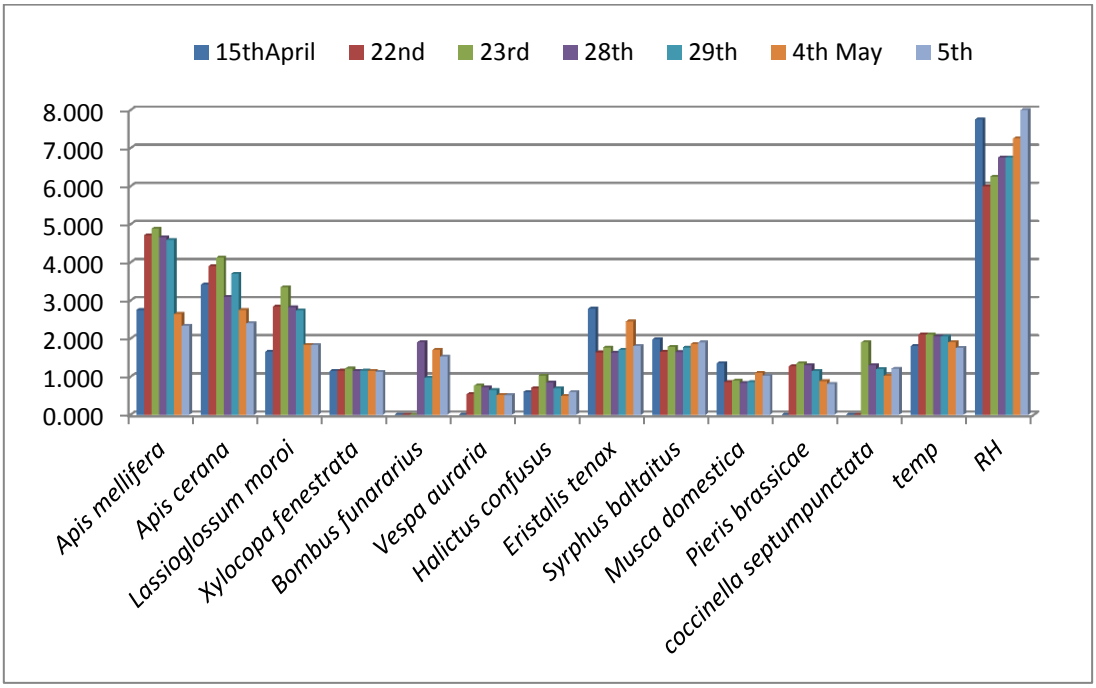

Fig. 1: Intensity and period of activity of insect visitors on Red Delicious cultivar of apple in district Anantnag

2. Srinagar

In district Srinagar, the activity of insect visitors *Apis mellifera* L., *Apis cerana indica* F., *Lasioglossum moroi*, *Xylocopa fenestrata*, *Halictus confusus*, *Eristalis tenax* (L.), *Syrphus balteatus* De Geer and *Musca domestica* started during the 2nd standard week (13th April) when the mean temperature and relative humidity were 17.8°C and 75.5 per cent, respectively (Fig. 2). Peak intensity (number of pollinators/15minutes/m^2) of *Apis mellifera* L.(4.20), *Apis cerana indica* F. (4.12), *Lasioglossum moroi*. (2.34), *Xylocopa fenestrata* F. (1.13), *Halictus confusus* (0.816), were recorded on 24th April when temperature and relative humidity was 21°C and 57.5 per cent, respectively. However, the peak intensity of *Eristalis tenax* (L.) (2.017), *Syrphus balteatus* De Geer (1.733) and *Musca domestica* (1.388), was recorded 13th April at a temperature (17.5°C) and relative humidity of 75.5 per cent. The activity of *Bombus funerarius* Smith started from the 4th week of April and its peak population (0.810) was recorded on 24th April when the mean temperature and relative humidity was 21°C and 57.5 per cent, respectively. *Coccinella septumpunctata* L., *Vespa auraria* Smith and *Pieris brassicae* started their activity on 3rd week of April and attained their peak population of 1.50, 0.822 and 0.825, respectively on 24th of April when the mean temperature and relative humidity was 21°C and 57.5 per cent, respectively.The correlation coefficient matrix of apple pollinators in relation to weather parameters presented in Table 3,revealed that the activity of *Apis mellifera* L. (r=+0.94, +0.97, -0.97), *Apis cerana indica* F. (r=+0.89, +0.91, -0.92), *Lasioglossum moroi* (r=+0.99, +0.96, -0.89), *Xylocopa fenestrata* (r=+0.81, +0.86, -0.82), *Bombus funerarius* (r=+0.96, +0.92, -0.92), *Halictus confusus* (r=+0.95, +0.97, -0.96), *Vespa auraria* Smith (r=+0.95, +0.98, -0.97) and *Pieris brassicae* (r=+0.93, +0.94, -0.94) was significantly and positively correlated with temperature and light intensity and negatively correlated with relative humidity.

