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Seasonal Occurrence of Greater Banded Hornet (*Vespa tropica* Linn.) in Western Honey Bee (*Apis mellifera* Linn.) Colonies under Terai Agro-ecological Region of West Bengal

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ABSTRACT

The present study was conducted during September, 2018 to August, 2020 on the seasonal incidence of *Vespa tropica* Linn. on *Apis mellifera* Linn. under terai agro-ecological region of West Bengal, India. Ten numbers of *A. mellifera* colonies of similar strength was placed in the apiary unit of Uttar Banga Krishi Viswavidyalaya, West Bengal, India in which no pest management strategies were carried out. Incidence of *V. tropica* was recorded higher during July to October peaking in the month of July (251.50±22.17 visits day^{-1}) with annual average success rate of 57.23%±1.16%. From December to March little or no incidence was recorded. Minimum abundance of hornets was recorded at 07:00–09:00 hours. After that incidence started increasing with maximum incidence recorded at 13:00–15:00 hours i.e., 43.52±11.97 visits to the bee colonies day^{-1} during this time gap. Both maximum and minimum temperature and relative humidity showed significantly positive correlation with the incidence of *V. tropica*. However, rainfall was found to be detrimental for their incidence as it showed negative and non-significant correlation with their incidence. As *V. tropica* has been considered as a major enemy of honey bees, so the results obtained from the study can be used for designing integrated pest management strategies against this pest that will allow the beekeepers to focus on that particular time period when this pest is more abundant.

KEYWORDS: *Apis mellifera*, seasonal incidence, *Vespa tropica*, weather parameters

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

In the present scenario of burgeoning population and food crisis, pollination is a service that can secure our food production (Bommarco et al., 2013) and bees are pre-eminent in this role (Hristov et al., 2020, Khalifa et al., 2021). There are approximately 20,000 species of bees belonging to seven recognized families (Ascher and Pickering, 2014) performing important role in pollination. Western honey bees, *Apis mellifera* Linn. (Hymenoptera: Apidae) provide highly valuable pollination services (Breeze et al., 2011, Calderone, 2012, Aslan et al., 2016), and while considering a single species, *A. mellifera* is the most frequent pollinator for different agricultural and horticultural crops around the world (Garibaldi et al., 2013, Sharma et al., 2016, Nath et al., 2023). Besides pollination, beekeeping is also considered as a remunerative venture providing livelihood for rural communities (Hinton et al., 2020). However, recent evidences indicate that the regional population of both hive and wild bees are showing a downward trend (Biesmeijer et al., 2006, Kluser et al., 2010, Meixner, 2010, Potts et al., 2010, Cameron et al., 2011, Saha et al., 2023). Ultimately this situation threatens our food security and increases concerns among scientists, apiculturists and general public (Allsopp et al., 2008, Gallai et al., 2009). Several biotic and abiotic stresses are responsible for this decline (Goulson et al., 2015, Meeus et al., 2018). Among different biotic stresses, greater banded hornet, *Vespa tropica* Linn. (Hymenoptera: Vespidae) is an important threat to the honey bees (Burgett and Akratanakul, 1982, Paschapur et al., 2022).

These hornets are considered as predators of honey bees as they prey upon both foraging and indoor bees. Usually, hornets are found to wait near hive entrances and catch one bee at a time, carrying it back to their nests. Later in the season they expand the nest and prey on honey bees through group-synchronizing attacks during which, the hornets enter into the colony for feeding on broods (Topitzhofer et al., 2020). They may take away all the pupae and larvae from brood cells and rob the honey store (Burgett and Akratanakul, 1982). They utilize the captured bees and larvae as the major sources of protein, and took away the nectar and honey to fulfill their carbohydrate requirement (Ibrahim and Mezid, 1967, Matsuura and Sakagamim, 1973). Indian honey bees can defend the hornet attack to some extent by forming a ball-like cluster around the hornet and killing them by heat effect. Lack of such a defense mechanism in Western honey bees (Topitzhofer et al., 2020) results in absconding of the colonies even in temperate regions (Burgett and Akratanakul, 1982). Weather parameters also have a significant role on the incidence of hornets, as changes in different weather parameters maintain their population over time. However, a little information is available regarding the environmental influence on the incidence of this pest. Whereas such information can allow the beekeepers to design appropriate management strategies against it.

