Impact of weather on foraging area of artificially and naturally inseminated colonies of *Apis mellifera* L. and *Apis cerana indica* F.

ABSTRACT

Experiment conducted to study the impact of weather parameters on brood area, pollen area and nectar area of artificially inseminated and naturally inseminated colonies of *Apis mellifera* L. and *Apis cerana indica* F. during April'16 to March'18. Investigation revealed significant negative correlation of brood area (r= -0.57 in both AI and NI colonies) of *A. mellifera* L., during 2016-17 and nectar area (r = -0.71 in AI and r= - 0.70 in NI colonies) with maximum temperature and maximum relative humidity, respectively. Whereas, pollen area having significant positive correlation with bright sunshine hours (0.83 in AI and 0.84 in NI colonies) and significant negative correlation with maximum temperature (r = -0.89 in AI and r= - 0.88 in NI colonies) and total rainfall (r = -0.57 in AI and r= - 0.60 in NI colonies). During 2017-18, pollen area showed positive significant correlation with maximum relative humidity (r = 0.57 in AI and r= 0.60 in NI colonies) and negatively significant correlation with maximum temperature (r = -0.87 in AI and r= - 0.90 in NI colonies) and total rainfall (r = -0.74 in AI and r= - 0.76 in NI colonies). Nectar area having negatively significant correlation with maximum relative humidity (r = -0.74 in AI and r= - 0.77 in NI colonies). However, *A. c. indica* F. revealed significant negative correlation of brood area (r = -0.58 in AI and r= - 0.60 in NI colonies) and nectar area(r = -0.66 in AI and r= - 0.70 in NI colonies) with maximum relative humidity during 2017-18.

Key words: Weather, *A. mellifera* L., *A. c. indica* F., brood area, pollen area, nectar area

INTRODUCTION

Weather influences the growth and development of honeybees. The weather parameters like temperature, relative humidity, rain fall, number of rainy days and sunshine hours might have positive or negative influence on developmental parameters of honeybees. The important developmental parameters of honeybees are brood rearing activity, pollen and nectar store. Weather conditions influences forage availability and

thereby directly and indirectly influence honey bee health. Weather factors can affect the onset and decline of specific foraging resources, lengthen or shorten the time in which resources are available for bees, change the quality of these resources, and alter the span during which bees can actively forage(Calovi *et al.*2021). Reddy (1979) reported that relative humidity and rainfall showed a positive relationship with the pollen gathering activity by the bees. Verma (1983) noticed the increase in the pollen foraging activity with rise in the relative humidity, but not so affected by temperature. Mahrotra and Bisht (1984) found significant correlation of foraging activity for pollen and nectar foragers with day temperature and humidity. Abrol and Bhat (1987) reported that the foraging activity of *A. cerana* was significant and positive with temperature and non significant with relative humidity. The correlation between weather parameters and honeybees are critically important. Therefore the present investigation was aimed to study impact of weather on brood area, pollen area and nectar area of artificially and naturally inseminated colonies of *Apis mellifera* L. and *Apis cerana indica* F.

MATERIALS AND METHODS

An investigational data on weather parameters *viz.*, maximum temperature, relative humidity, total rainfall and bright sunshine hours were recorded during the entire period of study from Department of Agro meteorology, AAU, Jorhat to determine the influence of weather parameters on brood area, pollen area and nectar area of artificially and naturally inseminated colonies of *Apis mellifera* L. and *Apis cerana indica* F.

Statistical analysis

The data was analysed statistically using Randomized Block Design and correlation of the weather parameters was investigated for their influence on brood area, pollen area and nectar area with independent variables to find out the influence of weather parameters. The statistical analysis was as follows:

Simple correlation studies

To calculate the correlation co-efficient(r), the following standard statistical formula by Karl Pearson was adopted (Panse and Sukhatme, 1985).

$$r = \frac{\sum xy - \frac{\sum x . \sum y}{N}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{N}\right)\left(\sum y^2 - \frac{(\sum y)^2}{N}\right)}}$$

Where, r = Correlation co-efficient

n = Number of observation

x = Independent variables

y = Dependent variables

Then the Correlation co-efficient(r) was tested for significant or non significant by Fisher 't' test, which is defined as follows :

$$t = \frac{r}{\sqrt{(1 - r^2)}} \times \sqrt{n - 2}$$ with n-2 degrees of freedom

For correlation studies, monthly average values of the environmental factors were taken into consideration to know the influence of weather parameters on brood area, pollen area and nectar area during the present investigation.

Simple regression analysis

Simple regression line was fitted to know the impact of independent variables on the dependent variables.

The regression line was given by the equation:

$$Y = a + bx$$

Where, for each unit increase in 'x' variable, the 'Y' variable increases by 'b' unit.

Y= Dependent variables

x = Independent variables

a =Intercept

RESULT AND DISCUSSION

The influence of various weather factors, viz; maximum temperature, maximum relative humidity, total rainfall and bright sunshine hours on brood area, pollen area and nectar area of *A. mellifera* L. and *A. c. indica* were worked out through simple

correlation method. However, Karl Pearson's correlation co-efficient(r) which were found to be significant after being tested by Fisher't' were further studied through regression equation and illustrated graphically as follows:

1. Correlation of weather parameters with brood area, pollen area and nectar area of *A. mellifera L.*

Correlation studies of weather parameters with brood area, pollen area and nectar area were carried out in *A. mellifera L.* during April'16 to March'17 and the results have been discussed below (Table 1).

