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Effect of temperature and humidity on honey bee visits in safflower crop

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Abstract
The investigation on effect of temperature and humidity on honey bee visits in safflower crop were conducted on research farm of Department of Agricultural Entomology, College of agriculture, V.N.M.K.V. Parbhani (MS). The aim of this research was to determine the foraging behaviour of honeybees in relation to climatic factors. The data were collected at time intervals of 8:00-10:00 AM, 12:00-02:00PM, 04:00-06:00PM, during one day. To study the effect of weather parameters, five bee species were used i.e *Melipona irridipenis*, *Apis dorsata*, *Apis cerana*, *Apis florea* and *Apis mellifera*. The highest no of bee visits were observed on 17th March 2020 at which Max. temperature was 34.3 °C and humidity was in the range of 67%. The results shows that the temperature have positive correlation, whereas, the relative humidity have negative correlation with the bee visits.

Keywords: Temperature, humidity, honey bee, safflower

Introduction
The importance of temperature and relative humidity for honey bees is well understood, and these factors regulate all honey bee colony activities. Temperature, in particular, is critical for honey bee colonies' internal and external activities. It is important for honey bee colonies to maintain a temperature range of 33° to 36 °C within their hives. (Petz *et al.* 2004) [11]. Deviation from this range may have an effect on the honey bee immature stages' developmental cycle, emergence rate. (Tautz *et al*. 2003) [13], colour of emerged bees (De Grandi-Hoffman *et al*. 1993) [7], wing morphology (Ken *et al*. 2005) [10], learning ability (Tautz *et al*. 2003) [13], adult brain (Groh *et al*. 2004) [8] and disease prevalence. The temperature of the environment has a significant impact on foraging behaviour, with high temperatures having a negative impact on bee foraging. (Cooper, Schaffer 1985; Al-Qarni 2006; Blazyte-Cereskiene *et al*. 2010) [6, 3, 4]. Furthermore, temperatures below 10 degrees Celsius will prevent flight operation (Joshi, Joshi 2010) [9].

Materials and Methods
With eight treatments and three replications, the experiment was performed with Randomised Block Design. Following the suggested agronomic set of practises, the crop was grown in plots of 3×1.8 m^2.

Results and Discussion
The effect of temperature and humidity on visits of honey bee on safflower crop are presented in Table (01) and graphically represented in Fig (01). The data from Table (01) revealed that bee activities are closely related with temperature and humidity. The intensity of bee visits was found highest on 17th March, 2020 when maximum temperature and maximum relative humidity were 34.3 °C and 67% respectively.

Joshi and Joshi (2010) [9] reported that flight begins at earnest at 16 °C and the number of bees having foraging trips increases as the temperature continues to rise. They also reported that at 20 °C flight reaches a relatively high level.

Puskadija Z. *et al*. (2002) [12] reported that weather conditions have evident influence on sunflower inflorescence visited by honey bees. The most frequent visits were estimated at 20° to 25 °C and humidity at range of 65-75%. These results are in line with results obtained in present investigation.

Abrol (2011) [1] in between commencement and cessation, *Apis florea* activity was highest on flowers when temperature ranged between 27˚-38.5 °C and declined at higher temperatures.

Abrol *et al*. (2017) [2] Foraging populations of *Apis florea* were significantly and negatively influenced by morning relative humidity. However, the evening relative humidity though negatively influenced the population but the relationship was not significant.

Burill and Dietz (1981) [5] reported that the bee activity increased with temperature but was not affected by relative humidity and vapour pressure. These results are in line with results obtained in present investigations.

Table 1: Effect of temperature and humidity on honey bee visits in safflower crop

Sr. No	Observation Date	Number of bees/m^2/day					Temperature (°C)		Humidity (%)	
		Melipona irridipenis	*Apis dorsata*	*Apis cerana*	*Apis florea*	*Apis mellifera*	Max	Min	RH1	RH2
1	25/02/2020	7.33	3.0	2.66	2.0	1.33	33.6	14.3	78	24
2	03/03/2020	09.66	5.0	4.66	4.0	3.66	33.0	12.3	66	24
3	10/03/2020	8.66	4.66	4.00	3.66	3.00	32.9	15.9	75	30
4	17/03/2020	10.33	5.66	5.33	4.33	4.00	34.3	17.8	67	27