Different biotic stresses has been found as threat to the *A. mellifera* colonies in apiaries of terai region of West Bengal and incidence of some of them has been described in previous study (Singha et al., 2022). The greater banded hornet, *Vespa tropica* is one of those major threats causing a great loss to the *A. mellifera* colonies. Keeping in view the impact of *V. tropica* on the colony strength of *A. mellifera*, the current investigation had been designed to determine the seasonal incidence of *Vespa tropica* in *A. mellifera* colonies under terai agro-ecological region of West Bengal.

2. MATERIALS AND METHODS

2.1. Description of study area

The investigation was carried out at the apiary unit of Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, Cooch Behar, West Bengal, India between September, 2018 to August, 2020. The apiary unit was located at 26 °19' N latitude and 89 °23' E longitude and at an altitude of 43 meter above the mean sea level (MSL). For study ten numbers of *A. mellifera* colonies were placed in the apiary unit. The colonies were of similar strength. In those bee hives no management strategies were carried out. During dearth period colonies were fed with sugar-syrup solution to maintain their strength.

The Terai region of West Bengal has a characteristic per-humid climate. This region received an annual average rainfall of more than 3000 mm and the relative humidity (R.H.) ranged between 65–95%. About 80% of the total rainfall was caused by the South-West monsoon during June–September. However, the pattern of rainfall was erratic and not uniform in distribution throughout the year. Average maximum and minimum temperatures ranged between 24°–33.2°C. The area faced a short spell of winter from December–February.

2.2. Assessment of greater banded hornet abundance

Observation was taken during the active foraging period at an interval of two hours right from morning to last entrance (07:00–09:00, 09:00–11:00, 11:00–13:00, 13:00–15:00 and 15:00–17:00 h). Data was recorded randomly by visual observation based on two aspects: number of visits by predatory hornets in front of the hives and number of forager bees predated by them (successful visits). Only the information regarding hornets hovering near to the colonies was documented and hornets that passed by the colonies or didn't take part in predatory activity have not been considered. Data was recorded as both seasonal and time variation in their incidence on the bee colonies.

2.3. *Weather information for the study*

The meteorological data regarding the maximum and minimum temperature (°C), RH (%), rainfall (mm) were collected from the Meteorological Unit that is located at the Instructional Farm of UBKV, about 500 m away from the experimental sites.

2.4. *Statistical analysis*

The seasonal occurrence of *V. tropica* was correlated with different environmental parameters by following the standard statistical methodologies. Correlation and regression analysis were also carried out so as to determine the impact of environmental parameters on the seasonal occurrence of this pest.

3. RESULTS AND DISCUSSION

3.1. *Seasonal incidence of greater banded hornets*

The greater banded hornet, *V. tropica* was found to catch the returning *A. mellifera* honey bee foragers and carried them to their nests which was made in proximity of the apiary unit. The seasonal abundance of *V. tropica* was presented in Table 1. Data revealed that the number of attacks to *A. mellifera* colonies by the hornets was higher during July, August, September and October (251.50±22.17, 235.00±9.25, 223.75±5.02 and 217.88±7.18 visits day^{-1} respectively) with peak incidence in July. A sharp increase in the incidence of hornets was noticed in July. The abundance was more or less similar in these four months. After October there was a sharp decline in the hornet incidence and little or no incidence was recorded from December to March when there was also a steady decline in the ambient temperature. Thus, hornets were found to be active from June to October. The hornets were found quite successful as a predator as their average success rate was 57.23%±1.16% with a mean daily predation of 60.02±16.29 number of honey bees.

