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Collection Efficiency of Fresh Pollen under Different Pollen Trapping Frequencies by *Apis mellifera* L. Colonies in Mustard

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present experiment was carried out at apiary of Krishi Vigyan Kendra, Morena and at beekeeper's apiary in Morena, M.P. during 2022-23 and 2023-24 to evaluate the consumption pattern of different artificial diets by *Apis mellifera* L. colonies during dearth periods. Front mounted wooden pollen traps were mounted under five different pollen trapping frequencies as treatments, including control and the amount of pollen collection was recorded per colony per day. The results

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revealed that, colonies with daily trapping had the highest average pollen collection rate (167.45 and 157.34 g/colony/day) and the lowest average pollen collection rate (13.34 and 12.79 g/colony/day) was observed in weekly trapping across the trapping period of both the consecutive years. However, the control group, with no pollen trapping, was observed with no pollen collection. Additionally, the total pollen collection across the trapping frequencies was highest in daily trapping (1.340 and 1.259 kg/colony) and lowest in weekly trapping (0.107 and 0.102 kg/colony) during 2022-23 and 2023-24, respectively. During the trapping weeks, the lowest amount of pollen (17.89 and 20.67 g/colony/day) was collected in 1st week i.e. during 03 – 09 December at the initiation of the mustard flora. However, the highest amount of pollen collection (101.03 g/colony/day pollen) was recorded in 4th week (24 - 31 December, 2022) while during 2023-24 it was recorded highest in 6th week (8 - 14 January) with 99.24 g/colony/day pollen. The correlation analysis showed that the average amount of collected pollen was significantly negative correlated with wind speed.

Keywords: *Apis mellifera L.; bee pollen; beekeeping; collection; floral period; honeybees; pollen trap; trapping frequency.*

1. INTRODUCTION

Honeybees (*Apis mellifera* L.) play a pivotal role in enhancing agricultural productivity through effective pollination. Nowadays, the products of the honey bee, *Apis mellifera* L., such as honey, bee pollen, propolis, beeswax, royal jelly and bee venom, are of great concern in many fields, e.g. nutritional and pharmaceutical industries. According to Simal et al. [1], pollen is the primary source for supply of protein, lipids, free amino acids, vitamins, and minerals, while nectar satisfies their need for carbohydrates. According to Keller et al. [2], pollen is important for the growth of pharyngeal gland, production of royal jelly, feeding and nursing larvae, colony cleanliness, and overall bee health and development. Worker bees store the surplus pollen near the brood area during the rich pollen season. The stored pollen is used to meet the pollen needs of the colony during dearth. The quantity and the quality of pollen collected by honey bees influence reproduction, brood rearing, longevity, and consequently the colony's productivity. In addition to being used by honeybees, pollen is widely used worldwide as a "super food, by humans" in medicine (apitherapy), and in cosmetics [3].

Honey bees rely on pollen and nectar for nutrition, but these resources are not available all year, causing the colony's products to deplete. In contrast to honey, pollen generally is not kept in the hive in large quantities beyond what the colony needs. During the scarcity of pollen flora, bees limit their brood rearing activities, leading to a sharp decline in colony strength. These colonies are unable to effectively use the upcoming honey flow. Therefore, pollen traps can be used to collect it during times when there is an abundance of pollen available. It offers a reserve of pollen to feed colonies during periods of scarcity if maintained appropriately, which in turn aids in healthy colony development. Trapping incoming pollen can also substantially aid in the research of bee foraging activities, identification and classification of pollen sources at a specific site and to gain more income in addition to honey. For this motive, numerous pollen trap designs have been developed and evaluated [4-7]. Throughout the year, honey bees collected a significant amount of pollen from various crops; however, the amount of pollen they collected varied based on a number of factors, including their race, health, environment, and the crop grown area surrounding their colonies. The value of harvested pollen loads may be added also to a beekeeper's gross income [8]. A strong honeybee colony can gather 15-40 kg of pollen in one year [9,10]. According to Naglaa and Nowar [11], the highest pollen was collected during the summer season (1731.44 g/colony) when the pollen traps were used at three days intervals [12]. Numerous studies on this topic have been carried out in various locations. The diversification of bee products from an apiary may significantly boost the beekeepers' returns. According to reports, diversification's gross income can boost apiary profitability by 21–33% [8,11]. A beekeeper can profit from gathering honey (15–20 kg/hive) and pollen (0.9–2.6 kg) even in a small apiary with 50 colonies [13].

