Original Research Article

Assessing the Impact of Trap Nests on *Megachile* Bee Population in Mung Bean

Abstract

This study explores the impact of nest installation on *Megachile* bee populations, which are potential pollinators of mung bean crops in Uttarakhand, India. Field investigations over two seasons reveal that six *Megachile* species visit mung bean blooms regularly for their provisioning. Assessments performed pre- and post-nest installation showslight changes in *Megachile* abundance and species-specific responses to environmental factors. Correlation analyses of weather parameters show preferences for specific climatic conditions. These findings highlight the delicate connection between *Megachile* beesand environmental conditions, highlighting the significance of specialized pollinator management measures. Further investigation on *Megachile* nesting behaviours is essential to advancing crop pollination and ensuring sustainable agricultural practices.

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Keywords:*Megachile* bees, Mung bean, Trap nest, Pollinator management, Environmental factors.

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Introduction

India stands as the leading producer and consumer of pulses on a global scale. This includes 25% of production, and 27% of consumption globally including more than two-thirds of pulse production accounted by the six states viz., Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, and Uttar Pradesh.Apart from the key states in pulse production, Uttarakhand has shown an ongoing rise in pulse yield from 2015-16, with an expected production of 1069 kg/ha by 2021-22**(ASAG, 2022)**. Among pulses, mung bean (*Vigna radiata*L. Wilczek) is nutritionally valuable with high protein content and adaptability to diverse climates **(Pratap, 2021; Miller, 1989).** It is cultivated in broad rows, but reduced row spacing is more effective in weed control **(Pratap, 2021)**. This plant is a member of the Leguminosae family, specifically the Papilionoideae subfamily, theybear tiny yellow or greenish-yellow flowers that cluster into groups of 10-15. Mung beans have a rare trait: they are cleistogamous, which implies that pollination can occur whilst the flowers are closed. **(Huppertz *et al.*, 2023).** However,pollinators facilitate cross-pollination, which benefits legume crops including mung beans, insect pollination has a substantial influence on mung bean production in smallholder systems of farming **(Elisante*et al.*, 2020)**. Among these pollinators, those in the genus *Megachile*, are excellent pollinators.

Megachile bees (leafcutter or mason bees) are a large solitary species in the family Megachilidae, having unique nesting practices, and displaying a wide range in size, colour, and habits. Leafcutter bees build their nests by excising leaf pieces. In contrast, mason bees use resin or clay **(Chaudhary and Jain, 1978)**to create partitions within tunnels or cavities, resulting in distinct cells for their provisioning and egg-laying leading to progeny development**(Michener, 2007)**. These complex nesting behavioursshow*Megachile* bees' persistence and resourcefulness, supporting pollination dynamics across various plant species.

For bees and wasps, which commonly create their nests in pre-existing cavities trap nests are builtto provideartificial nesting sites. Trap nests are artificial cavities used by bees and wasps to attract females seeking suitable nesting sites **(Staab *et al.*, 2018)**. Six Megachile bee species (subgenus: *Callomegachile, Pseudomegachile,* and *Eutricharaea*) have been found to nest in tunnels (5-10 mm diameter) in various nests, including drilled tunnels in posts, wooden logs, and hollowed tunnels in bamboo sticks and reed stems**(Kunjwal and Khan, 2023)**.These artificial nests are used to study cavity nesters' groups and environmental impact on them, with the size of the nest crucial for success, progeny characteristics, and survival. Trap nesting is also a conservation tool in areas where farming practices destructively affect bee populations.

Material and Methods

The study was conducted to understand the effect of nest installation on the *Megachile*population in the mung bean cropat Norman E. Borlaug Crop Research Centre at the G.B.P.U.A.T., Pantnagar (29.0222° N, 79.4908° E) from Sept. 2021 to Oct.2022. *Megachile*bees were tallied on flowers from Mung beans. Counts were made per square meter area for five minutes amid different day hours using a stopwatch. Overall visits were recorded three times a day. Data were averaged to get adaily count of bees. To study the impact of artificial nesting on *Megachile*abundance, the data on*Megachile*was recorded for two seasons viz.,pre- and post-nestinstallation. Meteorological data from the Department of Agrometeorology,G.B.P.U.A.T., Pantnagar were also used to evaluate the correlation between weather parameters and *Megachile* abundance.