Relationship of brood area with maximum temperature: From the investigation, it was revealed that the relationship between average maximum temperature and brood area of *A. mellifera L.* was found to be significant, negative and linear with artificially inseminated colonies (r= - 0.57, P<0.05). The data revealed 32.9 per cent variation in brood area, which was observed to be controlled by maximum temperature (R^2=0.329). The regression of brood area on maximum temperature could be expressed by the equation Y= -144.18X +7390.1 (Fig. 1A). Similarly, a significant, negative and linear relationship (r= -0.57, P<0.05) was reported between average maximum temperature and brood area of naturally inseminated colonies of *A. mellifera L.*. The data indicated 32.4 per cent variation in brood area which was controlled by maximum temperature (R^2=0.324). The regression of brood area on maximum temperature could be expressed by the equation Y= -147.94X +7316.1 (Fig. 1B). The result was in conformity with the observations of Rahman (1992) where he found significant correlation of maximum temperature with brood area of *A. mellifera L.* .

Relationship of pollen area with maximum temperature: An investigation revealed that the relationship between average maximum temperature and pollen area was negatively significant and linear in artificially inseminated colonies of *A. mellifera L.* (r= -0.89, P<0.05). The data indicated that 80.07 per cent variation in pollen area was controlled by maximum temperature (R^2=0.8007). The regression of pollen area on maximum temperature could be expressed by the equation Y= -108.66X + 3926.8 (Fig. 1C).The relationship between average maximum temperature and pollen area of naturally inseminated colonies of *A. mellifera L.* was found to be significant, negative and linear (r= - 0.88, P<0.05). The data indicated 78.4 per cent variation in brood area was observed to be controlled by maximum temperature (R^2=0.784). The equation Y= -103.99X +3680.1 indicated the magnitude of this association (Fig. 1D). Zapart *et al.*

(2018) found negatively significant correlation with maximum, minimum, and average temperatures as well as precipitation in the season.

Relationship of pollen area with total rainfall: A significant, negative and linear relationship was revealed between total rainfall and pollen area of artificially inseminated colonies of *A. mellifera L.* (r= -0.57, P<0.05). The data indicated that 32.0 per cent variation in pollen area was controlled by total rainfall (R^2=0.320). The regression of pollen area on total rainfall could be expressed by the equation Y= -1.1638X +940.36 (Fig. 1E). However, rainfall showed significant, negative and linear effect on pollen area of naturally inseminated colonies of *A. mellifera L.* (r= -0.60, P<0.05). However, 37 per cent variation in pollen area was regulated by total rainfall (R^2=0.370) and the regression of pollen area on total rainfall could be expressed by the equation Y= -1.2093X +839.17 (Fig. 1F). Contrary to the present findings Nag (2016) documented positive impact of total rainfall on pollen area.

Relationship of pollen area with bright sunshine hours: From the investigation, it was revealed that bright sunshine hours has positive and linear (r= 0.83, P<0.05) effect on pollen area of artificially inseminated colonies of *A. mellifera L.*. The data indicated 68.9 per cent variation in pollen area was controlled by bright sunshine hours (R^2=0.689) and the regression of pollen area on bright sunshine hours could be expressed by the equation Y= 177.34X +98.326 (Fig. 1G). Similarly, the relationship between bright sunshine hours and pollen area of *A. mellifera L.* was found to be significant, positive, and linear with naturally inseminated colonies (r= 0.84, P<0.05). From the data it was revealed that 71.2 per cent variation in pollen area was regulated by bright sunshine hours (R^2=0.712). The regression of pollen area on bright sunshine hours could be expressed by the equation Y= 174.25X +193.17 (Fig. 1H). This was in conformity with the observations of Nag (2016).

Relationship of nectar area with maximum relative humidity: A significant, negative and linear relationship (r= -0.71, P<0.05) was came into light between maximum relative humidity and nectar area of artificially inseminated colonies of *A. mellifera L.*. The data indicated 51 per cent variation in nectar area was found to be controlled by maximum relative humidity (R^2=0.51) where the equation Y= -420.99X +41875 indicated the magnitude of the association (Fig. 1I). Similarly, the relationship between maximum relative humidity and nectar area of naturally inseminated colonies of *A. mellifera L.* was found to be negatively significant and linear

(r= - 0.70, P<0.05). The data indicated that 49.1 per cent variation in nectar area was regulated by maximum relative humidity (R^2=0.491). The regression of nectar area on maximum relative humidity could be expressed by the equation Y= -398.47X +39515 (Fig. 1J). Nag (2016) also made similar observations of negative and significant impact of maximum relative humidity on nectar area.

2. Correlation of brood area, pollen area and nectar area with different weather parameters of *A. mellifera L.*

During April'17 to March'18, correlation studies of brood area, pollen area and nectar area were again carried out with weather parameters in *A. mellifera L.* and the results discussed below (Table 2).