Table 3: Correlation between weather parameters and pollinators during 2011 & 2012 in Srinagar

Weather parameter	Pollinators/15 minutes											
	Am	Ac	L	X	B	V	H	E	S	M	P	C
Temperature	0.946**	0.898**	0.997**	0.817*	0.968**	0.953**	0.959**	0.989**	-0.892**	-0.940**	0.932**	0.573
Relative humidity	-0.965**	-0.920**	-0.972**	-0.825*	-0.929**	-0.978**	-0.964**	0.985**	0.910**	0.926**	-0.946**	-0.525
Solar intensity	0.970**	0.919**	0.960**	0.863*	0.925**	0.986**	0.970**	-0.983**	-0.938**	-0.940**	0.946**	0.488

**Significant at 1% level, *significant at 5% level

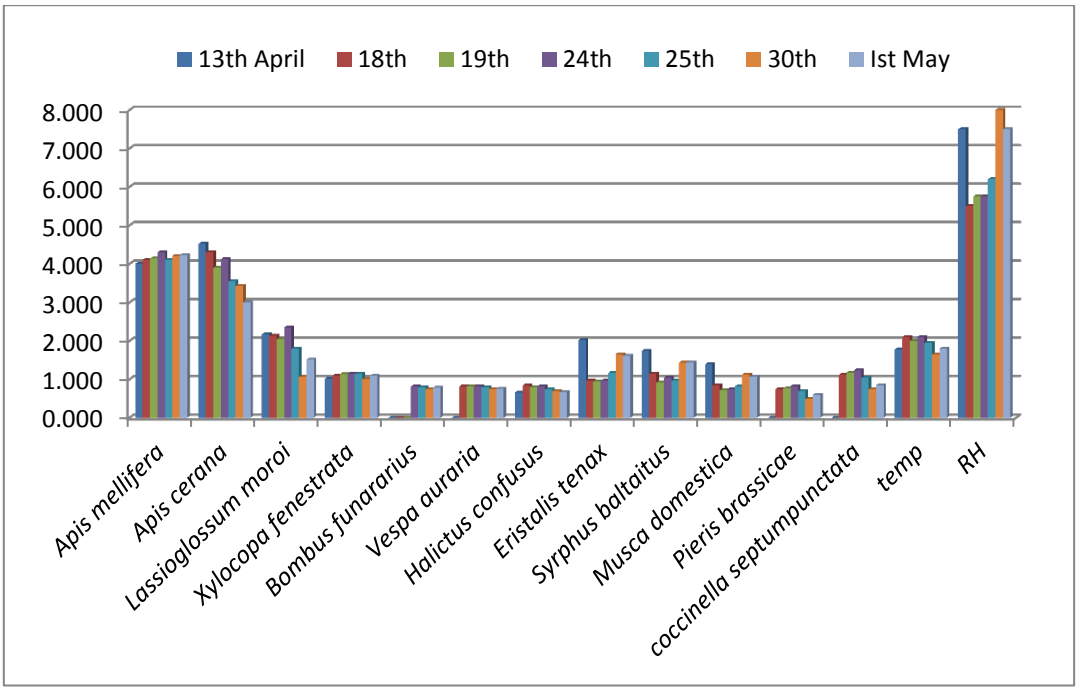

Fig. 2: Intensity and period of activity of insect visitors on Red Delicious cultivar of apple in district Srinagar

Whereas, significant and negative correlation was found with respect to activity with temperature and light intensity, and positive correlation with relative humidity was recorded for *Eristalis tenax* (L.) (r=-0.98, -0.98, +0.98), *Syrphus balteatus* De Geer (r=-0.89, -0.93, +0.91) and *Musca domestica* (r=-0.94, -0.94, +0.92). However the activity of *Coccinella septumpunctata* L.(r=+0.57, +0.48, -0.52) was positively correlated with temperature and light intensity and negatively correlated with relative humidity but the effect was non-significant.