Results and discussion

Six *Megachile* species (*M.* (*Creightonella*) *albirons, M.*(*Xanthosarus*) *anthracina, M.* (*Amegachile*) *bicolor, M.* (*Pseudomegachile*) *lanata, M.* (*Callomegachile*) *relata,* and *M.*(*Callomegachile*) *umbripennis*) were identified to be regular visitors to the experimental fields in both seasons, suggesting that these bees could be possible pollinators for mung beans. Tables 1. and 2. indicate the population abundance (bees/m²/5min) of *Megachile*bees visiting mung bean flowers pre- and post-nestinstallation.The results presented in Table 1. indicate that the abundance of all *Megachile* pollinators varied significantly during the pre-nest installation phase across the various weeks of the mung bean flowering period. *M. umbripennis* was the most abundant on most observation days, followed by *M. bicolor* and *M. relata*. In the 39thstandard meteorological week,*M. umbripennis* had a higher abundance than *M. relata* and other species. *M. albirons* and *M. anthracina* had the lowest activity levels during the observation period. However, Table 2. data from the post-nest installation phase indicates the number of *Megachile* pollinators changed significantly across different standard meteorological weeks throughout the mung bean flowering period. *M. lanata* was the most abundant during the majority of the observation days, followed by *M. umbripennis* and *M. bicolor*. In the 40thstandard meteorological week, *M. lanata* had the highest abundance than *M. umbripennis* and other species. Again, *M. albirons* and *M. anthracina* exhibited the lowest activity rates throughout the observation period. Only *M. lanata* nested in the trap nests provided in the fields, and even then, the nest occupancy rate remained low.

These findings point to a broader role for these species in legume pollination. Similar to this study different*Megachile*beeshave been reported from all over the country. The importanceof *Megachile* bees has been thoroughly studied in states like *M. anthracina* in

Jammu and Kashmir (**Abrol and Chatterjee, 2022)**, *M. bicolor* in the pigeon pea in Odishaand Arunachal Pradesh **(Padhey *et al.*, 2019**; **Bora *et al.*, 2021)**,*M. cephalotes* in mung bean and pigeon pea in Uttarakhand and Odisha respectively (**Kunjwal *et al.*, 2016; Singh *et al.*, 2017)**,*M. lanata* in Arunachal Pradesh and Odisha (**Bora *et al.*, 2021; Singh *et al.*, 2017)**,*M. relata* in Odisha and Uttarakhand**(Singh *et al.*, 2017; Kunjwal *et al,* 2016)**,and *M. umbripennis* in Uttarakhand **(Kunjwal *et al,* 2016).** This broad spectrum of *Megachile* Bees pollinating legume crops warrants additional exploration into other crops as well.

Correlation with weather parameter

Megachile bees' relative abundance was affected by a variety of meteorological conditions, positive as well as negative. Correlation and regression studies were carried out in 2021 and 2022 to assess the connection between the dependent and independent variables [(maximum temperature (TMAX), minimum temperature (TMIN), morning relative humidity (MRH), evening relative humidity (ERH), rainfall (RF) no. of rainy days (NRD), sunshine hours (SSH), wind velocity (WV), and evaporation (EVP)]. The impact of different dependent variables on different independent factorson mung bean flowers is described below (Table 3).

Megachile anthracina

The findings indicated that the pre-nest installation, TMAX, TMIN, MRH, and SSH showed non-significant and positive correlation (r=0.048,0.030, 0.185, and 0.072) however ERH,RF, RD, WV, EVP showed non-significant and negative correlation (r= -0.292,-0.596,-530,-0.419 and -0.434) with *M. anthracina*population. The regression equation being y=-67.85+1.48(TMAX)+0.12(RHM)+0.19(RHE)-0.15(RF).Whereas post nest installation, *M. anthracina* showed a non-significant and negative correlation with MRH and RF (r= -0.404 and -0.585) but a non-significant and positive correlation withTMAX, TMIN, ERH, NRD, SSH, and WV (r=0.531, 0.783, 0.378, 0.030, 0.187 and 0.368). The regression equation being y=8.48 -0.21(RHM)+0.19(RHE)-0.01(RF)+0.15(NRD).

