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Predatory Behaviour And Seasonal Attack Pattern Of Asian Hornet,*Vespa Velutina* In *Apis Mellifera* Colonies At Dehradun,Uttarakhand"

Hitendra Kumar
Associate Professor
Department of Entomology,
School of Agricultural Sciences, Shri Guru Ram Rai University, Dehradun, India

Abstract: The seasonal predatory behavior of the Asian hornet, *Vespa velutina*, on *Apis mellifera* colonies was observed over a two-year period (2021-2023) at Pathribagh, Dehradun. Hornet activity peaked in the warmer months, with the highest number of visits recorded in July (261.50 ± 23.17) and the highest number of successful attacks in the same month (137.38 ± 12.02). The lowest visit rate occurred in December (5.25 ± 4.00), with the highest percentage of successful attacks observed in December (62.86 ± 7.25). The seasonal incidence of unsuccessful visits also followed a similar trend, with the highest number of unsuccessful visits in July (125.13 ± 9.55), and the lowest in December (1.48 ± 0.91). Weather factors such as temperature and relative humidity were positively correlated with hornet activity, with significant correlations observed for minimum temperature ($r = 0.811$, $R^2 = 0.659$), relative humidity ($r = 0.769$, $R^2 = 0.591$), and maximum temperature ($r = 0.556$, $R^2 = 0.309$). Rainfall showed no significant correlation with hornet activity ($r = -0.219$, $R^2 = 0.048$). These findings suggest that hornet activity is influenced by environmental conditions, particularly temperature and humidity, with a marked increase during the warmer months.

Index Terms **-** Vespa velutina, Apis mellifera, Seasonal variation, Predatory behaviour

I. INTRODUCTION

The Asian hornet (*Vespa velutina* Linn.) is an invasive species that poses a significant threat to honeybee populations, particularly *Apis mellifera*, which are critical for pollination and ecological balance. Originating in Southeast Asia, this hornet has spread to various parts of the world, including Europe, where its rapid expansion has been well-documented over the past two decades (Topitzhofer et al., 2020; Poidatz et al., 2013). Its predatory behavior on honeybees has been identified as a key factor contributing to colony stress, reduced foraging activity, and, in severe cases, colony collapse (Poidatz et al., 2013).

In India, increasing reports of *Vespa velutina* preying on *Apis mellifera* colonies have raised concerns, particularly in regions like Dehradun, renowned for its robust apiculture industry. Pathribagh, with its favorable climate and floral diversity, is a critical site for beekeeping but has also emerged as a hotspot for hornet activity (Guleria et al., 2020). This necessitates a comprehensive understanding of the seasonal occurrence and behavior of *Vespa velutina*. Asian hornets are recognized as aggressive predators of honeybees, targeting both foraging and hive-bound individuals. Typically, hornets station themselves near hive entrances, capturing individual bees and transporting them back to their nests (Burgett and Akratanakul, 1982). As the season progresses, hornets expand their nests and intensify their predatory activities through synchronized group raids. During these attacks, hornets invade colonies to feed on brood, extracting pupae and larvae from brood cells and even looting honey stores. Captured bees and

larvae provide a primary protein source, while nectar and honey fulfill their carbohydrate requirements (Topitzhofer et al., 2020; Burgett and Akratanakul, 1982).Indian honeybees (*Apis cerana*) have evolved a defense mechanism against *Vespa velutina*, forming heat-generating ball-like clusters around invading hornets to neutralize them. However, *Apis mellifera* lacks such a mechanism, making it particularly vulnerable to predation. This often results in weakened colonies, brood loss, and in extreme cases, colony absconding or collapse (Topitzhofer et al., 2020; Guleria et al., 2020).

The seasonal dynamics of *Vespa velutina* are closely tied to its life cycle and environmental factors. Hornet activity begins in spring, as overwintered queens emerge to establish new colonies. During this period, predation on honeybees is minimal, as hornet populations are low, and their primary focus is on nest establishment (Topitzhofer et al., 2020). By summer, the hornet population grows significantly, and workers actively prey on bees, particularly those near hive entrances. Predation peaks in late summer and autumn, coinciding with the development of reproductive individuals in the hornet colony (Poidatz et al., 2013).

In regions like Pathribagh, warmer temperatures and longer daylight hours in spring and summer support the growth and foraging activity of hornets. With the onset of winter, hornet activity declines sharply as workers die off, and only mated queens overwinter in sheltered locations (Guleria et al., 2020).