The Northern region of Madhya Pradesh is suitable place for beekeeping owing to its topography, sub-tropical climate and bee-friendly environment. Pollen and nectar floral sources are available in abundance during the mustard bloom from December to February [14]. This research aims by investigating the impact of different pollen trapping frequencies on the quantity of pollen collected by *Apis mellifera* colonies in mustard fields. By systematically varying the trapping intervals, the study seeks to determine the most effective frequency for maximizing pollen collection. Understanding the optimal pollen trapping frequency is crucial for enhancing beekeeping practices and improving pollination services.

2. MATERIALS AND METHODS

The field experiment was carried out at apiary of Krishi Vigyan Kendra, Morena and at beekeeper's apiary in Morena district of Madhya Pradesh during mustard bloom of 2022-23 and 2023-24. In the beginning of experiment, 20 colonies of European honey bee, *Apis mellifera* L. with no clinical signs of any disease, having equal bee frames strength, equalized in terms of brood and food stores were selected and labelled properly. The experiment was conducted in Randomized Block Design (RBD). Each selected bee colony acted as one replicate and treatments were replicated four times. A front mounted 3-piece wooden pollen trap (Dimensions: 28 cm length, 7 cm breadth and 9 cm height) was fixed at the entrance of each colony for pollen collection during the study period in a definite pattern and frequency being treatments as T1= Throughout flowering period (Daily), T2= Every alternate day (Alternate), T3= Every third day (3 days), T4= Every seventh day (Weekly) and T5= No pollen trap mounted (Control). The collected pollen was brought to the laboratory for cleaning and weighing and it was stored at freezing temperature (-18^{o}C) in air tight polythene bags until further use. Daily total pollen loads from collection trays of all the treatments was collected, cleaned and weighted in plastic pouches by using digital weighing scale and average weight of pollen collection was estimated. Statistical analysis of the averaged data was carried out by two-way ANOVA in MS Excel and the means were compared by using Duncan's Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1 Collection of Pollen Pellets

The results shows that different pollen trapping frequencies significantly affects the amount of pollen collection per colony per day among weeks. Colonies with daily trapping had the highest average pollen collection rate (167.45 and 157.34 g/colony/day) across the trapping period of both the consecutive years. Dalal [15] observed that with the increase in trapping frequency from, the mean pollen pellet collection (g/colony/day) also increased *i.e.,* more pollen was collected in daily trapped colonies as compared to other frequencies. Further, the mean pollen collection rate in alternate days and three days trapped colonies was 80.24 and 72.70 g/colony/day and 43.00 and 38.86 g/colony/day, respectively. However, among the different trapping frequencies, the lowest average pollen collection rate (13.34 and 12.79 g/colony/day) was observed in weekly trapping across the trapping period of both years. In contrary, the control group, with no pollen trapping, was observed with no pollen collection. Akyol and Unalan [16] reported that the first group (pollen traps were used every day) gathered in average the maximum amount of pollen as to be 75.20±4.08 g/day/colony, the second (pollen traps were used every second day) and the third (pollen traps were used every third day) groups gathered in average 40.35±1.41 and 37.23±1.54 g/day/colony respectively. Significant differences were detected between the groups in respect of both the number of pollen collectors and amount of pollen. Subsequently, the highest total pollen collection across the trapping frequencies was observed in daily trapping (1.340 and 1.259 kg/colony) followed by alternate days trapping (0.642 and 0.589 kg/colony), three days trapping (0.344 and 0.324 kg/colony) and weekly trapping (0.107 and 0.102 kg/colony) during 2022-23 and 2023-24, respectively. Stephen and Robert [17] indicated that honeybees respond to deficiencies in the quantity or quality of their pollen reserves by increasing the gross amount of pollen returned to the colony, rather than by specializing in collecting pollen with greater pollen content.