Relationship of pollen area with maximum temperature: The relationship between maximum temperature and pollen area of *A. mellifera L.* was found to be significant, negative and linear with artificially inseminated colonies (r= - 0.87, P<0.05) where 76.9 per cent variation in pollen area was observed to be controlled by maximum temperature (R^2=0.769). The regression equation Y= -91.56X +3443.8 indicated the magnitude of this association (Fig. 2A). Similarly, the relationship between maximum temperature and pollen area of *A. mellifera L.* was found to be significant, negative and linear in naturally inseminated colonies (r= -0.90, P<0.05) where 82.1 per cent variation in pollen area was observed to be controlled by maximum temperature (R^2=0.821). The regression of pollen area on maximum temperature could be expressed by the equation Y= -91.254X + 3314.4 (Fig. 2B). Similar results were also obtained by Chaand *et al.* (2017) in *A. mellifera* L.

Relationship of pollen area with maximum relative humidity: The relationship between maximum relative humidity and pollen area of *A. mellifera L.* was found to be significant, positive and linear with artificially inseminated colonies (r= 0.57, P<0.05). The data indicated that 31.8 per cent variation in pollen area was found to be regulated by maximum relative humidity (R^2=0.318). The equation Y= 84.73X +7288.3 indicated the magnitude of this association (Fig. 2C). Similarly, a significant, positive and linear relationship was existed between maximum relative humidity and pollen area of naturally inseminated colonies of *A. mellifera L.* (r= 0.60, P<0.05). The data indicated 36.5 per cent variation in pollen area was observed to be controlled by maximum relative humidity (R^2=0.365). The regression of pollen area on maximum relative

humidity could be expressed by the equation Y= 87.607X +7682 (Fig. 2D). Gebremedhn *et al*. (2014) also reported such observations in *A. mellifera L.* colonies.

Relationship of pollen area with total rainfall: The relationship between total rainfall and pollen area of *A. mellifera L.* was found to be significant, negative and linear with artificially inseminated colonies (r= - 0.74, P<0.05). The data indicated 55.1 per cent variation in pollen area was observed to be controlled by total rainfall (R^2=0.551). The regression of pollen area on total rainfall could be expressed by the equation

Y= -1.841X +1056 (Fig. 2E). Similarly, the relationship between total rainfall and pollen area of *A. mellifera L.* was found to be significant, negative and linear with naturally inseminated colonies (r= - 0.76, P<0.05). The data revealed that 58.5 per cent variation in pollen area was regulated by total rainfall (R^2=0.585). The equation Y=-1.829X +933.58 indicated the magnitude of this association (Fig. 2F). Such observations were in conformity with the results obtained by Chaand *et al.* (2017).

Relationship of nectar area with maximum relative humidity: A significant, negative and linear relationship was existed between maximum relative humidity and nectar area of artificially inseminated colonies of *A. mellifera L.* (r= -0.74, P<0.05). The data indicated 55.7 per cent variation in nectar area was observed to be controlled by maximum relative humidity (R^2=0.557). The regression of nectar area on rainfall could be expressed by the equation Y= -343.63X +34290 (Fig. 2G). Similarly, the relationship between maximum relative humidity and nectar area of *A. mellifera L.* was found to be significant, negative and linear relationship with naturally inseminated colonies (r= -0.77, P<0.05). The data indicated 59.8 per cent variation in nectar area was observed to be controlled by maximum relative humidity (R^2=0.598). The regression of nectar area on maximum relative humidity could be expressed by the equation Y= -338.9X +33634 (Fig. 2H). The results were in agreement with the findings of Gebremedhn *et al.* (2014).

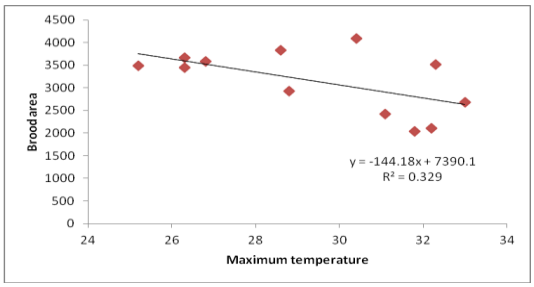
3. Correlation of weather parameters with brood area, pollen area and nectar area of *Apis cerana indica* F.

Correlation studies were also carried out in *A. c. indica* between weather factors and brood area, pollen area and nectar area during April'17 to March'18 and the results are discussed below (Table 3).

Relationship of brood area with maximum relative humidity: In *A. c. indica*, it was found that relative humidity has significant effect on brood area and has adverse and linear effect with artificially inseminated colonies (r= -0.58, P<0.05) where, 34.2 per

cent variation in brood area was observed to be controlled by maximum relative humidity (R^2=0.342). As shown in figure 12A, the regression of brood area on maximum relative humidity could be expressed by the equation Y= -248.82X +25463 (Fig. 3A). Similarly, the relationship between maximum relative humidity and brood area of *A. c. indica* was found to be significant, negative and linear with naturally inseminated colonies (r= -0.60, P<0.05) where, 36.3 per cent variation in brood area was observed to be regulated by maximum relative humidity (R^2=0.363). The regression of brood area on maximum relative humidity could be expressed by the equation Y= -258.18X + 26175 (Fig. 3B). Similar results were also obtained by Pastagia and Patel (2014) and Painkra *et al*.(2017).