As presented in Figure 1, *V. tropica* was found to be more dominant during the middle hours of the day, i.e. 13:00–15:00 (43.52±11.97 visits to the bee colonies day^{-1}). This time gap was characterized by the prevalence of high temperature and bright sunshine hours. At the early

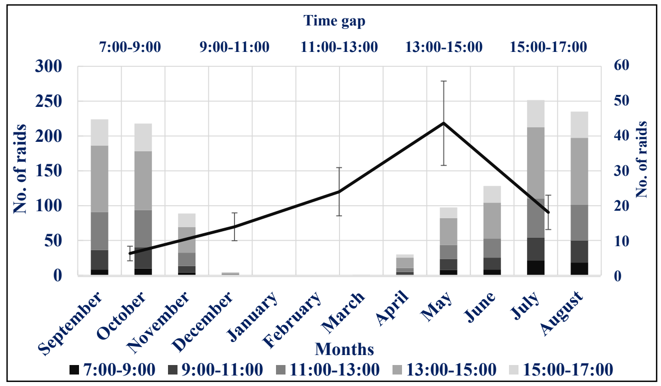

Figure 1: Time variation in the incidence of *V. tropica* at different hours of the day (data collected during 2018–2020 study period). Primary vertical axis indicate data for primary horizontal axis (months). Secondary vertical axis indicate the data for secondary horizontal axis (time interval). All vertical lines indicate SEm±

Table 1: Seasonal incidence of *V. tropica* in *A. mellifera* colonies (data collected during 2018-2020 study period)

Months	Total number of visits (Mean±S.E.)			Successful visits (Mean±S.E.)			Percentage of Successful attack (Mean±S.E.)
	2018–19	2019–20	Pooled	2018–19	2019–20	Pooled (Mean±S.E.)	
September	215.25±6.90	232.25±4.70	223.75±5.02	117.50±3.75	132.75±3.25	125.13±3.69	55.89±0.82
October	203.25±5.81	232.50±8.03	217.88±7.18	108.00±5.49	126.50±2.72	117.25±4.50	53.85±1.35
November	78.75±21.67	98.50±16.78	88.63±13.22	46.25±13.16	56.50±10.90	51.38±8.14	57.60±1.02
December	0.00	8.50±5.48	4.25±3.00	0.00	5.75±4.25	2.88±2.25	61.86±8.20
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	1.50±1.50	0.00	0.75±0.75	0.75±0.75	0.00	0.38±0.38	50.00±0.00
April	25.25±7.10	34.75±10.60	30.00±6.17	16.75±4.33	20.25±5.66	18.50±3.36	63.59±2.65
May	88.75±5.72	106.25±6.07	97.50±5.08	53.75±3.73	61.25±4.66	57.50±3.105	59.10±1.42
June	109.25±5.30	147.25±17.86	128.25±11.22	63.25±3.28	88.75±11.56	76.00±7.36	59.00±0.75
July	196.00±10.04	307.00±11.81	251.50±22.17	103.00±2.86	169.75±6.36	136.38±13.02	54.04±0.96
August	218.75±7.42	251.25±12.97	235.00±9.25	125.50±4.77	144.25±9.81	134.88±6.17	57.35±0.96
Mean	---	---	106.46±29.48	---	---	60.02±16.29	57.23±1.16

Table 1: Continue...

Months	Unsuccessful visits (Mean±S.E.)			Percentage of Unsuccessful attack (Mean±S.E.)
	2018–19	2019–20	Pooled	
September	97.75±3.35	99.50±4.33	98.63±2.56	44.11±0.82
October	95.25±7.28	106.00±5.58	100.63±4.71	46.15±1.35
November	32.50±8.54	42.00±6.34	37.25±5.24	42.40±1.02
December	0.00	2.75±1.60	1.38±0.91	38.14±8.20
January	0.00	0.00	0.00	NA
February	0.00	0.00	0.00	NA
March	0.75±0.75	0.00	0.38±0.38	50.00±0.00
April	8.50±2.96	14.50±4.94	11.50±2.90	36.41±2.65
May	35.00±2.52	45.00±3.67	40.00±2.80	40.90±1.42
June	46.00±2.68	58.50±6.33	52.25±3.96	41.00±0.75
July	93.00±8.02	137.25±5.88	115.13±9.55	45.96±0.96
August	93.25±3.57	107.00±6.23	100.13±4.22	42.65±0.96
Mean	---	---	46.44±13.23	42.77±1.16

morning hours, i.e. 07:00 to 09:00 when the ambient environmental temperature was low enough, their incidence was also recorded very low (6.55±2.08 visits to the bee colonies day^{-1}). Thereafter a gradual increase in the number of attacks was noticed. Pictorial presentation of *V. tropica* incidence has been presented in Figure 2.