Irrespective of the trapping frequencies, at the initiation of the mustard flora, the lowest amount of pollen (17.89 and 20.67 g/colony/day) was collected in 1st week i.e. during 03 – 09 December across all the trapping frequencies. In contrary with the findings of Mohamed et al. [18] who revealed that the lowest amount of bee pollen collected by the traps was during the last week of August and September. Against the current results, Taha et al. [19] found that the largest amount of pollen was collected from bees during May (440.77 and 425.33 g/colony), while the lowest trapped pollen loads were obtained during January (131.92 and 115.66 g/colony), followed by December (136.36 and 125.65 g/colony) in 2015 and 2016. This could be due to the difference in the region as well as the difference in the type of trap used and the different environmental conditions. Further, with the continuous increase in flowering of mustard crop, the amount of pollen in the collection trays also increased as 32.71 and 30.83 g/colony/day in 2nd week (10 – 16 December), 74.15 and 63.70 g/colony/day in 3rd week (17 - 23 December), 101.03 and 87.40 g/colony/day in 4th week (24 - 31 December). It was also noted that, pollen collection was slightly decreased in 5th week (1 – 7 January) with 93.92 and 72.58 g/colony/day and further it was increased to 100.56 and 99.24 g/colony/day pollen in 6th week (8 - 14 January). It was interesting to note that the average pollen collection during the trapping weeks attained different peaks in both the years of study. During mustard bloom of 2022-23 the highest amount of pollen collection (101.03 g/colony/day pollen) was recorded in 4th week (24 - 31 December) while during 2023-24 it was 99.24 g/colony/day pollen in 6th week (8 - 14 January). The present results are in accordance with the findings of Kumar and Aggarwal [20] who reported that the maximum pollen (1033.1 gm per colony) was collected in the month of January in Gwalior, while in Panchkula maximum quantity of pollen was collected in February month (880.2 gm per colony). Similarly, Stephen and Robert [17] also indicated that maximum collection of pollen during February and March month and this can be due to the availability of flowers, favourable climatic conditions due to which forager bees are more active and collect maximum amount of pollen. Results are also in accordance with that of Chhuneja et al. [21] who stated that maximum amount of pollen is collected in the pollen flow period. In contrast with the present findings, Mesbah et al. [22] reported that the highest amount of trapped pollen was in the August and summer seasons, while the lowest amount was in May and spring seasons. Hassan et al. [23] also reported that over spring and summer seasons, the highest amount of trapped pollen (240.07 gram/colony/week) was recorded in August, however the lowest amount (13.38 gram/colony/week) was in April. This could be due to the difference in the region as well as the difference in the type of trap used and the different environmental conditions. Thereafter, the amount of pollen collected in the present study was decreased gradually to 46.71 and 43.27 g/colony/day pollen in 7th week (15 - 21 January) and 19.48 and 33.04 g/colony/day in 8th week (22 - 28 January) across all the trapping frequencies. Statistical analysis of the data revealed that differences in the amount of pollen collection was statistically significant for both, pollen trapping frequencies and trapping weeks. Similar studies related to pollen trapping frequencies also done by Lau et al. [24] and Hoover and Ovinge [25].

3.2 Correlation of Amount of Pollen Collection with Weather Parameters

The data presented in Table 3 provides insights on correlation coefficients of the amount of pollen collection and weather parameters for the study period 2022-23 and 2023-24. Analysis showed that the average amount of collected pollen was significantly negative correlated with wind speed among all other meteorological parameters in both years with correlation coefficients $r = -0.729$ (2022-23) and $r = -0.718$ (2023-24). Understanding the negative impact of wind speed on honeybee activity is crucial for beekeepers in optimizing hive productivity and ensuring favourable conditions for bee foraging and pollination. The negative correlation between wind speed and honeybee foraging activity suggests that bees prefer calmer weather conditions for their foraging activities, which allows them to efficiently collect nectar and pollen without being disrupted by strong winds.

The present results are in accordance with the finding of Gounari et al*.* [26] who reported that honeybee activity is influenced by wind speed, showing a negative correlation, especially in spring. Strong winds can impact bees' flying ability, leading to decreased honey yields as bees may not be able to fly efficiently. Similarly, Singh [27] concluded that the Foraging rate and amount of pollen collected by honeybees is influenced by wind speed. Increased wind speed negatively affects the foraging activity of honeybees, making it harder for them to visit flowers and collect nectar and pollen efficiently. The present results are in partial accordance with the Alqarni [28] who reported that the foraging and pollen-gathering activities were negatively affected by temperature and wind speed and positively affected by relative humidity. Other parameters such as maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rain fall and sunshine hours were found to have varied insignificant correlations with average pollen collection over both years of study. In contrary with these findings of Kaur and Kumar [29] who reported that the external factors such as temperature, light, wind, rain, clouds also influenced the pollen foraging activities.