Megachile bicolor

The findings indicated that the pre-nest installation, TMIN, ERH, WV, and EVP showed a non-significant and positive correlation (r=0.680, 0.308, 0.348, and 0.213) however TMAX, MRH, RD, and SSH showed non-significant and negative correlation (r= -0.459, -0.073, 0.037 and -0.469) with *M. bicolor* population. The regression equation being y=127.47-2.79(TMAX)-0.53(RHM)+0.26(RHE)-0.16(RF).Whereas post-nest installation, *M. bicolor* showed a significant and negative correlation with EVP (r= -0.919). The regression equation being y=24.66-0.41(RHM)+0.22(RHE)-0.37(NRD).

Megachile cephalotes

The findings indicated that the pre-nest installation and sunshine hours showed a significant and negative correlation (r=-0.936) with *M. cephalotes* population. The regression equation being y= 7.63 -0.27 (TMAX) +0.02 (RHE) +0.01 (RF). Whereas, post-nest installation, *M. cephalotes* showed non-significant and negative correlation with TMAX, TMIN, MRH, ERH, NRD, SSH, WV,and EVP however non-significant and positive correlation with RF (r= -0.188, -0.381, -0.127, -0.075, -0.201, -0.305, -0.293, -0.259 and

0.565). The regression equation being y=27.30-0.28(RHM)-0.03(RHE)+0.01(RF)-0.11(NRD).

Megachile lanata

The findings indicated that the pre-nest installation, TMAX, TMIN, ERH, WV, and EVP showed a non-significant and positive correlation (r= 0.064, 0.455,0.022,0.083, and 0.055) however MRH, RF, RD, and SSH showed non-significant and negative correlation (r= -0.196, -0.327, -0.384, -0.040) with *M. lanata* population. The regression equation being y=-41.17+1.04(TMAX)-0.11(RHM)+0.35(RHE)-0.25(RF). Whereas post-nest installation, *M. lanata* showed a significant and positive correlation with TMIN and a significant and negative correlationwith EVP (r= 0.950 and -0.880). The regression equation being y=11.66-0.14(RHM)+0.11(RHE)-0.36(NRD).

Megachile relata

The findings indicated that the pre-nest installation, TMIN, ERH, RF, NRD, WV, and EVP showed a non-significant and positive correlation (r= 0.849, 0.489, 0.120, 0.083, 0.473, and 0.306) however TMAX, MRH,and SSH showed non-significant and negative correlation (r= -0.193, -0.159 and -0.467) with *M. relata* population. The regression equation being y=12.78-0.27(TMAX)-0.30RHM)+0.46(RHE)-0.27(RF). Whereas post-nest installation, *M. relata* showed a significant and negative correlation with EVP(r= -936).The regression equation being y=7.32-0.18(RHM)+0.18(RHE)-0.39(NRD).

M. umbripennis

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The findings indicated that the pre-nest installation, TMAX, TMIN, ERH, WV, and EVP showed non-significant and positive correlation (r= 0.014, 0.708, 0.327, 0.343, and 0.237) however MRH, RF, NRD, and SSH showed non-significant and negative correlation (r= -0.220, -0.038, -0.091, -0.256) with *M. umbripennis* population. The regression equation being y=-46.41+1.15(TMAX)-0.19(RHM)+0.52(RHE)-0.33(RF). Whereas post-nest installation, *M. umbripennis* showed a significant and negative correlation with TMIN (r= 0.935). The regression equation being y=-29.29-0.28(RHM)+0.17(RHE)-0.01(RF)-0.17(NRD).

The present study shows similarity with the higher preference of *Megachile* bees towards warmer temp and higher activity during flowering seasons **(Felicioli and Pinzauti 2008)**. Megachilid bees thrive in temperatures ranging from 26.9°C to 38.9°C, with peak activity between March-May and October-November, and activity dropping amid high humidity and winter/rainy seasons **(Kunjwal *et.al.*, 2016)**. Similar environmental interactions have been identified for *M. lanata* **(Abrol and Kapil, 1986)**. However, the prevalence and nesting of these pollinators in mung bean fields remain unresolved necessitating additional research.

Conclusion:

This study highlights the vital role of *Megachile* bees as mung bean pollinators in Uttarakhand, India. Nest installation influences *Megachile* abundance and species responses to environmental conditions, as shown by meteorological parameter correlation analysis.

Despite low pollinator population and nest occupancy rates in mung bean, *Megachile* bees were reported to frequently visit them. Trap nests substantially enhance pollinator populations, such as *M. lanata*. This shows the potential of trap nests for increasing bee numbers in mung bean crop as well as in other crops for managed pollination. Understanding *Megachile* nesting behaviour and habitat management is essential for improving pollination services while promoting sustainable agriculture.

