

Temporal Abundance of Different Floral Visitors on Egyptian Clover (*Trifolium Alexandrinum* L.) and Correlation with Weather Parameters

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Abstract

The temporal abundance of different floral visitors on Egyptian clover, *Trifolium alexandrinum* L. and correlation with weather parameters was studied at Forage Section, Department of Genetics and Plant Breeding, CCS, Haryana Agricultural University, Hisar during 2012 and 2013. The mean temporal abundance of *A. dorsata* was the maximum (4.90/m²/5 min.) followed by *A. mellifera* (2.69), *H. armigera* (2.24), *Eristalinus* spp. (1.59) and *A. florea* (1.20/m²/5 min.) during 2012. During 2013, *A. dorsata* abundance decreased to and it 3.08/m²/5 min. followed by *A. mellifera* (2.61), *P. brassicae* (2.03), *Eristalinus* spp. (1.91), *Coccinella septempunctata* (1.63) and *A. florea* (1.62/m²/5 min.). *A. cerana* abundance during 2012 was 0.30/m²/5 min. but became almost negligible (0.06) in 2013. Floral visitor's abundance was maximum at 1400 h (2.97/m²/5 min.) followed by at 1200 noon (2.66) and 1600 h (2.50) and least during the morning hours of 0600 (0.09) and 0800 h (0.42/m²/5 minutes). Abundance of *A. mellifera* and *A. dorsata* during 2012 had a highly significant positive correlation with wind speed ($r=0.77$ and 0.86) at 0800 h while the later was also correlated with maximum (negative) and minimum relative humidity at 1800 h ($r=-0.89$ and 0.85 , respectively).

Highlights

- The hymenopterans floral visitors on *T. alexandrinum* were most abundant as compared to other floral visitors.
- *Apis dorsata* was the most abundant floral visitor (4.90/m²/5 min.) followed by *Apis mellifera* (2.69/m²/5 min.), *Helicoverpa armigera* (2.24/m²/5) and *Apis florea* (1.20/m²/5).

Keywords: Temporal abundance, diversity, floral visitors, Egyptian clover, *T. alexandrinum*.

Egyptian clover, *Trifolium alexandrinum* L. commonly called *berseem* (Family Leguminaceae, sub-family Papilionaceae), owing to higher quantitative yield parameters viz., green fodder yield (85 t/ha) and multi-cut nature (4–6 cuts) along with qualitative parameters

namely, succulency, high palatability, nutritive value (20% crude protein), digestibility (up to 65%) and continuous supply of over seven months (November to May) Egyptian clover is one of the most entomophilic crop requiring insects, especially bees for cross pollination.

Seed yield increase to the tune of 3496.86 per cent due to honey bee pollination has been reported by Deodikar and Suryanarayana (1977). According to Narayanan *et al.*, (1961), hourly split up of floral visitors show that the honey bees, *A. indica*, *A. florea* and *A. dorsata* started foraging at 0700 h, the activity peaked between 0800-1100 h and bees were not seen after 1300 h as sufficient nectar of desired consistency was not available. But Batra (1976) recorded maximum intensity of *A. mellifera* at 1500 h (5.40 bees/m²/min.) than at 1200 h (4.50 bees) while for *A. dorsata*, it was maximum at 1200 h (1.40) and minimum at 0900 h (0.10 bees/m²/min.). The hourly split up of floral visitors show that the honey bees, *A. indica*, *A. florea* and *A. dorsata* started foraging at 0700 h, the activity peaked between 0800-1100 h and bees were not seen after 1300 h as sufficient nectar of desired consistency was not available.

Materials and Methods

Egyptian clover, *T. alexandrinum* cultivar “HB-2”, the most widely adapted and important cultivar in North India was used @ 25 kg seed/ha for the present investigations. The seed material was provided by Fodder Section of the Department of Genetic and Plant Breeding, CCS Haryana Agricultural University, Hisar.

Temporal abundance of floral visitors

To study the abundance of floral visitors, experimental area was randomly selected and marked at different locations to ensure the maximum flowering. Care was taken to assure similar crop dimensions with respect to the number of plants, plant spread, phase of flowering and number of flowers. The counts of floral visitors were made in one square meter bloom area for 5 minutes continuously and replicated thrice. These observations were recorded when the crop was at 30-80 per cent of flowering at two-hourly intervals from 0600 till 1800 h (7 intervals) of the day for ten calm, clear and sunny days. Any observation on windy, cloudy or otherwise unsuitable day was rejected out-rightly. All the data were statistically analyzed by using randomized block design following the methods given by Free (1993).

Correlation of different floral visitors with weather parameters

Relevant meteorological parameters including relative humidity, atmospheric temperature (maximum and minimum), rainfall, sunshine hours and wind speed during the experiment period were also recorded from the observatory of the Department of Agro-meteorology, CCS HAU, Hisar. The weather parameters were correlated with different floral visitors of *T. alexandrinum* during different days and periods of observation. The data were statistically analyzed using Pearson method.