Relationship of nectar area with maximum relative humidity: Relative humidity revealed significant, negative and linear relationship with nectar area of artificially inseminated colonies of *A. c. indica* (r= -0.66, P<0.05). The data indicated 44 per cent variation in nectar area was observed to be controlled by maximum relative humidity (R^2=0.440). The regression of nectar area on maximum relative humidity could be expressed by the equation Y= -122.31X +12277 (Fig. 3C).Similarly, the relationship between maximum relative humidity and nectar area of *A. c. indica* was found to be significant, negative and linear with naturally inseminated colonies (r= - 0.70, P<0.05). The data indicated 50.2 per cent variation in nectar area was observed to be controlled by maximum relative humidity (R^2=0.502). The regression of nectar area on maximum relative humidity could be expressed by the equation Y= -130.22X +12901 (Fig. 3D). Contrary to the present finding Painkra (2017) documented positive significant correlation of maximum relative humidity with nectar area.



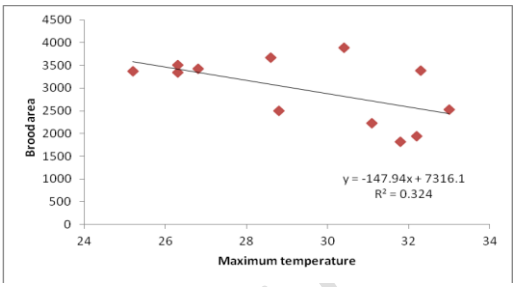
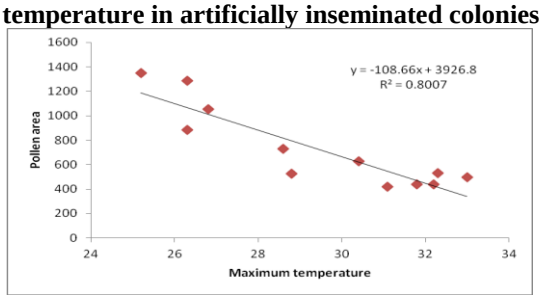
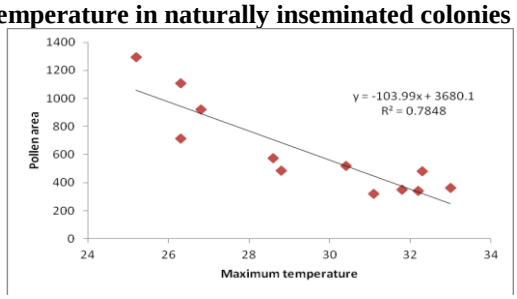


Fig. 1. Correlation of weather parameters with brood area, pollen area and nectar area of *Apis mellifera* L. (April'16 to March'17)

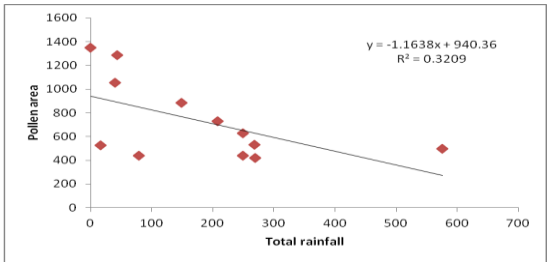
a) Relationship of brood area with maximum temperature in artificially inseminated colonies



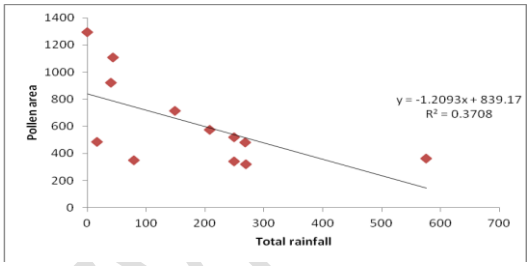
b) Relationship of brood area with maximum temperature in naturally inseminated colonies



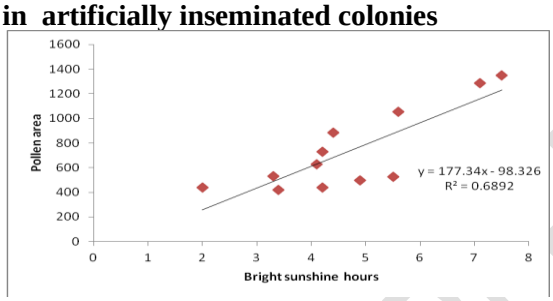
c) Relationship of pollen area with maximum temperature in artificially inseminated colonies



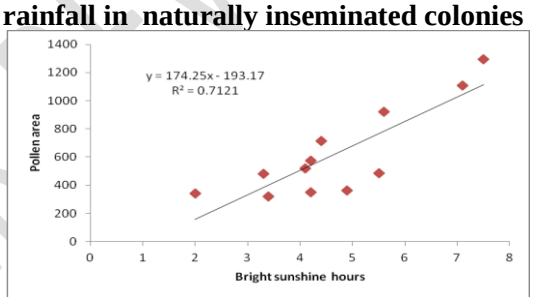
d) Relationship of pollen area with maximum temperature in naturally inseminated colonies



