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Short Communication

Environmental factors influencing pollination activity of *Apis mellifera* on *Brassica campestris*

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Abstract

The relationship of bee visits to environmental factors was studied by simple and by path coefficient analysis Bee activity was significantly correlated with air temperature ($r = 0{\cdot}449$), light intensity ($r = 0{\cdot}555$), solar radiation ($r = -0{\cdot}526$), soil temperature ($r = 0{\cdot}820$), relative humidity ($r = -0{\cdot}630$) and nectar-sugar concentration ($r = 0{\cdot}434$), but not with wind velocity ($r = 0{\cdot}100$). Direct effects of light intensity (0·619), solar radiation (0·579) and soil temperature (0·304) were positive, while those of other factors were negligible or negative.

Key words: Environmental factors, path analysis, *Apis mellifera*

1. Introduction

Bee activity commences when the minimum threshold of several environmental factors is surpassed[1–3]. The factors responsible for maintaining the once initiated rhythm of activity are not fully known. Lerer *et al*[1] reported that temperature provides a minimum threshold for initiation of the field activity by *Megachile rotundata* F., but once the minimum threshold was surpassed and appropriate temperature levels maintained, solar radiation controlled the pollination activity. Light intensity and soil temperature are important in the pollination activity of *Apis cerana indica*[4]. Also light intensity and solar radiation were predominant factors influencing the pollination activity of *Apis florea*[5]. The present study analyses the influence of several variable parameters such as air temperature, relative humidity, light intensity, solar radiation, nectar-sugar concentration, soil temperature and wind velocity on the pollination activity of *A. mellifera* on *Brassica campestris* to know the cause-effect relationship.

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2. Materials and methods

The study was conducted during November–December 1984 at the plant breeding farm of Haryana Agricultural University, Hisar (28°59′–29°46′ N and 75°11′–76°18′ E) where a plot of *Brassica campestris* var Toria was grown for seed production. Populations/m^2 of *A. mellifera* were recorded at hourly intervals from 0900 to 1700 h. Concurrently, hourly records were made of air temperature (T), relative humidity (RH), soil temperature (ST) at a depth of 30 cm, light intensity (LI), solar radiation (SR), wind velocity (WV) 1 m above the crop canopy. Total dissolved sugars in the nectars (NSC) were estimated using a pocket refractometer (model-1093, manufactured by M/s Toshniwal Brothers Pvt. Ltd., New Delhi). The recorded data were analysed for simple correlation[6] and path coefficient analysis[7]. The bee activity was considered as the resultant variable and environmental factors: T, RH, LI, SR, ST, NSC and WV as the causal variables.

3. Results and discussion

The correlation coefficient matrix (Table I) shows that bee activity is positively correlated with T, LI, SR, ST and NSC but negatively with RH. Thus bee visits increased at higher values of the former five factors and at the lower value of the last factor. Diurnal variations in WV did not affect *A. mellifera* activity. Further, the environmental factors themselves are found to interact in a complex way. For instance, T was significantly and positively correlated with SR, ST and NSC but negatively with RH.

Due to the correlated interactions of the environmental factors, the relationship between bee activity and environmental factors may not be a direct one, some factors may act directly whereas others indirectly. Therefore, path coefficient analysis was used which partitions the apparent association of different environmental factors into direct and indirect effects and facilitates the precise determination of relative importance of each factor. The estimates of direct effect path coefficients and indirect effect path coefficients influencing pollination activity of *A. mellifera* are presented in Table II. The direct effects of LI (0·6192), SR (0·5792) were pronounced followed by that of ST (0·3041). The direct effect of LI on bee visits was greater than the total correlation due to its positive interactions with T, RH, SR and NSC. Similarly, the direct effect of SR was greater than the total correlation. It was, however, reduced by its negative interactions with RH, NSC and ST. The direct effect of ST on bee visits was positive. Its negative interactions with WV tended to reduce its positive effects. But its overall highly significant positive association with bee visits was strengthened through its favourable interactions with other factors.

The direct effect of T was low (0·0686). Overall positive correlation of T with bee visits was largely due to its favourable interactions with other factors. The direct effect of WV was low (−0·0613) and negligible and its overall association with bee visits was also non-significant. The direct effect of RH and NSC on bee visits was negative. However, their overall significant negative or positive associations with bee visits were largely due to their favourable or unfavourable interactions with other factors.

Table I
Correlation coefficient matrix of environmental factors and *A. mellifera* activity on *B. campestris* during November–December 1984 and the interrelationships of these factors

Factors	Bee activity	Relative humidity	Light intensity	Solar radiation	Nectar-sugar concentration	Soil temperature	Wind velocity
Air temperature	−0·449*	−0·798*	0·250**	0·412*	0·646*	0·925*	0·116 NS
Relative humidity	−0·630*		−0·167 NS	0·080 NS	−0·311**	−0·702*	−0·111 NS
Light intensity	0·555*			0·333*	0·626*	0·423*	0·190 NS
Solar radiation	0·526*				0·655*	0·509*	−0·017 NS
Nectar-sugar concentration	0·434*					0·745*	0·004 NS
Soil temperature	0·820*						−0·029 NS
Wind velocity	0·100 NS						

*P < 0·01, n−2 = 64; **P < 0·05, n−2 = 64; NS = Not significant.

It is thus evident that LI, SR and ST had pronounced effect on the foraging activity of honeybees on *B. campestris*. The path coefficient analysis gives a somewhat different pattern of effects from those anticipated from simple correlation analysis. For instance, the correlation coefficient between bee activity and T was highly significant (0·449) but by path coefficient analysis the direct effect was negligible (0·0686). However, T influenced the bee visits indirectly through other factors. This analysis clearly reveals

Table II
Direct and indirect effect path coefficients of different environmental factors influencing *A. mellifera* activity on *B. campestris* during November–December 1984

Factors	Coefficient of correlation with bee activity	Effect *via*						
		Air temperature	Relative humidity	Light intensity	Solar radiation	Nectar-sugar concentration	Soil temperature	Wind velocity
Air temperature	0·449	0·0686	0·6920	0·0298	0·1152	−0·0751	−0·3738	0·0071
Relative humidity	−0·630	−0·0548	−0·4912	−0·0199	0·0223	0·0361	0·2838	−0·0068
Light intensity	0·555	0·0171	0·0822	0·6192	0·0930	−0·0728	−0·1711	−0·0116
Solar radiation	0·526	0·0283	−0·0393	0·0397	0·5792	−0·0761	−0·0059	0·0010
Nectar-sugar concentration	0·434	0·0443	0·4528	0·0747	0·2828	−0·1162	−0·3014	−0·0029
Soil temperature	0·820	0·0635	0·3450	0·0504	0·1422	−0·0867	0·3041	0·0017
Wind velocity	0·100	−0·0080	−0·0546	0·0426	−0·0080	0·0005	−0·0017	−0·0613

Figures underlined denote direct effects.

that LI, SR and ST were responsible in maintaining the initiated diurnal rhythm of honeybees and agrees with earlier studies[1,4,5,8,9].

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