Results and Discussion

Temporal abundance of flower visitors during different days and periods of observation

Abundance of various flower visitors of *T. alexandrinum* during different days (Table 1, 4) revealed the predominance of *Apis dorsata* but it was more abundant during 2012 than 2013 (4.90 and 3.08/m²/5 minutes, respectively) followed by *Apis mellifera* with almost static population (2.69 and 2.61). It was further followed by *A. florea* having lower mean population during 2012 (1.20) than 2013 (1.62/m²/5 minutes). *A. cerana* was least abundant (0.30) and became almost negligible during 2013 (0.01/m²/5 minutes). These studies find support from Sharma and Singh (2003) who reported that *A. dorsata* was most abundant at Hisar (6.55 bees/m²/5 min.) followed by *A. mellifera* (4.4 bees) and *A. florea* (1.52) but are in contrast to Malaviya *et al.*, (1999) from Jhansi and Singh *et al.*, (2012) from Punjab reporting predominance of *A. mellifera*. Singh *et al.*, (2012) reported highest mean intensity of *A. mellifera* (3.80 bees/m²/min.) followed by *A. dorsata* (1.13) and *A. cerana*. This variation in the temporal abundance of the honey bee species is attributed to geographical location, its bee fauna composition, crop competition, etc.

At different periods of observation (hours) during 2012, (Table 2) floral visitor's abundance was maximum at 1400 h (2.97/m²/5 minutes) followed by at 1200 noon (2.66) and 1600 h (2.50); moderate at 1000 (1.51) and 1800 h (1.28) while the least during the morning hours of

**Table 1. Abundance of floral visitors of *T. alexandrinum* on different days of observations during 2012**

Floral visitors	Mean abundance of floral visitors on <i>T. alexandrinum</i> on different days of May 2012										Mean
	03	04	05	06	07	08	09	10	11	12	
<i>Apis mellifera</i>	2.62* (1.84)**	2.48 (1.78)	2.24 (1.71)	3.43 (1.94)	1.52 (1.53)	3.10 (1.91)	3.00 (1.86)	3.19 (1.91)	3.19 (1.91)	2.19 (1.70)	2.69 (1.81)
<i>Apis dorsata</i>	5.00 (2.33)	4.48 (2.21)	4.62 (2.22)	5.38 (2.36)	2.48 (1.81)	5.67 (1.43)	5.76 (2.44)	6.14 (2.53)	6.14 (2.53)	3.33 (2.00)	4.90 (2.29)
<i>Apis florea</i>	1.95 (1.64)	1.67 (1.56)	1.33 (1.46)	1.05 (1.38)	1.05 (1.40)	1.14 (1.42)	1.05 (1.38)	1.00 (1.36)	0.62 (1.24)	1.14 (1.43)	1.20 (1.43)
<i>Apis cerana</i>	0.38 (1.15)	0.24 (1.10)	0.33 (1.14)	0.48 (1.20)	0.24 (1.10)	0.33 (1.14)	0.29 (1.11)	0.29 (1.12)	0.19 (1.08)	0.24 (1.10)	0.30 (1.12)
<i>Polistes olivaceus</i>	1.19 (1.46)	0.95 (1.37)	1.33 (1.49)	0.91 (1.34)	0.81 (1.32)	1.19 (1.45)	1.05 (1.40)	0.95 (1.37)	0.71 (1.29)	0.86 (1.33)	1.00 (1.38)
<i>Megachile</i> spp.	1.05 (1.40)	0.86 (1.34)	0.86 (1.34)	0.86 (1.33)	0.43 (1.18)	0.95 (1.38)	0.86 (1.33)	0.52 (1.21)	0.57 (1.24)	0.52 (1.21)	0.75 (1.39)
<i>Campsomeriella collaris collaris</i>	0.71 (1.29)	0.38 (1.16)	0.76 (1.31)	0.62 (1.24)	0.57 (1.23)	0.43 (1.18)	0.52 (1.21)	0.29 (1.12)	0.33 (1.14)	0.19 (1.08)	0.48 (1.19)
<i>Eristalinus</i> spp.	1.48 (1.55)	1.14 (1.43)	1.43 (1.53)	1.48 (1.53)	1.14 (1.45)	2.05 (1.71)	2.05 (1.71)	1.86 (1.64)	1.81 (1.62)	1.48 (1.52)	1.59 (1.57)
<i>Pieris brassicae</i>	1.10 (1.43)	0.95 (1.36)	1.10 (1.42)	1.43 (1.51)	0.95 (1.37)	1.67 (1.59)	1.71 (1.60)	1.81 (1.64)	1.48 (1.53)	1.62 (1.55)	1.38 (1.50)
<i>Helicoverpa armigera</i>	1.95 (1.66)	2.05 (1.68)	1.76 (1.59)	1.86 (1.62)	2.24 (1.73)	2.48 (1.80)	2.38 (1.77)	2.38 (1.78)	2.33 (1.77)	3.00 (1.90)	2.24 (1.73)
<i>Andrallus spinidens</i>	1.33 (1.50)	0.86 (1.34)	1.24 (1.44)	1.19 (1.45)	0.95 (1.37)	1.81 (1.65)	2.14 (1.72)	2.14 (1.73)	1.57 (1.57)	1.95 (1.66)	1.52 (1.54)
<i>Coccinella septempunctata</i>	1.33 (1.51)	1.05 (1.40)	1.38 (1.52)	1.48 (1.55)	1.24 (1.46)	1.62 (1.58)	1.95 (1.67)	1.95 (1.68)	1.81 (1.63)	1.76 (1.62)	1.56 (1.56)
CD (p≤0.05)						0.11					0.04
SE(m)						0.03					0.01
Mean	1.68 (1.56)	1.43 (1.48)	1.53 (1.51)	1.68 (1.54)	1.14 (1.41)	1.87 (1.60)	1.90 (1.60)	1.88 (1.59)	1.73 (1.55)	1.52 (1.51)	
CD (p≤0.05)						0.03					
SE(m)						0.01					