The impact of *Vespa velutina* is further compounded by its ability to raid honey stores and brood resources, leading to significant economic losses for beekeepers and challenges for pollination-dependent agriculture (Poidatz et al., 2013). Effective management of *Vespa velutina* populations is critical for sustaining apiculture in affected regions. Strategies such as trapping, nest destruction, and habitat management during peak seasons have been employed to mitigate their impact (Topitzhofer et al., 2020).
Research into the seasonal occurrence of *Vespa velutina* provides valuable insights into its predation patterns and ecological preferences. Studies in Pathribagh can help identify peak activity periods and environmental factors influencing hornet abundance, informing targeted interventions. This knowledge is crucial for protecting honeybee colonies and ensuring sustainable apiculture practices in regions where *Vespa velutina* poses a threat (Guleria et al., 2020).

In conclusion, the seasonal occurrence of *Vespa velutina* in *Apis mellifera* colonies underscores the complex predator-prey dynamics between these species. Addressing the challenges posed by this invasive predator requires region-specific research and innovative management strategies to safeguard honeybee populations and maintain ecological balance.

II. OBJECTIVE OF STUDY

The main objective of present research work is to investigate the seasonal occurrence and predator-prey dynamics of *Vespa velutina* in *Apis mellifera* colonies, and to develop region-specific management strategies for mitigating its impact on honeybee populations and ecological balance.

III. RESEARCH METHODOLOGY

3.1 Description of Study Area

The investigation was conducted at the Bee keeping Unit located at Research Farm,School of Agricultural Sciences ,Shri Guru Ram rai University, Pathribagh, Dehradun, Uttarakhand, India, from January 2021 to December 2023. The apiary is situated at approximately 30°19' N latitude and 78°04' E longitude, at an altitude of around 640 meters above mean sea level (MSL). For the study, ten colonies of *Apis mellifera* were placed within the bee keeping unit, all maintained at similar strength. No specific management strategies were implemented during the study period, although colonies were supplemented with sugar-syrup during dearth periods to sustain their strength.
The Pathribagh area of Dehradun experiences a characteristic humid subvelutinal climate. This region receives an average annual rainfall of approximately 2000 mm, with relative humidity (R.H.) ranging between 50–90%. The majority of the rainfall is brought by the South-West monsoon, occurring primarily between June and September. However, rainfall patterns are often erratic and unevenly distributed throughout the year. The average maximum and minimum temperatures in this region range between 10°C and 36°C. Pathribagh experiences distinct seasonal variations, including a pronounced winter period from December to February and a hot summer from April to June, making it a suitable location for apiculture research.

3.2 Study of Asian Hornet predatory behaviour

Observations were made during the active foraging period, (08:00 am–9:00am, 9:00 am–10:00 am, 3:00 pm–4:00 pm, 4:00 pm–5:00 pm). The data collection was conducted randomly through visual observation, focusing on two aspects: the number of visits by predatory hornets in front of the hives and the number of foraging bees predated by them (successful visits). Only hornets observed hovering near the colonies were documented, while those passing by or not engaging in predatory behavior were excluded. The data was analyzed for both seasonal and time-related variations in their interaction with the bee colonies.

3.3 Collection of Weather data

Meteorological data, including maximum and minimum temperature (°C), relative humidity (RH, %), and rainfall (mm), were obtained from the Meteorological Unit located at Research Farm,School of Agricultural Sciences ,Shri Guru Ram rai University, Pathribagh, Dehradun.

3.4 Statistical Analysis

The seasonal occurrence of *V. velutina* was analyzed in relation to various environmental factors using standard statistical methods. Correlation and regression analyses were conducted to assess the influence of environmental parameters on the seasonal occurrence of this pest.

IV. RESULTS AND DISCUSSION

The Asian hornet, *Vespa velutina*, was observed to capture returning *Apis mellifera* honey bee foragers and transport them to their nests, which were located near the apiary. The seasonal predatory behaviour of *V. velutina* is presented in Table 1. Data indicated that hornet attacks on *A. mellifera* colonies were most frequent during July, August, September, and October, with an average of 261.50±23.17, 236.00±10.25, 224.75±6.02, and 218.88±8.18 visits per day, respectively, peaking in July. A noticeable surge in hornet activity occurred in July, with abundance remaining relatively consistent across these months.