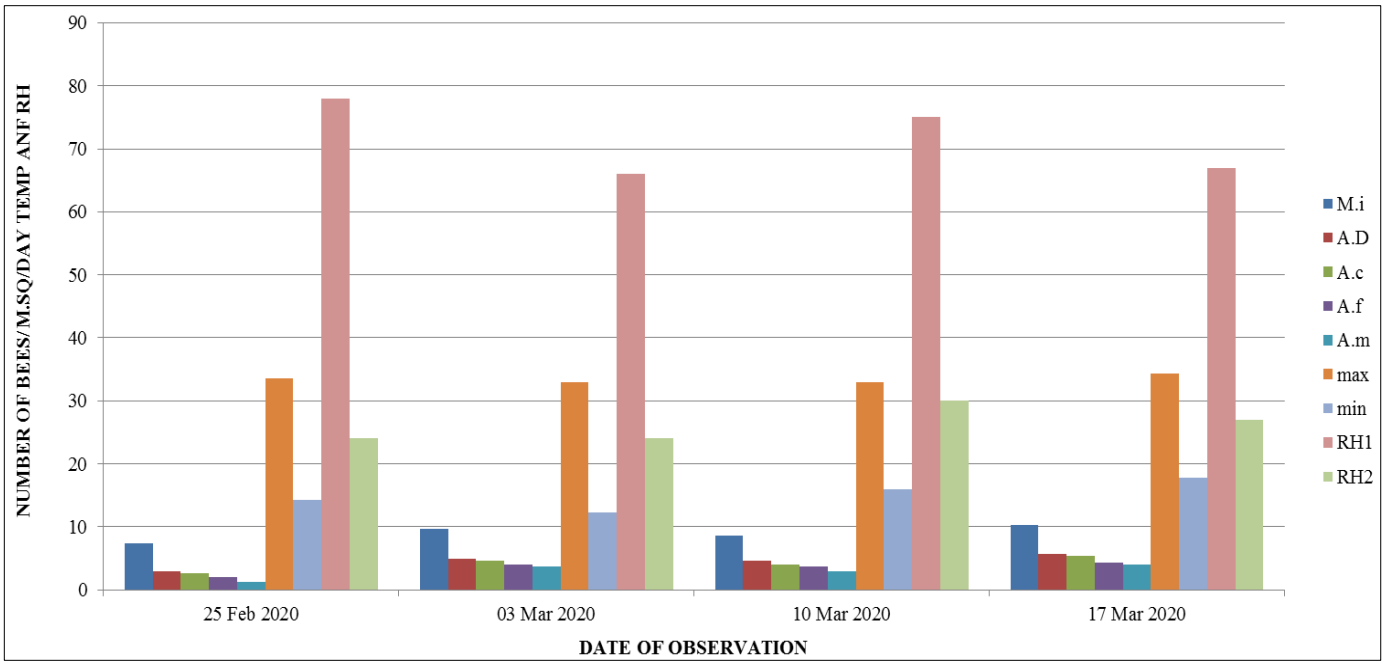

Fig 1: Effect of temperature and humidity on be visite on safflower

Correlation between effect of temperature and humidity on bee visits

Correlation between effect of temperature and humidity on bee visits. (*Apis cerana indica*.): The correlation analysis between weather parameters (temperature and humidity) on bee visits is represented in Table (02).

The visits of *Apis cerana indica* were positive and significant with maximum temperature. The minimum temperature had positive non-significant effect on visits of *Apis cerana indica*. However morning and evening relative humidity showed negative and non-significant relationship with *Apis cerana indica.*

Table 2: Correlation between effect of temperature and humidity on bee visits. (*Apis cerana indica*.)

Date	Bee species	Temperature (°C)		Humidity %	
	Apis cerana indica	Max	Min	RH1	RH2
25-Feb	2.66	33.6	14.3	78	24
03-Mar	4.66	33.00	12.30	66.00	24.00
10-Mar	4.00	32.90	15.90	75.00	30.00
17-Mar	5.33	34.90	17.80	67.00	27.00
		0.889	0.344	-0.808	-0.496

Correlation between effect of temperature and humidity on bee visits (*Apis mellifera*)

The correlation analysis between weather parameters (temperature and humidity) on bee visits is represented in Table (03).