Table 1. Effect of pollen trapping frequency on pollen collection from *Apis mellifera* L. colonies during 2022-23

Weeks	Pollen Pellets Collection (g/ colony/ day)					
	Trapping Frequency					
	Daily	**Alternate Days**	**Three Days**	**Weekly**	**Control**	**Mean**
1 Week (3 - 9 Dec)	71.85* (8.51)**	13.42 (3.73)	3.42 (1.97)	0.75 (1.06)	0.00 (0.71)	17.89^{h} (3.19)
2 Week (10 - 16 Dec)	107.98 (10.41)	35.41 (5.99)	16.29 (4.09)	3.86 (1.99)	0.00 (0.71)	32.71^{f} (4.64)
3 Week (17 - 23 Dec)	197.79 (14.08)	103.02 (10.17)	59.23 (7.73)	10.73 (3.32)	0.00 (0.71)	74.15^{d} (7.2)
4 Week (24 - 31 Dec)	258.37 (16.09)	151.68 (12.34)	80.98 (9.02)	14.10 (3.79)	0.00 (0.71)	101.03^{a} (8.39)
5 Week (1 - 7 Jan)	242.73 (15.59)	118.04 (10.88)	72.92 (8.56)	35.94 (6.02)	0.00 (0.71)	93.92^{c} (8.35)
6 Week (8 - 14 Jan)	256.35 (16.03)	144.49 (12.04)	79.54 (8.94)	22.43 (4.76)	0.00 (0.71)	100.56^{b} (8.5)
7 Week (15 - 21 Jan)	146.03 (12.1)	51.81 (7.23)	22.36 (4.76)	13.36 (3.69)	0.00 (0.71)	46.71^{e} (5.7)
8 Week (22 - 28 Jan)	58.51 (7.68)	24.02 (4.95)	9.28 (3.1)	5.59 (2.39)	0.00 (0.71)	19.48^{g} (3.76)
Mean	167.45^{A} (12.56)	80.24^{B} (8.42)	43.00^{C} (6.02)	13.34^{D} (3.38)	0.00 (0.71)	-
Total (kg/ colony)	1.340	0.642	0.344	0.107	0.000	-
Two- way test			**C.D.** $_{(p = 0.05)}$		**S.E.m ±**	
W (Weeks)			**0.196**		**0.070**	
F (Trapping Frequency)			**0.155**		**0.055**	
W x F (Weeks x Frequency)			**0.439**		**0.157**	

**Mean of four replications (n = 4); **figures in parentheses are $\sqrt{x + 0.5}$ transformed values; NS = Non-Significant; Means followed by a different alphabet letter within row or column are significantly different by DMRT (p<0.05)*

Table 2. Effect of pollen trapping frequency on pollen collection from *Apis mellifera* L. colonies during 2023-24

Weeks	Pollen Pellets Collection (g/ colony/ day)					
	Trapping Frequency					
	Daily	**Alternate Days**	**Three Days**	**Weekly**	**Control**	**Mean**
1 Week (3 - 9 Dec)	77.36* (8.82)**	19.55 (4.48)	5.17 (2.37)	1.25 (1.29)	0.00 (0.71)	20.67[h] (3.53)
2 Week (10 - 16 Dec)	100.60 (10.05)	33.10 (5.79)	15.83 (4.03)	4.61 (2.21)	0.00 (0.71)	30.83[g] (4.56)
3 Week (17 - 23 Dec)	179.42 (13.41)	87.85 (9.4)	44.74 (6.72)	6.48 (2.59)	0.00 (0.71)	63.70[d] (6.57)
4 Week (24 - 31 Dec)	213.00 (14.61)	137.00 (11.73)	66.00 (8.15)	21.00 (4.62)	0.00 (0.71)	87.40[b] (7.96)
5 Week (1 - 7 Jan)	223.96 (14.98)	93.33 (9.68)	35.98 (6.02)	9.64 (3.02)	0.00 (0.71)	72.58[c] (6.88)
6 Week (8 - 14 Jan)	215.15 (14.68)	147.58 (12.17)	100.24 (10.03)	33.24 (5.79)	0.00 (0.71)	99.24[a] (8.68)
7 Week (15 - 21 Jan)	137.95 (11.77)	31.23 (5.62)	31.20 (5.62)	15.95 (4.03)	0.00 (0.71)	43.27[e] (5.55)
8 Week (22 - 28 Jan)	111.30 (10.57)	32.00 (5.7)	11.75 (3.48)	10.14 (3.24)	0.00 (0.71)	33.04[f] (4.74)
Mean	157.34[A] (12.36)	72.70[B] (8.07)	38.86[C] (5.81)	12.79[D] (3.35)	0.00 (0.71)	-
Total (kg/ colony)	1.259	0.589	0.324	0.102	0.000	-
Two- way test			**C.D.** $_{(p = 0.05)}$		**S.E.m ±**	
W (Weeks)			**0.208**		**0.074**	
F (Trapping Frequency)			**0.165**		**0.059**	
W x F (Weeks x Frequency)			**0.465**		**0.166**	