E. Relationship of pollen area with total rainfall in artificially inseminated colonies

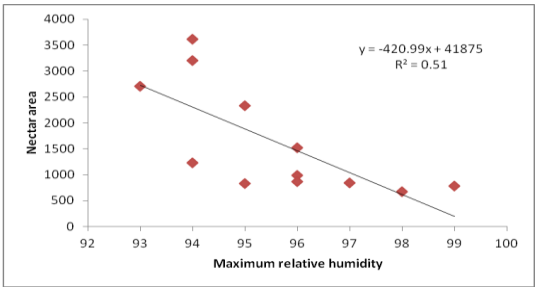


F. Relationship of pollen area with total rainfall in naturally inseminated colonies

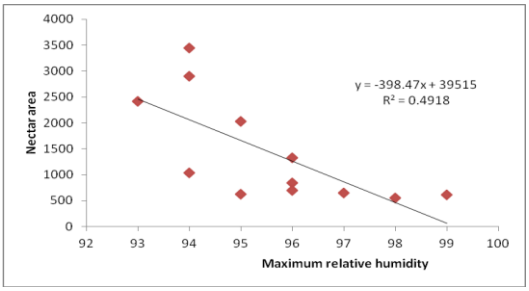


G. Relationship of pollen area with bright sunshine hours in artificially inseminated colonies

H. Relationship of pollen area with bright sunshine hours in naturally inseminated colonies

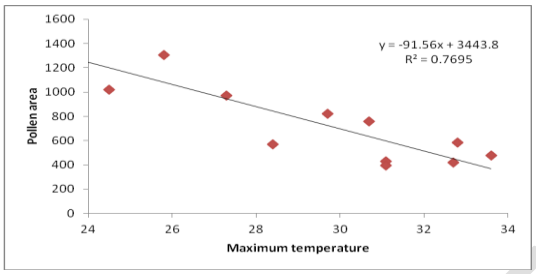


I. Relationship of nectar area with maximum relative humidity in artificially inseminated colonies

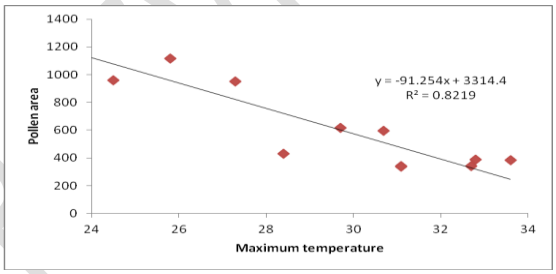


J. Relationship of nectar area with maximum relative humidity in naturally inseminated colonies

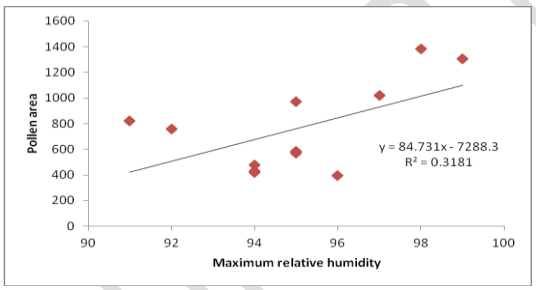
Fig. 2. Correlation of brood area, pollen area and nectar area with different weather parameters of *Apis mellifera* L. (April'17 to March'18)



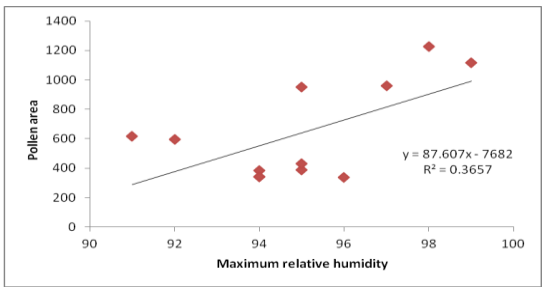
A) Relationship of pollen area with maximum temperature in artificially inseminated colonies



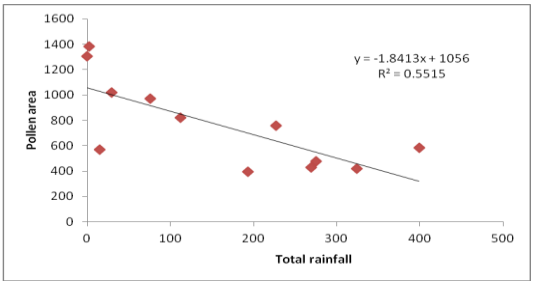
B) Relationship of pollen area with maximum temperature in naturally inseminated colonies



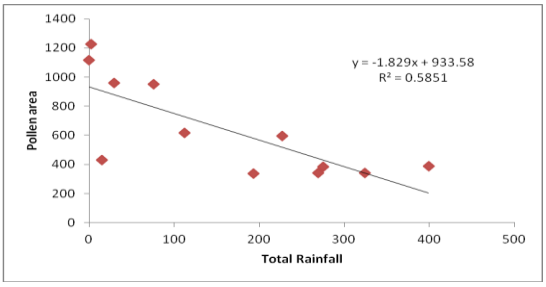
C) Relationship of pollen area with maximum relative humidity in artificially inseminated colonies