*Observations are mean of 30 replications (10 days × 3 replications). **Figures in parentheses are $\sqrt{n+1}$ values

Table 2. Abundance of floral visitors of *T. alexandrinum* during different hours of day during 2012

Floral visitors	Spatial distribution of floral visitors during different hours (h)							
	0600	0800	1000	1200	1400	1600	1800	Mean
<i>Apis mellifera</i>	0.00* (1.00)**	0.57 (1.24)	2.33 (1.81)	4.73 (2.37)	5.70 (2.57)	4.53 (2.22)	0.97 (1.35)	2.69 (1.81)
<i>Apis dorsata</i>	0.50 (1.21)	1.50 (1.57)	4.13 (2.24)	8.93 (3.11)	9.57 (3.22)	7.37 (2.87)	2.30 (1.78)	4.90 (2.29)
<i>Apis florea</i>	0.03 (1.01)	0.40 (1.17)	1.47 (1.54)	2.43 (1.83)	2.37 (1.79)	1.33 (1.50)	0.37 (1.15)	1.20 (1.43)
<i>Apis cerana</i>	0.00 (1.00)	0.00 (1.00)	0.37 (1.15)	0.73 (1.30)	0.60 (1.24)	0.37 (1.15)	0.03 (1.01)	0.30 (1.12)
<i>Polistes olivaceus</i>	0.10 (1.04)	0.17 (1.07)	0.80 (1.33)	1.43 (1.55)	1.83 (1.67)	1.57 (1.59)	1.07 (1.41)	1.00 (1.38)
<i>Megachile</i> spp.	0.00 (1.00)	0.13 (1.06)	0.60 (1.25)	1.20 (1.47)	1.53 (1.58)	1.13 (1.45)	0.63 (1.26)	0.75 (1.29)
<i>Campsomeriella collaris collaris</i>	0.00 (1.00)	0.03 (1.01)	0.60 (1.25)	0.90 (1.37)	0.83 (1.33)	0.63 (1.25)	0.37 (1.15)	0.48 (1.19)
<i>Eristalinus</i> spp.	0.13 (1.06)	0.60 (1.25)	1.53 (1.58)	2.53 (1.87)	2.73 (1.92)	2.23 (1.79)	1.37 (1.52)	1.59 (1.57)
<i>Pieris brassicae</i>	0.03 (1.01)	0.20 (1.08)	1.17 (1.45)	1.93 (1.70)	2.40 (1.83)	2.23 (1.78)	1.70 (1.63)	1.38 (1.50)
<i>Helicoverpa armigera</i>	0.07 (1.03)	0.37 (1.15)	1.97 (1.70)	2.70 (1.91)	3.17 (2.01)	4.03 (2.23)	3.40 (2.09)	2.24 (1.73)
<i>Andrallus spinidens</i>	0.03 (1.01)	0.57 (1.23)	1.57 (1.57)	2.23 (1.79)	2.43 (1.84)	2.17 (1.76)	1.63 (1.60)	1.52 (1.54)
<i>Coccinella septempunctata</i>	0.17 (1.07)	0.47 (1.19)	1.60 (1.60)	2.17 (1.77)	2.50 (1.86)	2.43 (1.84)	1.57 (1.58)	1.56 (1.56)
CD (p≤0.05)				(0.10)				(0.04)
SE(m)				0.03				0.01
Mean	0.09 (1.04)	0.42 (1.17)	1.51 (1.54)	2.66 (1.84)	2.97 (1.91)	2.50 (1.79)	1.28 (1.46)	
CD (p≤0.05)				(0.03)				
SE(m)				0.01				

*Observations are mean of 21 replications (7 intervals x 3 replications). ** Figures in parentheses are $\sqrt{n+1}$ values