**Mean of four replications (n = 4); **figures in parentheses are $\sqrt{x + 0.5}$ transformed values; NS = Non-Significant; Means followed by a different alphabet letter within row or column are significantly different by DMRT (p<0.05)*

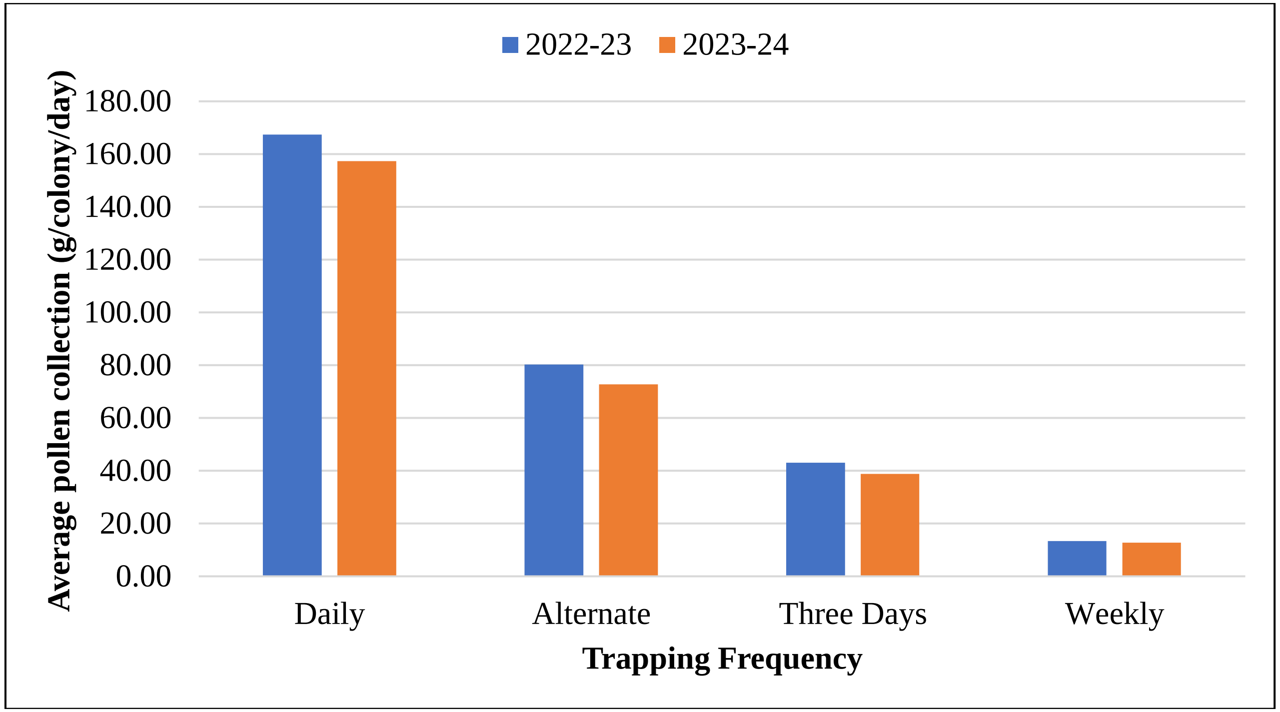

Fig. 1. Average pollen collection under different pollen trapping frequency from *Apis mellifera* L. colonies