The lowest number of visits was recorded in December (5.25±4.00). The highest number of successful visits was observed in July (137.38±12.02), followed by August (135.88±5.17). The lowest number of successful visits was in December (3.88±1.25). The percentage of successful attacks was highest in December (62.86±7.25), with a marked increase in the latter months of the study period. The lowest successful attack percentage occurred in March (52.00±0.00) and July (55.04±0.95). The overall trend suggests that *V.velutina* exhibited a higher number of visits and successful attacks in the warmer months, particularly from May to August. However, the percentage of successful attacks showed variability, with December having a particularly high success rate despite a low number of visits. The pooled mean values for the total number of visits, successful visits, and percentage of successful attacks were 107.45±39.45, 62.05±17.25, and 58.25±2.15, respectively, demonstrating the overall activity pattern of *V. velutina* in the colonies.

The seasonal incidence of unsuccessful visits and attacks by *V. velutina* in *A. mellifera* colonies was analyzed over a two-year period (2021-2023). The highest number of unsuccessful visits occurred in July (125.13±9.55), followed by August (101.13±4.32). The lowest number of unsuccessful visits was recorded in December (1.48±0.91). March showed very few unsuccessful visits (0.48±0.28), indicating a potential decrease in activity during this month.

Table 1: Predatory behaviour of *Vespa velutina* in *Apis mellifera* colonies (2021–2023 study period).

Months	Total visit count **(Mean±S.E.)**			**Successful visit Count (Mean±S.E.)**			**Successful attack (%) (Mean±S.E.)**
	2021–22	2022–23	Pooled	2021–22	2022–23	Pooled (Mean±S.E.)	
September	216.26±5.90	243.25±4.80	224.75±6.02	118.50±4.75	134.75±5.25	127.13±4.69	55.89±0.72
October	204.26±5.92	242.50±9.03	218.88±8.18	109.00±6.45	128.50±4.72	119.25±4550	54.85±0.35
November	77.76±22.68	88.50±17.88	89.63±14.22	47.25±14.26	58.50±10.75	52.38±4.15	58.60±2.02
December	0.00	9.50±5.58	5.25±4.00	0.00	5.75±5.25	3.88±1.25	62.86±7.25
January	0.00	0.00	0.00	0.00	0.00	0.00	NA
February	0.00	0.00	0.00	0.00	0.00	0.00	NA
March	1.90±1.60	0.00	0.85±0.75	0.85±0.85	0.00	0.37±0.28	52.00±0.00
April	26.25±7.10	35.75±11.60	31.00±6.17	17.75±5.33	20.35±5.66	19.50±3.36	64.55±1.75
May	89.75±5.82	107.25±7.07	98.50±6.08	54.75±4.73	62.35±4.66	57.50±2.10	60.10±1.45
June	119.25±6.30	148.25±18.86	129.25±12.22	64.25±4.28	85.75±10.55	77.00±7.36	60.00±0.75
July	186.00±11.04	308.00±13.81	261.50±23.17	104.00±3.86	168.75±7.36	137.38±12.02	55.04±0.95
August	228.75±7.52	252.25±11.97	236.00±10.25	126.50±5.75	145.25±8.81	135.88±5.17	58.35±0.95
Mean	---	---	107.45±39.45	---	---	62.05±17.25	58.25±2.15

The percentage of unsuccessful attacks was highest in March (51.00±0.00), reflecting that more visits in this month were unsuccessful. The overall percentage of unsuccessful attacks was lowest in December (37.14±8.30) and January and February, where no unsuccessful visits were recorded. The data indicate a consistent number of unsuccessful visits and relatively stable percentages of unsuccessful attacks from May to August, with a noticeable decline from September to December. Specifically, September to November had higher percentages of unsuccessful attacks compared to the warmer months, particularly in March. The pooled mean values for the number of unsuccessful visits and the percentage of unsuccessful attacks were 47.44±12.23 and 43.77±1.26, respectively, showing moderate activity across the study period. In summary, *V. velutina* showed a higher number of unsuccessful visits in the warmer months, particularly in July and August, with a relatively higher percentage of unsuccessful attacks in March.

Table 2: Predatory behaviour of *Vespa velutina* in *Apis mellifera* colonies (2021–2023 study period).