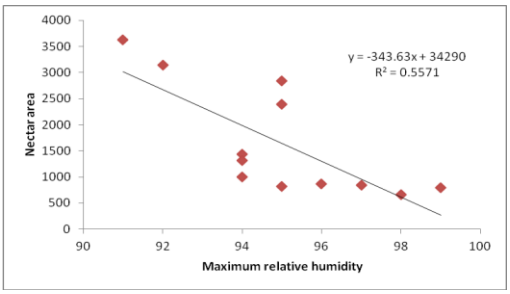
D) Relationship of pollen area with maximum relative humidity in naturally inseminated colonies



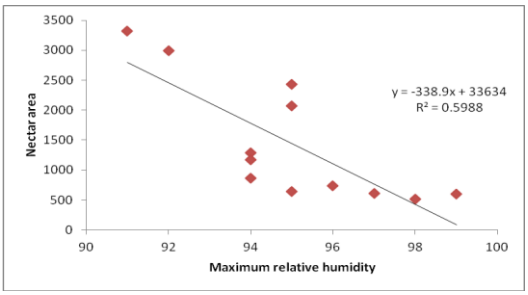
E) Relationship of pollen area with total rainfall in artificially inseminated colonies



F) Relationship of pollen area with total rainfall in naturally inseminated colonies

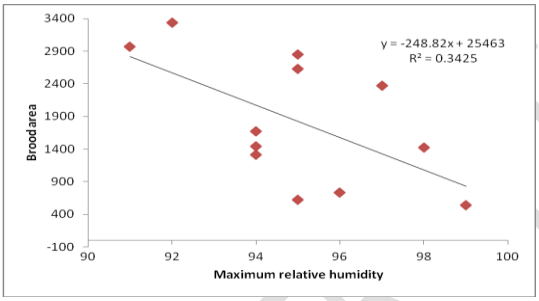


G) Relationship of nectar area with maximum relative humidity in artificially inseminated colonies

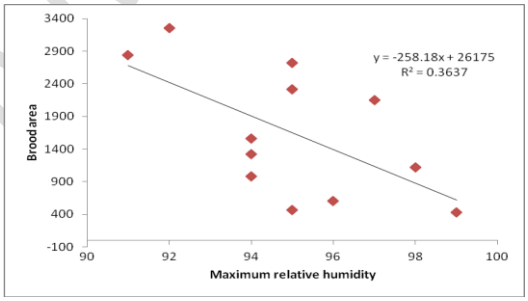


H) Relationship of nectar area with maximum relative humidity in naturally inseminated colonies

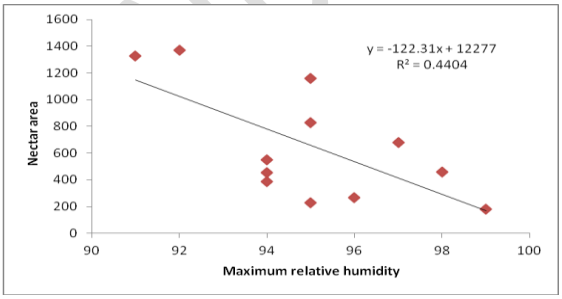
Fig. 3. Correlation of weather parameters with brood area, pollen area and nectar area of *Apis cerana indica* F. (April'17 to March'18)



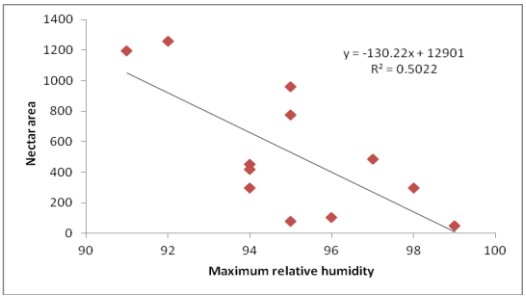
A) Relationship of brood area with maximum relative humidity in artificially inseminated colonies



B) Relationship of brood area with maximum relative humidity in naturally inseminated colonies



C) Relationship of nectar area with maximum relative humidity in artificially inseminated colonies



D) Relationship of nectar area with maximum relative humidity in naturally inseminated colonies

Table 1. Correlation of brood area, pollen area and nectar area of *A. mellifera L. L.* with different weather factors

Month of observation	Brood area		Pollen area		Nectar area		Maximum temperature (°C)	Maximum relative humidity (%)	Total rainfall (mm)	Bright sunshine hours (hr)
	AI	NI	AI	NI	AI	NI				
April'16	3829.8	3678.0	730.2	573.2	3619.8	3443.2	28.6	94	208.1	4.2
May'16	4091.2	3882.4	629.8	519.4	3201.8	2903.4	30.4	94	249.7	4.1
June'16	3517.8	3381.6	532.2	479.6	2333.8	2030.2	32.3	95	267.5	3.3
July'16	2680.8	2524.6	497.4	362.2	1524.8	1323.8	33.0	96	576.0	4.9
August'16	2427.2	2229.0	420.2	321.8	1233.6	1038.2	31.1	94	269.1	3.4
September'16	2102.6	1946.2	436.8	342.6	992.2	847.8	32.2	96	249.2	2.0
October'16	2039.2	1813.8	440.8	349.0	872.0	695.2	31.8	96	78.4	4.2
November'16	2926.8	2507.0	527.8	486.4	845.0	654.4	28.8	97	16.5	5.5
December'16	3449.8	3342.8	1287.4	1108.0	783.4	612.2	26.3	99	43.5	7.1
January'17	3494.2	3368.4	1349.2	1295.2	671.8	556.0	25.2	98	0.1	7.5
Februay'17	3581.8	3423.6	1052.4	922.8	832.8	625.2	26.8	95	39.4	5.6
March'17	3672.6	3503.6	882.4	714.4	2712.6	2411.0	26.3	93	148.8	4.4