Table 3. Correlation of different floral visitors with weather parameters during 2012

Floral visitors	0600 h					0800 h					1000 h				
	TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RHMax	RHMin	WS
<i>Apis mellifera</i>	-	-	-	-		0.03	0.05	0.31	0.09	0.77**	0.01	0.41	-0.29	-0.30	-0.41
<i>Apis dorsata</i>	-0.29	-0.34	0.50	0.43	-0.62	0.29	0.16	0.18	-0.01	0.86**	-0.15	-0.08	-0.56	-0.46	-0.54
<i>Apis florea</i>	0.12	0.10	-0.08	-0.33	-0.20	-0.27	-0.32	0.71*	0.82**	-0.03	0.26	0.31	-0.56	-0.41	-0.02
<i>Apis cerana</i>	-	-	-	-	-	-	-	-	-	-	0.12	0.31	-0.45	-0.47	-0.23
<i>Polistes olivaceus</i>	-0.17	-0.18	0.32	0.22	-0.39	-0.08	-0.12	0.63*	0.54	0.46	-0.32	-0.12	-0.02	0.09	-0.23
<i>Megachile</i> spp.	-	-	-	-	-	0.31	0.32	-0.03	0.09	0.56	0.19	-0.04	-0.13	-0.27	-0.31
<i>Campsomeriella collaris collaris</i>	-	-	-	-	-	0.46	0.42	-0.01	0.13	0.455	0.56	0.41	-0.02	0.13	-0.34
<i>Eristalinus</i> spp.	0.39	0.29	0.10	0.07	0.07	0.14	0.33	-0.01	-0.01	0.67*	-0.18	-0.14	-0.32	-0.23	-0.47
<i>Pieris brassicae</i>	-0.10	-0.03	-0.39	-0.26	0.07	0.29	0.21	0.20	0.15	0.76*	-0.47	-0.31	-0.08	0.12	-0.48
<i>Helicoverpa armigera</i>	-0.42	-0.47	-0.06	0.24	0.49	0.05	0.03	0.17	0.14	0.52	-0.41	0.15	-0.07	-0.21	-0.46
<i>Andralus spinidens</i>	0.43	0.41	0.04	0.02	0.14	0.11	0.16	0.12	0.08	0.67*	-0.46	-0.17	0.25	0.26	0.03
<i>Coccinella septempunctata</i>	0.08	0.08	0.24	-0.01	-0.61	-0.34	-0.26	-0.15	-0.25	0.42	-0.20	-0.02	-0.14	-0.01	-0.46

1200 h					1400 h					1600 h					1800 h				
TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RHMax	RHMin	WS
0.40	0.18	-0.18	-0.31	0.46	0.04	0.04	-0.41	-0.39	0.10	0.29	0.25	0.20	-0.42	-0.04	-0.58	-0.55	0.44	0.46	0.09
0.51	0.25	-0.47	-0.58	0.46	0.06	0.11	-0.47	-0.50	-0.10	0.53	0.49	-0.13	-0.67*	-0.23	-0.83**	-0.83**	0.89**	0.85**	0.44
0.18	-0.21	-0.71*	-0.79**	0.39	-0.12	-0.05	-0.52	-0.52	-0.21	0.12	0.00	-0.16	-0.35	0.10	-0.06	0.03	0.12	0.20	-0.50
0.31	0.49	0.12	0.03	0.47	-0.31	-0.27	-0.38	-0.33	0.15	0.39	0.28	-0.06	-0.45	0.08	-0.14	-0.24	0.30	0.18	0.84**
0.55	0.61	-0.09	-0.18	0.37	0.36	0.40	-0.48	-0.59	-0.38	0.22	-0.09	-0.29	-0.17	0.44	-0.04	-0.20	0.00	-0.02	0.55
0.26	0.33	-0.26	-0.37	0.32	-0.13	-0.07	-0.57	-0.61	-0.35	0.27	0.06	-0.09	-0.25	-0.07	0.54	0.62	-0.62	-0.60	-0.52
0.53	0.31	-0.05	0.01	0.05	0.12	0.11	-0.28	-0.44	-0.55	0.42	0.38	-0.37	-0.50	-0.27	0.25	0.24	-0.42	-0.41	-0.09
-0.19	0.37	0.25	0.14	0.41	-0.11	-0.07	0.25	0.25	0.27	-0.08	-0.29	0.34	0.35	0.52	-0.37	-0.37	0.48	0.50	0.05
0.04	0.26	0.17	0.04	0.47	-0.15	-0.08	0.08	0.19	0.55	-0.43	-0.65*	0.66*	0.61	0.71*	-0.15	-0.21	0.31	0.26	0.43
-0.31	0.30	0.08	-0.01	0.45	-0.12	-0.13	0.53	0.60	0.39	-0.14	-0.5	0.18	0.31	0.48	-0.4	-0.3	0.33	0.41	-0.23
0.03	0.56	0.00	-0.02	0.65*	-0.25	-0.19	0.12	0.25	0.574	-0.27	-0.46	0.15	0.42	0.59	-0.32	-0.32	-0.38	0.40	0.35
-0.57	0.38	0.70*	0.65*	0.33	-0.33	-0.35	0.48	0.52	0.40	-0.48	-0.64*	0.56	0.77**	0.59	-0.52	-0.56	0.62	0.57	0.50