Months	Unsuccessful visit Count (Mean±S.E.)			Unsuccessful attack (%) (Mean±S.E.)
	2021–22	2022–23	Pooled	
September	98.75±3.45	97.50±3.33	97.53±2.56	45.11±0.62
October	96.25±6.28	108.00±4.58	101.63±4.61	47.15±1.25
November	33.50±7.54	43.00±5.34	38.25±5.34	41.40±1.02
December	0.00	2.85±1.60	1.48±0.91	37.14±8.30
January	0.00	0.00	0.00	NA
February	0.00	0.00	0.00	NA
March	0.85±0.75	0.00	0.48±0.28	51.00±0.00
April	8.60±2.96	15.50±3.94	12.50±2.80	37.41±3.65
May	36.00±2.52	45.00±2.67	41.00±2.70	41.90±2.42
June	48.00±2.68	57.50±5.33	52.25±3.86	40.00±0.75
July	92.00±7.02	138.25±4.88	125.13±9.55	44.96±0.95
August	92.25±2.57	108.00±6.33	101.13±4.32	41.65±0.85
Mean	---	---	47.44±12.23	43.77±1.26

After November, hornet activity during the early morning hours (08:00 to 09:00), when temperatures were lower, was significantly reduced, with only 5.25±4.00 visits per day recorded during December. The incidence of *V. velutina* is illustrated in Figure 1. Other studies from various regions in India have also reported hornet activity, although these reports often refer to different hornet species with similar behaviors. For instance, some studies indicated that *Vespa* populations peaked from August to September (Abrol and Kakroo, 1998; Ranabhat and Tamrakar, 2008). In Punjab, however, the peak incidence of hornet attacks on *A. mellifera* colonies occurred between July and December, with the highest activity between August and October (Brar et al., 1985). Kumar et al. (1998) noted that hornet incidence peaked at 282.4 wasps per day in the first week of September. Differences between these findings and our current study could be attributed to varying weather conditions, topography, and the positioning of colonies relative to food sources.

Table 3: Regression equations, correlation coefficient (r), and coefficient of determination (R^2) for the seasonal occurrence of *V. velutina* in relation to different environmental factors.

Environmental parameters	Effect on Asian hornets		
	Regression equation	r	R^2
Temperature (max.)	y=13.662 x-335.30	0.556^{**}	0.309
Temperature (min.)	y=13.908 x-186.78	0.811^{**}	0.659
RH (max.)	y=4.4308 x-175.8	0.259^{*}	0.068
RH (min.)	y=6.9309 x-276.98	0.769^{**}	0.591
Rainfall day^{-1}	y=-3.2745 x+118.92	-0.219^{NS}	0.048

**: Significant at (p=0.01) level of significance;
*: Significant at (p=0.05) level of significance;
NS: Non-significant

The incidence of *V. velutina* was influenced by weather factors such as temperature, relative humidity, rainfall, and wind speed. As shown in Table 2, both maximum and minimum temperatures and relative humidity exhibited a significant positive correlation with the seasonal occurrence of *V. velutina* (r=0.556, 0.811, 0.259, and 0.769, respectively). However, rainfall showed a negative and non-significant correlation, indicating that *V. velutina* was less abundant during rainy days. The regression equation for maximum temperature was y=13.662x−335.30y = 13.662x - 335.30y=13.662x−335.30, with a correlation coefficient (r) of 0.556**, which is significant at the 0.01 level. The coefficient of determination (R^2) is 0.309, indicating a moderate positive relationship between maximum temperature and the seasonal incidence of *V. velutina*. The maximum relative humidity with a correlation coefficient (r) of 0.259 and coefficient of determination (R^2) is 0.068, indicating a weak positive relationship between maximum relative humidity and the seasonal incidence of *V. velutina*.

Data presented in table 2 indicates a moderate to strong positive relationship between minimum relative humidity and the seasonal incidence of *V. velutina*. There is a very weak and non-significant relationship between rainfall and the seasonal incidence of *V. velutina*.

Weather factors are considered key in influencing hornet attacks on apiaries (Sauvard et al., 2018; Dieguez-Anton et al., 2022). According to Rodriguez-Flores et al. (2019), high minimum temperatures, low maximum temperatures, dew temperature, and relative humidity promote hornet activity. Other studies have also found that hornet incidence correlates positively with both maximum and minimum temperatures, as well as relative humidity, while rainfall shows a negative correlation (Sharma and Mattu, 2014; Bista et al., 2020). Our findings align with this literature, though some variations may stem from differences in local environmental conditions.

V.Conclusion

The predatory behavior of *Vespa velutina* on *Apis mellifera* colonies intensifies during warmer months, peaking from May to August, particularly in July, and declines significantly in colder months like December. Hornet activity positively correlates with temperature and humidity, while rainfall shows a non-significant negative effect. Regional variations in activity are influenced by climate, topography, and apiary management. These findings highlight the seasonal dynamics of *V. velutina* and offer insights for beekeeping strategies to reduce hornet-related losses.

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