	AI	NI	AI	NI	AI	NI	AI	NI
Correlation with brood area (r=)	-0.57*	-0.57*	-0.20	-0.19	-0.19	-0.15	0.38	0.37
Correlation with pollen area (r=)	-0.89*	-0.88*	0.45	0.49	-0.57*	-0.60*	0.83*	0.84*
Correlation with nectar area(r=)	0.10	0.09	-0.71*	-0.70*	0.36	0.35	-0.37	-0.36

*= Significant at 5% level of probability

Table 2. Correlation of brood area, pollen area and nectar area of *A. mellifera L. L.* with different weather factors

Month of observation	Brood area		Pollen area		Nectar area		Maximum temperature (°C)		Maximum relative humidity (%)		Total rainfall (mm)		Bright sunshine hours (hr)	
	AI	NI	AI	NI	AI	NI								
April'17	3888.6	3744.2	823.4	616.6	3620.8	3321.2	29.7		91		111.8		4.5	
May'17	4203.8	3836.8	758.0	595.2	3145.0	2989.8	30.7		92		226.9		4.2	
June'17	3674.8	3421.4	581.8	386.8	2391.2	2071.6	32.8		95		399.2		3.7	
July'17	2842.6	2564.0	478.2	384.6	1438.6	1286.4	33.6		94		275.1		4.0	
August'17	2376	2123.4	427.2	342.6	1310.2	1172.2	31.1		94		269.1		3.4	
September'17	2113.6	1974.6	419.0	340.4	1006.0	865.8	32.7		94		324.4		3.3	
October'17	2018.8	1944.2	395.4	337.2	867.8	742.4	31.1		96		192.8		5.2	
November'17	2953.0	2729.8	569.8	428.8	818.0	640.8	28.4		95		14.7		7.4	
December'17	3426.4	3239.4	1305.6	1115.0	796.0	605.0	25.8		99		0.0		5.4	
January'18	3483.0	3317.0	1382.2	1226.8	664.4	510.0	23.9		98		2.7		4.7	
February'18	3556.4	3423.2	1021.0	961.6	848.6	615.0	24.5		97		29.1		3.4	
March'18	3583.6	3463.0	971.6	952.4	2835.8	2436.0	27.3		95		76.0		4.0	
							AI	**NI**	**AI**	**NI**	**AI**	**NI**	**AI**	**NI**
Correlation with brood area (r=)							-0.39	-0.45	-0.12	-0.08	-0.29	-0.35	-0.01	-0.01
Correlation with pollen area (r=)							-0.87*	-0.90*	0.57*	0.60*	-0.74*	-0.76*	0.10	0.05
Correlation with nectar area(r=)							0.28	0.31	-0.74*	-0.77*	0.25	0.27	-0.25	-0.25

*= Significant at 5% level of probability

Table 3. Correlation of brood area, pollen area and nectar area of *A. c. indica* with different weather factors

Month of observation	Brood area		Pollen area		Nectar area		Maximum temperature (°C)		Maximum relative humidity (%)		Total rainfall (mm)		Bright sunshine hours (hr)	
	AI	NI	AI	NI	AI	NI								
April'17	2971.8	2837.2	1055.2	834.0	1328.8	1194.8	29.7		91		111.8		4.5	
May'17	3337.0	3250.4	839.8	645.0	1370.2	1257.2	30.7		92		226.9		4.2	
June'17	2850.4	2717.4	774.4	571.4	829.4	773.2	32.8		95		399.2		3.7	
July'17	1671.6	1559.4	569.8	515.8	548.8	451.2	33.6		94		275.1		4.0	
August'17	1443.6	1324.2	529.4	472.6	455.8	418.0	31.1		94		269.1		3.4	
September'17	1309.0	983.2	522.6	452.8	388.2	295.2	32.7		94		324.4		3.3	
October'17	735.0	607.8	464.4	306.2	265.4	105.2	31.1		96		192.8		5.2	
November'17	622.8	466.8	285.6	254.8	228.4	79.8	28.4		95		14.7		7.4	
December'17	539.0	427.2	352.2	302.4	179.0	48.0	25.8		99		0.0		5.4	
January'18	1421.2	1122.8	827.4	593.2	461.2	299.0	23.9		98		2.7		4.7	
February'18	2368.2	2153.6	966.6	881.2	679.8	484.2	24.5		97		29.1		3.4	
March'18	2632.6	2319.2	1233.8	1099.2	1158.6	958.4	27.3		95		76.0		4.0	
							AI	**NI**	**AI**	**NI**	**AI**	**NI**	**AI**	**NI**
Correlation with brood area (r=)							-0.13	-0.16	-0.58*	-0.60*	-0.27	-0.29	-0.53	-0.50
Correlation with pollen area (r=)							-0.25	-0.27	0.27	0.25	-0.09	-0.13	-0.49	-0.51
Correlation with nectar area(r=)							-0.09	-0.17	-0.66*	-0.70*	-0.13	-0.23	-0.37	-0.41