* Significant at 5 per cent level

** Significant at 1 per cent level

**Table 4. Abundance of floral visitors of *T. alexandrinum* on different days of observations during 2013**

Floral visitors	Mean abundance of floral visitors on different days of May 2013											
	01	02	03	04	05	06	07	08	09	10	Mean	
<i>Apis mellifera</i>	2.62* (1.82)**	2.19 (1.72)	2.38 (1.77)	2.52 (1.80)	2.81 (1.89)	2.62 (1.83)	2.76 (1.87)	2.86 (1.89)	2.52 (1.80)	2.76 (1.87)	2.61 (1.83)	
<i>Apis dorsata</i>	2.38 (1.76)	2.57 (1.81)	2.86 (1.89)	2.95 (1.91)	3.24 (1.98)	3.43 (2.03)	3.38 (2.03)	3.33 (2.01)	3.24 (1.98)	3.43 (2.03)	3.08 (1.94)	
<i>Apis florea</i>	1.33 (1.48)	1.43 (1.52)	2.05 (1.69)	1.71 (1.58)	1.67 (1.59)	1.86 (1.64)	1.71 (1.60)	1.57 (1.54)	1.29 (1.46)	1.62 (1.56)	1.62 (1.57)	
<i>Apis cerana</i>	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)	0.05 (1.02)	0.05 (1.02)	0.05 (1.02)	0.01 (1.01)	
<i>Polistes olivaceus</i>	0.71 (1.29)	1.14 (1.43)	1.19 (1.45)	1.24 (1.47)	1.48 (1.55)	1.43 (1.52)	1.43 (1.53)	1.29 (1.48)	1.24 (1.47)	1.76 (1.63)	1.29 (1.48)	
<i>Megachile</i> spp.	0.52 (1.22)	0.62 (1.25)	1.00 (1.38)	0.67 (1.27)	0.67 (1.26)	0.62 (1.24)	0.71 (1.29)	0.76 (1.29)	0.86 (1.32)	0.86 (1.33)	0.73 (1.29)	
<i>Campsomeriella collaris collaris</i>	0.29 (1.11)	0.29 (1.12)	0.24 (1.10)	0.19 (1.08)	0.38 (1.16)	0.24 (1.10)	0.24 (1.10)	0.33 (1.14)	0.29 (1.12)	0.19 (1.08)	0.27 (1.11)	
<i>Eristalinus</i> spp.	1.33 (1.50)	1.24 (1.46)	1.71 (1.60)	2.29 (1.78)	2.05 (1.72)	2.19 (1.77)	2.00 (1.71)	1.95 (1.69)	2.10 (1.74)	2.24 (1.79)	1.91 (1.68)	
<i>Pieris brassicae</i>	1.14 (1.44)	1.81 (1.62)	1.95 (1.69)	2.05 (1.71)	2.14 (1.73)	2.33 (1.77)	2.29 (1.76)	2.29 (1.75)	2.33 (1.77)	2.00 (1.67)	2.03 (1.69)	
<i>Helicoverpa armigera</i>	0.86 (1.34)	1.29 (1.47)	1.48 (1.55)	1.48 (1.53)	1.33 (1.49)	1.48 (1.53)	1.76 (1.61)	1.14 (1.43)	1.33 (1.48)	1.57 (1.56)	1.37 (1.50)	
<i>Andrallus spinidens</i>	1.00 (1.39)	1.05 (1.40)	0.91 (1.35)	1.52 (1.55)	1.62 (1.59)	1.76 (1.63)	1.38 (1.51)	1.48 (1.54)	1.38 (1.51)	1.76 (1.62)	1.39 (1.51)	
<i>Coccinella septempunctata</i>	0.95 (1.37)	1.33 (1.50)	1.57 (1.56)	1.67 (1.60)	1.52 (1.57)	1.81 (1.64)	1.86 (1.66)	2.00 (1.70)	1.71 (1.62)	1.86 (1.66)	1.63 (1.59)	
CD (p≤0.05)						0.12						0.03
SE(m)						0.04						0.01
Mean	1.10 (1.39)	1.25 (1.44)	1.44 (1.50)	1.52 (1.52)	1.58 (1.54)	1.65 (1.56)	1.63 (1.56)	1.59 (1.54)	1.53 (1.52)	1.68 (1.57)		
CD (p≤0.05)						0.03						
SE(m)						0.01						

*Observations are mean of 30 replications (10 days \times 3 replications). ** Figures in parentheses are $\sqrt{n+1}$ value

Table 5. Abundance of floral visitors of *T. alexandrinum* during different hours of day during 2013