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Table 1. The abundance of *Megachile* pollinators on Mung bean fields in the blooming period at Pantnagar (2021)

***Megachile* species**	**Number of *Megachile* bees on different dates (bees/m2/5 min)**					**Grand Mean**
	37th SMW	**38th SMV**	**39th SMV**	**40th SMV**	**41th SMV**	
Megachile anthracina	1.06	1.46	2.52	2.43	1.48	**1.90± 0.65**
Megachile bicolor	2.49	4.77	4.10	1.75	1.49	**3.17± 1.45**
Megachile cephalotes	0.66	0.80	0.28	0.54	0.16	**0.56± 0.27**
Megachile lanata	1.31	1.94	3.59	2.07	0.99	**2.11± 1.00**
Megachile relata	2.48	3.56	4.20	2.25	0.48	**2.84± 1.42**
Megachile umbripennis	3.21	3.81	5.58	3.61	1.63	**3.89± 1.41**
Mean	**2.80± 1.00**	**2.72± 1.55**	**3.38± 1.81**	**2.11± 1.00**	**1.04± 0.61**	**2.22± 1.42**
SEm±	**0.41**	**0.63**	**0.74**	**0.41**	**0.25**	**0.26**
CD at 5%	**2.401**	**2.711**	**3.392**	**2.685**	**1.805**	**1.011**

Table 2: The abundance of *Megachile* pollinators on Mung bean fields in the blooming period at Pantnagar (2022)

***Megachile* species**	**Number of *Megachile* bees on different dates (bees/m2/5 min)**					**Grand Mean**
	37th SMW	**38th SMV**	**39th SMV**	**40th SMV**	**41th SMV**	
Megachile anthracina	3.33	1.94	1.52	1.01	0.42	**1.64± 1.10**
Megachile bicolor	2.97	4.55	2.97	2.16	1.63	**2.86± 1.10**
Megachile cephalotes	0.24	0.97	1.35	0.83	0.94	**0.86± 0.40**
Megachile lanata	5.31	5.98	5.09	5.38	3.88	**5.13± 0.77**
Megachile relata	2.40	4.28	2.50	2.12	1.79	**2.62± 0.97**
Megachile umbripennis	5.92	5.56	3.96	4.89	3.45	**4.76± 1.05**
Mean	**3.36± 2.06**	**3.87± 2.00**	**2.89± 1.44**	**2.73± 1.95**	**2.01± 1.38**	**2.98± 1.77**
SEm±	**0.84**	**0.82**	**0.59**	**0.80**	**0.56**	**0.32**
CD at 5%	**3.176**	**2.495**	**2.805**	**3.125**	**1.742**	**0.893**

Table 3:Correlation between pollinator and weather parameters on mung bean flowers (2021-2022)

Megachile Species	TMAX		TMIN		MRH		ERH		RF		NRD		SSH		WV		EVP	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
M. albifrons	-0.574	-0.188	0.771	-0.381	0.361	-0.127	0.843	-0.075	0.661	0.565	0.799	-0.201	-.936*	-0.305	0.496	-0.293	0.156	-0.259
M. anthracina	0.048	0.531	0.030	0.783	0.185	-0.404	-0.292	0.378	-0.596	-0.585	-0.530	0.030	0.072	0.187	-0.419	0.368	-0.434	-0.276
M. bicolor	-0.459	0.382	0.680	0.809	-0.073	-0.173	0.308	0.742	0.000	0.069	-0.037	-0.378	-0.469	-0.413	0.348	-0.421	0.213	-.919*
M. lanata	0.064	0.803	0.455	.950*	-0.196	-0.456	0.022	0.285	-0.327	-0.409	-0.384	-0.752	-0.040	0.120	0.083	-0.413	0.055	-.880*
M. relata	-0.193	0.244	0.849	0.709	-0.159	0.028	0.489	0.770	0.120	0.245	0.083	-0.414	-0.467	-0.546	0.473	-0.626	0.306	-.936*
M. umbripennis	0.014	0.649	0.708	.935*	-0.220	-0.213	0.327	0.352	-0.038	-0.569	-0.091	-0.382	-0.256	0.177	0.343	-0.141	0.237	-0.521