3. Baramulla

In district Baramulla, the activity of insect visitors *Apis mellifera* L., *Apis cerana indica* F., *Lasioglossum moroi*, *Xylocopa fenestrata*, *Halictus confusus*, *Eristalis tenax* (L.), *Syrphus balteatus* De Geer and *Musca domestica* started during the 2nd standard week (14th April) when the mean temperature and relative humidity were 15.8°C and 80.5 per cent, respectively (Fig. 3). Peak intensity (number of pollinators/15minutes/m^2) of Apis mellifera L.(5.50), *Apis cerana indica* F.(3.16), *Lasioglossum moroi* (1.96), *Xylocopa fenestrata* F. (1.26), *Halictus confusus* (0.82), were recorded on 26th April when temperature and relative humidity was 22.4°C and 58.5 per cent, respectively. However, the peak intensity of *Eristalis tenax* (L.) (2.314), *Syrphus balteatus* De Geer (1.458) and *Musca domestica* (1.025), was recorded 14th April at a temperature (15.8°C) and relative humidity of 80.5 per cent. The activity of *Bombus funerarius* Smith started from the 4th week of April and its peak population (0.943) was recorded on 26th April

when the mean temperature and relative humidity was 22.4°C and 58.5 per cent, respectively. *Coccinella septumpunctata* L., *Vespa auraria* Smith and *Pieris brassicae* started their activity on 3rd week of April and attained their peak population of 1.50, 0.84 and 1.06, respectively on 26th of April when the mean temperature and relative humidity was 22.4°C and 58.5 per cent, respectively.

The correlation coefficient matrix of apple pollinators in relation to weather parameters presented in Table 4, revealed that the activity of *Apis mellifera* L. (r=+0.87, +0.91, -0.87), *Apis cerana indica* F. (r=+0.91, +0.93, -0.88),

Table 4: Correlation between weather parameters and pollinators during 2011 & 2012 in Baramulla

Weather parameters	Pollinators/15 minutes											
	Am	Ac	L	X	B	V	H	E	S	m	P	C
Temperature	0.879**	0.912**	0.965**	0.935**	0.954** *	0.926**	0.798*	-0.943**	-0.926**	-0.263*	0.914**	0.472
Relative humidity	-0.874*	-0.880*	-0.88**	-0.887**	-0.900**	-0.894**	-0.836*	0.897**	0.852**	-0.852**	0.841*	-0.461
Solar intensity	0.910**	0.931**	0.947**	0.941**	0.956**	0.925**	0.767*	-0.928**	-0.892**	0.892**	0.867*	0.526

**Significant at 1% level, *significant at 5% level

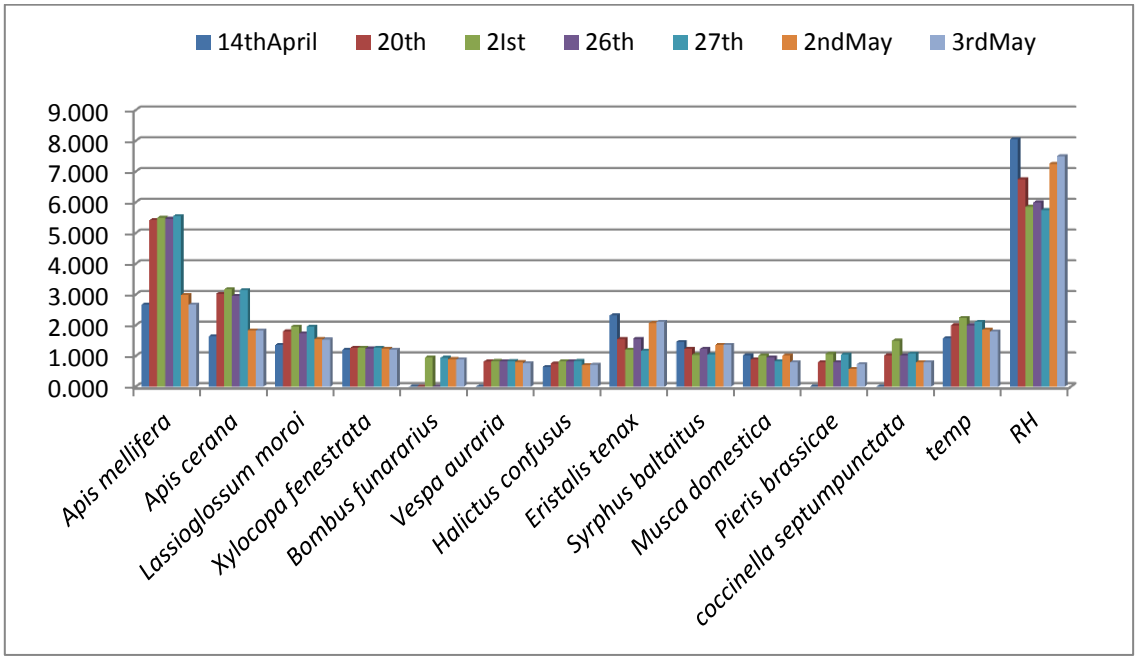

Fig. 3: Intensity and period of activity of insect visitors on Red Delicious cultivar of apple in district Baramulla