Floral visitors	Spatial distribution of floral visitors during different hours (h)									
	0600	0800	1000	1200	1400	1600	1800	Mean		
<i>Apis mellifera</i>	0.07* (1.03)**	0.90 (1.33)	2.93 (1.97)	4.03 (2.24)	4.57 (2.35)	3.87 (2.20)	1.87 (1.66)	2.61 (1.83)		
<i>Apis dorsata</i>	0.23 (1.09)	1.27 (1.46)	3.67 (2.15)	4.77 (2.39)	5.23 (2.49)	4.30 (2.30)	2.10 (1.72)	3.08 (1.94)		
<i>Apis florea</i>	0.00 (1.00)	0.47 (1.18)	2.17 (1.76)	2.87 (1.96)	2.83 (1.95)	2.23 (1.79)	0.80 (1.31)	1.62 (1.57)		
<i>Apis cerana</i>	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.10 (1.04)	0.01 (1.01)		
<i>Polistes olivaceus</i>	0.27 (1.11)	0.90 (1.36)	1.33 (1.50)	2.00 (1.72)	1.87 (1.69)	1.80 (1.66)	0.87 (1.35)	1.29 (1.48)		
<i>Megachile</i> spp.	0.03 (1.01)	0.20 (1.08)	0.87 (1.35)	1.33 (1.52)	1.40 (1.54)	0.93 (1.37)	0.33 (1.14)	0.73 (1.29)		
<i>Campsomeriella collaris collaris</i>	0.00 (1.00)	0.00 (1.00)	0.47 (1.19)	0.60 (1.25)	0.50 (1.21)	0.30 (1.12)	0.00 (0.00)	0.27 (1.11)		
<i>Eristalinus</i> spp.	0.67 (1.26)	1.87 (1.66)	2.50 (1.86)	2.57 (1.88)	2.33 (1.82)	2.17 (1.77)	1.27 (1.49)	1.91 (1.68)		
<i>Pieris brassicae</i>	0.13 (1.05)	1.03 (1.40)	2.20 (1.78)	3.13 (2.02)	3.23 (2.05)	3.03 (2.00)	1.47 (1.54)	2.03 (1.69)		
<i>Helicoverpa armigera</i>	0.03 (1.01)	0.70 (1.27)	1.40 (1.52)	2.20 (1.78)	2.27 (1.79)	2.00 (1.72)	1.00 (1.39)	1.37 (1.50)		
<i>Andralus spinidens</i>	0.27 (1.10)	0.97 (1.38)	1.53 (1.58)	1.90 (1.69)	2.13 (1.76)	2.03 (1.73)	0.87 (1.35)	1.39 (1.51)		
<i>Coccinella septempunctata</i>	0.47 (1.18)	0.97 (1.38)	1.87 (1.68)	2.27 (1.80)	2.50 (1.86)	2.23 (1.79)	1.10 (1.43)	1.63 (1.59)		
CD ($p \leq 0.05$)				0.10				0.04		
SE(m)				0.04				0.01		
Mean	0.18 (1.07)	0.77 (1.29)	1.74 (1.61)	2.31 (1.77)	2.41 (1.79)	2.08 (1.70)	0.98 (1.37)			
CD ($p \leq 0.05$)				0.03						
SE(m)				0.03						

*Observations are mean of 21 replications (7 intervals \times 3 replications). ** Figures in parentheses are $\sqrt{n+1}$ valu



Table 6. Correlation of different floral visitors with weather parameters during 2013

Floral visitors	0600 h					0800 h					1000 h				
	TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RHMax	RHMin	WS
<i>Apis mellifera</i>	-	-	-	-	-	0.45	0.64*	0.36	0.74*	-0.42	-0.45	-0.39	0.18	0.14	0.05
<i>Apis dorsata</i>	-	-	-	-	-	0.53	0.59	0.80**	0.69*	0.14	0.12	0.24	0.00	0.06	0.13
<i>Apis florea</i>	-	-	-	-	-	0.04	0.38	0.49	0.52	-0.21	-0.39	-0.41	-0.17	-0.21	0.08
<i>Apis cerana</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Polistes olivaceus</i>	0.68*	0.38	0.11	0.22	0.00	-0.06	-0.32	-0.16	0.11	-0.33	0.16	0.31	0.37	0.38	0.46
<i>Megachile</i> spp.	-	-	-	-	-	0.24	0.15	0.40	0.49	-0.19	0.11	-0.41	-0.14	-0.11	0.34
<i>Campsomeriella collaris</i>	-	-	-	-	-	-	-	-	-	-	0.49	0.06	0.50	0.41	0.18
<i>Eristalinus</i> spp.	0.31	0.44	0.05	-0.10	0.35	0.38	0.46	0.06	0.66*	-0.31	0.09	-0.09	0.35	0.36	-0.39
<i>Pieris brassicae</i>	-	-	-	-	-	-0.15	-0.15	-0.01	-0.18	0.29	0.13	-0.07	0.12	0.14	-0.31
<i>Helicoverpa armigera</i>	-	-	-	-	-	0.01	-0.41	-0.25	-0.34	0.51	-0.34	-0.38	0.18	0.20	-0.02
<i>Andrallus spinidens</i>	0.38	0.14	0.40	0.39	0.03	-0.00	0.40	0.72*	0.62	0.05	0.50	0.63	0.51	0.59	0.24
<i>Coccinella septempunctata</i>	0.19	0.13	0.65*	0.55	0.20	0.55	0.61	0.73*	0.70*	-0.03	-0.10	-0.08	0.10	0.04	-0.28