The results from Table (03) indicated that the maximum temperature has significant and positive correlation with the visits of *Apis mellifera.* The minimum temperature had positive non-significant effect on visits of *Apis mellifera.* However morning and evening relative humidity showed negative and non-significant relationship with *Apis mellifera.*

Table 3: Correlation between effect of temperature and humidity on bee visits (*Apis mellifera*)

Date	Bee species	Temperature (°C)		Humidity %	
	Apis mellifera	Max	Min	RH1	RH2
25-Feb	1.33	33.6	14.3	78	24
03-Mar	3.66	33.00	12.30	66.00	24.00
10-Mar	3.00	32.90	15.90	75.00	30.00
17-Mar	4.00	34.90	17.80	67.00	27.00
		0.789	0.164	-0.904	-0.649

Correlation between effect of temperature and humidity on bee visits (*Apis dorsata*): The correlation analysis between weather parameters (temperature and humidity) on bee visits is represented in Table (04).

The results from Table (04) indicated that the maximum temperature has significant and positive correlation with the visits of *Apis dorsata*. The minimum temperature had positive non-significant effect on visits of *Apis dorsata*. However morning and evening relative humidity showed negative and non-significant relationship with *Apis dorsata.*

Table 4: Correlation between effect of temperature and humidity on bee visits (*Apis dorsata*)

Date	Bee species	Temperature (°C)		Humidity %	
	Apis dorsata	Max	Min	Max	Min
25-Feb	3.00	33.6	14.3	78	24
03-Mar	5.00	33.00	12.30	66.00	24.00
10-Mar	4.66	32.90	15.90	75.00	30.00
17-Mar	5.66	34.90	17.80	67.00	27.00
		0.956	0.505	-0.691	-0.334

Correlation between effect of temperature and humidity on bee visits (*Apis florea*): The correlation analysis between weather parameters (temperature and humidity) on bee visits is represented in Table (05).

The results from Table (05) indicated that the maximum temperature has significant and positive correlation with the visits of *Apis florae*. The minimum temperature had positive non-significant effect on visits of *Apis florea*. However morning and evening relative humidity showed negative and non-significant relationship with *Apis florae.*

Table 5: Correlation between effect of temperature and humidity on bee visits (*Apis florea*)

Date	Bee species	Temperature (°C)		Humidity %	
	Apis florea	Max	Min	RH1	RH2
25-Feb	2.00	33.6	14.3	78	24
03-Mar	4.00	33.00	12.30	66.00	24.00
10-Mar	3.66	32.90	15.90	75.00	30.00
17-Mar	4.33	34.90	17.80	67.00	27.00
		0.883	0.332	-0.816	-0.507

Correlation between effect of temperature and humidity on bee visits (*Melipona irridipenis*)

The correlation analysis between weather parameters (temperature and humidity) on bee visits is represented in Table (06).

The visits of bee species *Melipona irridipenis* were significant and positive with the maximum temperature however there was non-significant positive correlation with minimum temperature. The bee visits were significant and negative with RH1 (morning) humidity and non-significant and negative with RH2 (evening) humidity.

Table 6: Correlation between effect of temperature and humidity on bee visits (*Melipona irridipenis*)

Date	Bee species	Temperature (°C)		Humidity %	
	Melipona irridipenis	Max	Min	RH1	RH2
25-Feb	7.33	33.6	14.3	78	24
03-Mar	9.66	33.00	12.30	66.00	24.00
10-Mar	8.66	32.90	15.90	75.00	30.00
17-Mar	10.33	34.90	17.80	67.00	27.00
		0.829	0.231	-0.872	-0.595

D Hemalatha *et al.* (2018) found that the maximum temperature had positive correlations with bees coming with pollen (r = 0.120), nectar (r = 0.188) and outgoing bees (r = 0.117). The minimum temperature had negative relations by correspondingly making a correlation coefficient of r = -0.272, r = -0.256 and r = -0.222 respectively with pollen gatherers, nectar gatherers and outgoing bees. In the present observations relative humidity, rainfall and wind speed also had negative correlations with bees coming with pollen, nectar and outgoing bees.

Clarke Dominic and Robert Daniel (2018) fount that by using Spearman's rank correlation, we find that R_S (Sol Rad, ER) = 0.81 and R_S (Temp, ER) = 0.83, indicating a very high positive correlation with temperature. For humidity, the correlation is negative, with R_S (Hum, ER) = − 0.74. (ER= egress rate).

Puškadija Z. *et al* (2007) concluded that statistical analysis showed strong positive correlation between average as well as maximum daily temperature and the honey bee's visits. Higher humidity, heavy rain fall, wind, and low temperature had negative influence on sunflower inflorescences visits.

The present findings are in conformity with research of above scientist. However reviews are used for all bee species described in table (11, 12, 13 and 14).

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