Lasioglossum moroi (r=+0.96, +0.95, -0.88), *Xylocopa fenestrata* (r=+0.93, +0.94, -0.88), *Bombus funerariu* (r=+0.95, +0.95, -0.90), *Halictus confusus* (r=+0.79, +0.76, -0.83), *Vespa auraria* Smith (r=+0.92, +0.92, -0.89) and *Pieris brassicae* (r=+0.91, +0.86, -0.84) was significantly and positively correlated with temperature and light intensity and negatively correlated with relative humidity. Whereas, significant and negative correlation was found with respect to activity with temperature and light intensity, and positive correlation with relative humidity was recorded for *Eristalis tenax* (L.) (r=-0.94, -0.92, +0.89), *Syrphus balteatus* De Geer (r=-0.92, -0.89, +0.85) and *Musca domestica* (r=-0.96, -0.86, +0.84). However the activity of *Coccinella septumpunctata* L.(r=+0.47, +0.52, -0.46) was positively correlated with temperature and light intensity and negatively correlated with relative humidity but the effect was non- significant

4. Pooled Seasonal activity of apple pollinators in relation to weather parameters during 2011 and 2012

Data pertaining to pooled activity of pollinators (Table 5) in relation to weather parameters revealed that the activity and intensity of hymenoptera, lepidoptera and coleopteran pollinators like *Apis mellifera* L., *Apis cerana indica* F., *Lasioglossum moroi*, *Xylocopa fenestrata* F., *Halictus confusus*, *Bombus funerarius*, *Vespa aurari* and *Pieris brassicae* was observed maximum during 3rd week of April when the mean temperature and relative humidity was 21.46°C and 59.50 per cent, respectively. However, peak activity and intensity of diptera pollinators were maximum during 2nd week of April, when the temperature and relative humidity was 17.10°C 6 and 77.8 per cent.

The correlation coefficient matrix of apple pollinators in relation to weather parameters illustrated that hymenopterans and lepidopterans showed significant and positive correlation with temperature and light intensity and negative correlation with relative humidity. However, vice versa was observed for dipterans. Such a relationship has also been amply observed by Verma and Dulta[13] ,Dashad[2] and Knoxfield[5] who reported the honey bee (*Apis mellifera*, *Apis cerana indica* F.) activity increased with an increase in temperature and peaked between 19-25°C and decreased as the relative humidity increases beyond 60 per cent. Similarly, Vincens and Bosch[15] reported that number of bees taking foraging trips increased sharply, as the temperature continues to raise upto 25°C .The study demonstrates that each bee has a specific ecological threshold for activity which differs inter and intra specifically depending upon the level of adaptation. The bee species differ in their responses to climatic conditions and are indicative of their different physiological adaptation and partitioning of food sources in sympatric conditions e.g.in *Apis cerana Indica* F. and *Apis mellifera* L., air temperature act as stimulus for commencement of activity while cessation was controlled by light intensity[7] while in Dipteran flies moist conditions are more preferred for activity than drier sites[8]. In addition, their activity may be influenced by relative competition among different insect visitors as also supported by Samida, F. and Elbanna[10].

Table 5: Seasonal abundance of apple pollinators in relation to weather parameters in Kashmir Valley (Pooled)

Pollinators	Maximum period of activity	Maximun mean polpulation	Temperature (°C)	Relative humidity (%)
Apis mellifera	3nd week of April to May	4.84± 0.34	21.46±0.46	59.50±1.52
Apis cerana	3nd week of April to May	3.8 ± 0.32	21.46±0.46	59.50±1.52
Xylocopa fenestrate	3nd week of April to May	1.20± 0.41	21.46±0.46	59.50±1.52
Bombus funerarius Smith	4th week of April to May	1.21±0.34	21.46±0.46	59.50±1.52
Vespa auraria Smith	3nd week of April to May	0.80±0.02	21.46±0.46	59.50±1.52
Lasioglossum sp.	3nd week of April to May	2.54±0.41	21.46±0.46	59.50±1.52
Eristalis tenax (L.)	2nd week of April to May	2.37±0.22	17.10±0.66	77.8±1.45
Syrphus balteatus De Geer	2nd week of April to May	1.72±0.15	17.10±0.66	77.8±1.45
Musca domestica	2nd week of April to May	1.25±0.16	17.10±0.66	77.8±1.45
Halictus sp.	3nd week of April to May	0.99±0.09	21.46±0.46	59.50±1.52
Pieris brassicae	3rd week of April to May	1.07±0.15	21.46±0.46	59.50±1.52
Coccinella septumpunctata L.	3rd week of April to May	1. 411±0.08	21.46±0.46	59.50±1.52

Values are Mean±S.E of 10 observations

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