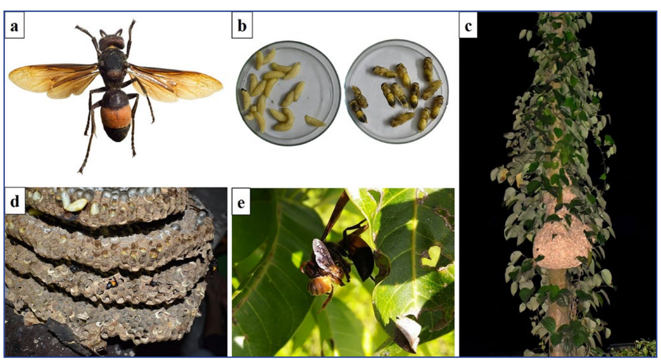

Figure 2: Incidence of *V. tropica*. (a) Adult, (b) Larval and pupal stage, (c) *V. tropica* nest near the apiary, (d) Inner view of *V. tropica* nest, (e) *V. tropica* catching *A. mellifera* forager

Different workers had also recorded the incidence of hornets from different parts of India. The information was not solely based on *V. tropica* rather based on different other hornet species that have similar types of incidence. According to some report, *Vespa* population attained a peak during August to September (Abrol and Kakroo, 1998, Ranabhat and Tamrakar, 2008). However, from Punjab the maximum hornet incidence on *A. mellifera* colonies was reported from July to December with peak incidence during August to October (Brar et al., 1985). Kumar et al. (1998) reported the incidence of hornets rose to its peak (282.4 wasps day^{-1}) in the first week of September. Though there is some variation in the results of our current investigation with the above mentioned works that may be due to the difference in the prevailing weather factors, topography and position of the colonies with the food sources.

3.2. Impact of environmental parameters on hornet incidence

The incidence of *V. tropica* was influenced by various weather factors like maximum and minimum temperature and relative humidity, rainfall, wind speed etc. As presented in Table 2, both temperature and R.H. (both maximum and minimum) showed significantly positive correlation (r=0.555, 0.812, 0.258 and 0.770 respectively) with the seasonal occurrence of *V. tropica*. However, rainfall had a negative and non-significant correlation with its incidence indicating low abundance of *V. tropica* during rainy days.

Weather factor was considered as an important parameter affecting hornets attack on apiaries (Sauvard et al., 2018, Dieguez-Anton et al., 2022). According to Rodriguez-

Table 2: Regression equations, correlation coefficient (r) and coefficient of determination (R^2) of seasonal incidence of *V. tropica* as influenced by various environmental parameters

Environmental parameters	Impact on greater bended hornets		
	Regression equation	r	R^2
Temperature (max.)	y=14.661x-334.31	0.555^{**}	0.308
Temperature (min.)	y=14.907x-185.77	0.812^{**}	0.660
RH (max.)	y=3.4308x-176.9	0.258^{*}	0.067
RH (min.)	y=5.9308x-275.99	0.770^{**}	0.592
Rainfall day^{-1}	y=-2.2744x+119.91	-0.221^{NS}	0.049

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

Flores et al. (2019) high minimum temperatures, low maximum temperatures, dew temperature and relative humidity favoured the incidence and spread of hornet. From different studies, it had been found that incidence of *Vespa* showed a positive correlation with both maximum and minimum temperature and relative humidity, whereas its correlation with rainfall was negative (Sharma and Mattu, 2014, Bista et al., 2020). This indicated that our present investigation was in corroboration with the aforesaid literature, however the certain variation might be due to the difference in the prevailing environmental conditions.

4. CONCLUSION

The incidence of hornets remained higher during June–October, when the temperature and relative humidity both were high and significantly contributed to the peak incidence of hornets. Not only season basis, even the incidence of this insect was noticed higher during mid-day hours than other time intervals during the day time. So, keeping this in view, monitoring need to be done during this period of year for early detection of the pest incidence.

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