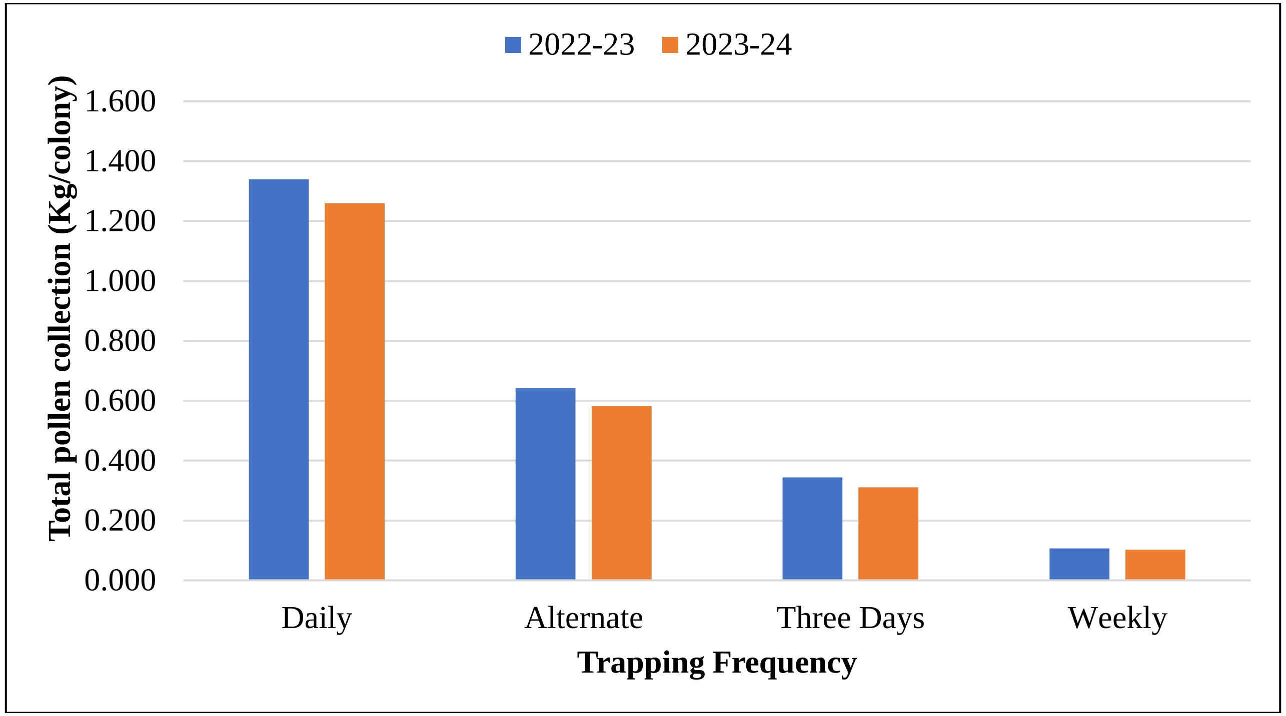

Fig. 2. Average pollen collection under different pollen trapping frequency from *Apis mellifera* L. colonies