*= Significant at 5% level of probability

CONCLUSION

The correlation study of *A. mellifera* during the year 2016-17 revealed significant negative correlation of brood area (r= -0.57 in both AI and NI colonies) and nectar area (r = -0.71 in AI and r= - 0.70 in NI colonies) with maximum temperature and maximum relative humidity, respectively. Whereas, pollen area was found to have significant positive correlation with bright sunshine hours (0.83 in AI and 0.84 in NI colonies) and significant negative correlation with maximum temperature (r = -0.89 in AI and r= - 0.88 in NI colonies) and total rainfall (r = -0.57 in AI and r= - 0.60 in NI colonies). Again in 2017-18, pollen area showed positive significant correlation with maximum relative humidity (r = 0.57 in AI and r= 0.60 in NI colonies) and negatively significant correlation with maximum temperature (r = -0.87 in AI and r= - 0.90 in NI colonies) and total rainfall (r = -0.74 in AI and r= - 0.76 in NI colonies). Nectar area was found to have negatively significant correlation with maximum relative humidity (r = -0.74 in AI and r= - 0.77 in NI colonies). *A. cerana indica* showed significant negative correlation of brood area (r = -0.58 in AI and r= - 0.60 in NI colonies) and nectar area(r = -0.66 in AI and r= - 0.70 in NI colonies) with maximum relative humidity during 2017-18.

REFERENCE

Abrol, D.P. and Bhat, A.A. (1987). Influence of atmospheric conditions and floral rewards on diurnal activity pattern, flower visitation rates and pollinating effectiveness of *Apis cerana indica* foragers. Res. Develop. Reporter, 4(1):13-16.

Bisht D.S. (1975) Pollen gathering activity of honey bees and *Halictus* sp. in roses, Indian Bee J. 37, 1-3. Keywords: *cerana* / *florea* / honey / pollen / India.

Bisht ,D.S., Naim, M. (1979) Pollen gathering capacity of the Indian honeybee, *Apis cerana* F., *Indian J. Entomol*. 41, 295-296. Keywords: *cerana* / foraging / pollen / India.

Calovi, M. ; Grozinger, C. M. ; D.A. Miller & S. C. Goslee (2021). Summer weather conditions infuence winter survival of honey bees (Apis mellifera) in the northeastern United States. *Scientifc Reports*. **11**:1553. https://doi.org/10.1038/s41598-021-81051-8 .

Chaand, D.; Sharma, D.; Ganai, S.A.; Norboo, T. and Sharma, S. (2017). Effect of colony strength on colony build up and foraging activity of *Apis mellifera* L. *J. Entomol. Zool. Stud*. **5**(6): 1369-1373.

Das, P.K. and Rahman, A. 2000. Brood reairing activity of *Apis cerana indica* F. In Assam. Crop. Res. 19(3): 469-473.

Gebremedhn,H.N. ; Tadesse,A. and Belay,T.(2014).Flight intensity of honeybees (Apis mellifera) and its relationship with temperature, sunshine hours, cloudiness and relative humidity. *Livestock Research for Rural Development26*(11).

Mehrotra, K.N. and Bisht, D.S. (1984).Current status of the biology, physiology and behaviour of the Indian hive bee, Apisceranaindica Fab. Indian Bee J., 46: 36-42.

Nag, Y.K. (2016). Performance of *Apis mellifera* L. under different migratory mode in Nothern parts of India. Thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur.

Painkra,M.K. ; Shaw,S.S.; Thakur,R.K. and Nag,Y(2017). Influence of Weather Parameters on Colonies Performance Parameters of Indian Bee, *Apis cerena indica*, *International Journal of Current Microbiology and Applied Sciences* ISSN: 2319-7706 Vol.6; pp. 2375-2380.

Panse, V.G. and Sukhatme, P.V. (1985). *Statistical methods for Agricultural Workers*, ICAR, New Delhi. pp. 87-93.

Pastagia, J.J. and Patel, M.B. 2014. Influence of weather parameters on brood rearing and foraging activities of Indian bee, *Apis cerena*. AGRES – An International Journal. Vol.3: 403-409.

Rahman, S. (1992). Comparative brood rearing and pollen gathering activities of *Apis cerana indica* F. and *Apis mellifera* L. under Jorhat conditions of Assam. Thesis, Assam Agricultural University, Jorhat.

Reddy, C.C. (1979). The influence of various weather factors on the foraging behaviour of Apis cerana indica. Proc. 4th Int. Symp. Pooln. College Park, Myrland, U.S.A., pp 341 345.

Verma, S. (1983). Studies on foraging behaviour of *Apis cerana indica* F. in Jeolikote, Nainital, India. Indian Bee J., 45: 5-9.

Zapart, K.D.; Chlopek, K. and Niedzwiedz, T. (2018). The impact of meteorological conditions on the concentration of alder pollen in Sosnowiec (Poland) in the years 1997-2017. *Aerobiologia*. **34**: 469-485.