1200 h					1400 h					1600 h					1800 h				
TMax	TMin	RH Max	RH Min	WS	TMax	TMin	RH Max	RH Min	WS	TMax	TMin	RHMax	RHMin	WS	TMax	TMin	RH Max	RH Min	WS
0.41	0.39	0.21	0.34	0.21	0.34	0.36	-0.21	-0.28	0.08	0.25	0.48	0.52	0.40	-0.03	0.61	0.77**	0.47	0.44	-0.21
0.67*	0.85**	0.50	0.39	-0.22	0.55	0.42	0.55	0.51	0.66*	0.03	0.31	0.18	0.20	0.17	0.79**	0.68*	0.53	0.60	0.11
0.13	0.46	0.48	0.37	-0.15	0.12	0.03	-0.40	-0.36	0.28	-0.03	0.05	-0.33	-0.25	-0.01	0.21	0.34	-0.28	-0.16	-0.22
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-0.12	0.57	0.27	0.33	0.33	0.62	0.40	0.51	0.43	0.45	-0.20	0.10	0.68*	0.74*	0.53	0.01	-0.11	-0.17	-0.10	0.14
0.33	0.39	0.25	0.33	-0.49	0.25	0.17	0.75*	0.79**	0.85**	0.02	0.02	-0.46	-0.30	-0.13	-0.38	-0.13	-0.40	-0.35	-0.26
0.28	-0.03	-0.11	-0.31	0.08	0.24	0.24	-0.09	-0.18	-0.08	-0.07	-0.12	-0.18	-0.38	-0.18	0.47	0.45	0.13	0.10	-0.14
0.61	0.45	0.09	-0.16	-0.43	-0.00	-0.17	0.09	0.21	0.47	-0.51	-0.23	0.27	0.28	0.64*	0.41	0.21	0.27	0.29	0.25
0.47	0.80**	0.15	0.08	-0.07	0.63*	0.39	0.22	0.20	0.31	0.23	0.38	0.60	0.64*	0.39	0.35	0.05	0.25	0.34	0.60
0.32	0.69*	0.14	0.31	-0.12	0.45	0.26	0.16	0.23	0.24	-0.06	0.08	0.65*	0.65*	0.29	-0.16	-0.42	-0.52	-0.47	-0.09
0.05	0.12	-0.50	-0.58	0.28	-0.23	-0.32	0.42	0.36	0.53	-0.32	-0.24	0.53	0.60	0.48	0.73*	0.62	0.52	0.51	0.20
-0.23	0.67*	-0.17	-0.05	-0.06	0.17	0.03	0.33	0.35	0.65*	0.18	0.48	0.40	0.52	0.42	0.55	0.39	0.03	0.07	0.32

*Significant at 5 per cent level

**Significant at 1 per cent level

T Max = Maximum temperature (°C)

T Min= Minimum temperature (°C)

RH Max=Maximum relative humidity (%)

RH Min= Minimum relative humidity (%)

WS= Wind speed (Km/h)



0600 (0.09) and 0800 h (0.42/m²/5 minutes). *A. dorsata* population was lowest at 0600 h (0.50/m²/5 minutes), increased significantly and progressively at 0800 h (1.50), 1000 h (4.13) and 1200 h (8.93) and was maximum at 1400 h (9.57) before decreasing marginally at 1600 h (7.37) and moderating at 1800 h (2.30/ m²/5 minutes). *A. mellifera* however, was not recorded at 0600 h, had a lower population at 0800 (0.57), before moderating at 1000 (2.33) and 1200 h (4.73) and peaked at 1400 h (5.70) before declining marginally at 1600 h (4.53) and further declining at 1800 h (0.97 foragers/m²/5 minutes). Similar was the pattern of other domesticated honey bee, *A. cerana* at drastically lower levels except that it was not recorded upto 0800 h. Pattern of *A. florea* was similar to *A. dorsata* but at lower levels. Syrphid fly *Eristalinus* spp. population was lower upto 0800 h (0.60) and was moderate throughout the days and that of *H. armigera* was lower in the morning, moderated later and higher in afternoon at 1600 h (4.03) and evening (3.40). During 2013, (Table 5) floral visitors were most abundant at 1400 and 1200 h (2.41 and 2.31/m²/5 minutes), moderate at 1600 (2.08) and 1000 h (1.74) and minimum in the morning hours of 0600 and 0800 h (0.18, 0.77, respectively) and 1800 h (0.98 m²/5 minute). *A. mellifera* population was lower in the early morning hours of 0600 and 0800 h (0.07 and 0.90/m²/5 minute), moderated at 1000 h (2.93) and peaked from 1200 to 1400 h (4.03 to 4.57) and still higher at 1600 h (3.87) and 1800 h (1.87). *A. dorsata* populations were low at 0600 h (0.23) and moderated later to peak at 1400 h (5.23 bees). *A. florea* peak was recorded at 1200 and 1400 h (2.87 and 2.83) and had higher populations in the day. *Megachile* sp. and *P. olivaceus* had similar pattern of apoidea and *Eristalinus* spp. maintained relatively higher populations throughout the day with a low in the early morning.