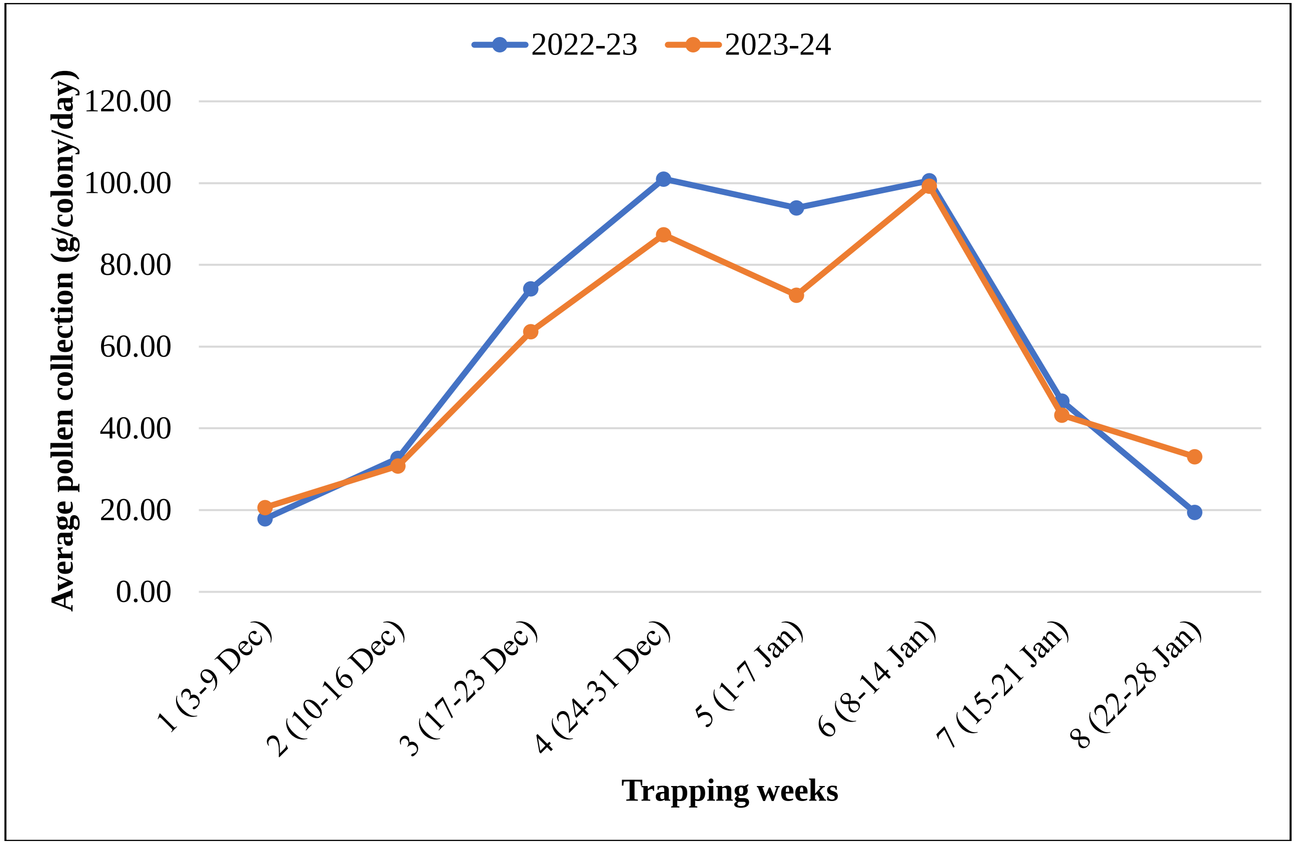

Fig. 3. Average pollen collection under different pollen trapping frequency across trapping weeks from *Apis mellifera* L. colonies

Table 3. Correlation analysis of pollen collection with prevailing weather parameters during the study period

Weather Parameters	Correlation Coefficient (r) Mean Pollen Collection (g/ colony/ day)	
	2022-23	**2023-24**
Maximum Temperature (ºC)	-0.418 NS	-0.309 NS
Minimum Temperature (ºC)	-0.683 NS	0.021 NS
Morning Relative Humidity (%)	-0.251 NS	0.520 NS
Evening Relative Humidity (%)	-0.657 NS	0.445 NS
Rainfall (mm)	-0.465 NS	-0.286 NS
Wind Speed (km/hr)	-0.729 *	-0.718 *
Sunshine (hrs)	-0.450 NS	-0.255 NS

**Significant at 5% level of significance; NS = Non-Significant*

4. CONCLUSION

Among the different trapping frequencies, colonies with daily trapping had the highest average pollen collection rate (167.45 and 157.34 g/colony/day) and the lowest average pollen collection rate (13.34 and 12.79 g/colony/day) was observed in weekly trapping across the trapping period of both the consecutive years. However, the control group, with no pollen trapping, was observed with no pollen collection. Additionally, the highest total pollen collection across the trapping frequencies was observed in daily trapping (1.340 and 1.259 kg/colony) and lowest in weekly trapping (0.107 and 0.102 kg/colony) during 2022-23 and 2023-24, respectively. During the trapping weeks of both the years, the lowest amount of pollen (17.89 and 20.67 g/colony/day) was collected in 1st week i.e. during 03 – 09 December at the initiation of the mustard flora. However, the highest amount of pollen collection (101.03 g/colony/day pollen) was recorded in 4th week (24 - 31 December, 2022) while during 2023-24 it was recorded highest in 6th week (8 - 14 January) with 99.24 g/colony/day pollen. The correlation analysis showed that the average amount of collected pollen was significantly negative correlated with wind speed among all the meteorological parameters.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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