Similar findings were reported by Shivrana (1996) who observed maximum abundance of *A. dorsata* at 1400 h (6.40/10 flowers) followed by at 1300 (6.13) and 1200 h (5.87); moderate at 0900 (2.67) and 1500 h (3.53) and least in the morning hours at 0800 (0.40). He further reported that *A. mellifera* and *A. florea* were most abundant at 1400 h (15.33 and 3.60) moderate at 1000 (8.20 and 3.33) and were least during morning hours of 0800 (0.60 and 0.00, respectively). Abrol (1985) also recorded maximum activity of bees between 1100 to 1400h while

Malaviya *et al.*, (1999) observed it from 0800 to 1100 h and in evening 1500 to 1600 h. Batra (1976) from Punjab also reported maximum intensity of *A. mellifera* at 1500 h (5.40 bees/m²/min.) than at 1200 h (4.50 bees) while for *A. dorsata*, it was maximum at 1200 h (1.40) and minimum at 0900 h (0.10 bees/m²/min.). However, the present findings are in stark contrast to Narayanan *et al.*, (1961) from Bihar, who showed that the honey bees (*A. indica*, *A. florea* and *A. dorsata*) started foraging at 0700 h and their activity was maximum from 0800-1100 h and bees were not seen after 1300 h. *A. cerana* was almost negligible or absent at all hours during 2013. The absence of wild bees could be attributed to various agricultural practices adopted by the farmers over the time period that has resulted in habitat destruction as the presence of other attractive rewards during this period is ruled out. Similar trend was observed by Narayanan *et al.* (1961) who reported decline in the visits of wild bees, *A. dorsata* and *A. florea* on this crop in certain years.

Correlations of abundance of different floral visitors with weather parameters

Abundance of floral visitors is dependent on weather parameters especially temperature, relative humidity, wind speed and many other crop dependent factors that are dynamic over time and space.

Abundance of *A. mellifera* and *A. dorsata* during 2012 (Table 3) had a highly significant positive correlation with wind speed ($r=0.77$ and 0.86) at 0800 h while the later was also correlated with maximum (negative) and minimum relative humidity at 1800 h ($r=-0.89$ and 0.85 , respectively). The *A. florea* abundance was positively correlation with RH (minimum and maximum) ($r= 0.82$, 0.71) at 0800 and negatively with RH (minimum and maximum, $r= -0.79$ and $r= -0.71$) at 1200 h. Wind speed significantly affected *A. cerana* population ($r=0.84$) at 1800 h and that of syrphid fly, *Eristalinus* spp. ($r=0.67$) at 0800 h. During 2013, (Table 6) *A. mellifera* population was positively correlated with minimum temperature at 1800 and 0800 h ($r= 0.77$, 0.64) and RH at 0800 h ($r=0.74$). *A. dorsata* too had highly significant correlation with RH (maximum) at 0800 h, minimum and maximum temperature at 1200 and 1800 h. *Eristalinus* spp. was positively correlated with RH (minimum) at 0800 and wind

speed at 1600 h. These studies form the first report where visitor's abundance is correlated with weather parameters in *T. alexandrinum*. Though Shivrana (1996) generalized to report a highly significant positive correlation of *A. dorsata*, *A. mellifera*, *A. florea* with temperature and negative with relative humidity.

Dhaliwal and Atwal (1976) generalized maximum abundance of 5 honey bee species (*A. dorsata*, *A. mellifera*, *A. florea*, *M. flavipes* and *P. smaragdula*) at 31.0°C, 54 per cent RH and wind speed of 0.20 kmph and the lowest abundance at 35°C, 52 per cent RH and wind speed of 1.00 kmph. Thakur (2007) from Uttrakhand, recorded congenial range of temperature (31-35°C) and RH (51-58%) for *A. mellifera* and recorded maximum abundance at 32°C and 57 per cent RH. According to Alexander (1980) foraging activity of bees increased with temperature upto 30 °C while Abrol (1985) reported it at an air temperature of 29-38°C and RH of 16 to 45 per cent.

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