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Research Paper

Seasonal activity of predatory wasps (*Vespa velutina*) attacking *Apis mellifera* L. Colonies in Zabarwan Himalayas of Kashmir

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ABSTRACT

Studies were conducted on the number of wasps attacking honeybees (*Apis mellifera*) colonies in three different times of the day for six continuous minutes every day on ten honeybee colonies. The study period was divided into 35 Standard Meteorological Weeks (SMW) among which the wasp incidence varied significantly, as recorded and low in early spring with a gradual increase in the late summer and the highest peak was observed in the autumn. The results showed that the maximum weekly population of predatory wasps at morning, mid-day and evening was (8.667), (27.394) and (13.052) respectively, during 38th SMW. Weekly mean population of wasps exhibited positive correlation with the maximum temperature and negative correlation with the minimum relative humidity. Monitoring the seasonal activity and spatial population variations, along with weather parameters indicate the estimate of peak period of their activity by which sustainable management strategies/plans of these predatory wasps will be developed.

Key words: *Apis mellifera*, attacking, loss, predatory wasp, seasonal activity, *Vespa velutina*,

Honeybees hold great importance in nature and in economy as they are essential for the health of people and the planet. Honey bees belong to genus *Apis* of family Apidae and order Hymenoptera, of class Insecta. They are eusocial, reserve honey and live in colonies, having a definite caste system. Their cherished products such as honey, beeswax, propolis, bee venom etc. have medicinal properties, and the role of bees as pollinators makes them vital for food supplies and in maintaining biodiversity and ecological balance. In fact, more than a third of the food we eat is pollinated by bees (Mendes *et al*., 1998). The introduction of high honey yielding European bee, *A. mellifera* during 1960s in the foot hills of Himachal Pradesh and agricultural plains of Punjab and in the union territory of Jammu and Kashmir during 1987 led to the commercial beekeeping in India (Abrol, 2004). The prevalence of diversified bee flora and suitable climatic conditions has shown tremendous potentiality for beekeeping enterprise in the country (Atwal, 1964; Atwal and Sharma, 1968).World honey production exceeded 1.1 million tonnes and is increasing. China is the leading honey producer in the world; with the annual production of 497, 286.00 metric tonnes (MTs), while India is at 7th position with the annual production of 1,20,000 metric tonnes (MTs), contributing about 10.90 percent to the total world honey production. The major markets for Indian honey are Germany, USA, United Kingdom, Japan, France, Italy, and Spain (Anonymous, 2019).

Despite the immense potential for beekeeping in India, beekeepers are not able to capitalize full production potential. One of the major causes behind this gap is the biotic stresson honeybees (Ahmad *et al*., 2003; Bista, 2011; Aryal *et al*., 2015). A honeybee colony is a vast resource of carbohydrates (honey) and protein substances (pollen, larvae and adults), making it vulnerable to a large number of potential vertebrate, invertebrate pests and predators (Matsuura and Sakagami, 1973; Chhuhuneja *et al*., 2008). Pests of honeybees are major cause of colony depletion and low honey productivity; hornets/wasps, are one of the most important factor. Predatory wasps pose a serious threat to the beekeeping industry in different parts of the world. A persistent attack of predatory wasps weakens the bee colonies mostly during floral dearth period, resulting in absconding (Gupta and Das, 1977; Abrol, 2006). Eusocial hornets live in colonies of several hundred individuals, but unlike bees, they don't rely on nectar and pollen for rearing their young. Instead, hornets feed their own young with other insects and their larvae. Thus a honey bee colony of several thousand bees provides a lot of food for hungry hornets and their youngones.

The wasps attack honeybees both in the field and at the entrance of the bee colony for protein rich food to their larvae and carbohydrate rich food to adult wasps. Hornet hover nearby a honeybee colony for more than 25 minutes in the attempt to catch a bee and also approach the nest entrance, landing near the defending bees to try and snatch a prey (Tan *et al*., 2007). After catching a bee, the hornet usually flies to a support where it manipulates its prey. The predator usually starts by beheading the bee and then with its mandibles cuts off the abdomen and crushes the bee thorax before taking the dismembered prey back to the nest to feed the larvae that require protein food to develop (Tan *et al*., 2007). The persistent attacks progressively weaken honey bee colonies, often leading to their death due to the intense predation pressure or to the inability to collect a sufficient amount of resources to survive the overwintering period, with potential colony losses of up to 30% to 50% (Sakagami and Akahira, 1960; Tan *et al*., 2007; Ken *et al*., 2005]. Indeed, the most intense period of hornet hawking over apiaries and feral colonies usually coincides with floral dearth periods, in late summer or early autumn at temperate and subtropical latitudes (Baracchi *et al*., 2010; Abrol, 2006). Then the hornet nests are at their peak in terms of immature brood population (i.e., larvae) in need of feeding with protein resources, while nectar and pollen sources for the honey bees are scant and insufficient (Matsuura, 1991).

Once the wasps have rid the hive of all its defending bees, they steal and feed on the honey and carry the bee larvae corpuses back to their own colony to rare their developing brood. The frequency of wasp attack is different at different time of the day, which is maximum in noon time followed by mid-day and morning. It is necessary to find out the seasonal activity of wasps to adopt management tactics in peak period. The present study was undertaken to determine the seasonal activity of wasps in Zabarwan Himalayas of Kashmir valley.

MATERIALS AND METHODS

The study was undertaken at the apiary of Research and Training Centre for Pollinators, Pollinizers and Pollination Management (RTCPPPM), SKUAST-K, Shalimar. This site consisted of more *A. mellifera* colonies and few *A. cerana* colonies. Availability of feral *A. cerana* colonies was low. The major honeybee floras were horticultural trees, ornamental plants, a variety of vegetable crops and some forest trees. Settlement with open places and running water existed therein. The study was carried out on *A. mellifera* colonies at Apiary placed in Shalimar Srinagar. Ten colonies were randomly selected and managed throughout the study period, following good beekeeping practices. The experimental colonies with ten frame strength were prepared one month prior to the study. Observations were made on wasps hovering in front of *Apis mellifera*, L. colonies and were counted for two hours each in the morning (08:00-10:00 h); mid-day (12:00-14:00 h) and evening (16:00-18:00 h) on daily basis. Each colony was observed for continuous six minutes at each time interval from April to November, 2020. The number of wasps collected, were counted to record the incidence of predatory wasp population.

Incidence of wasp population = No. of wasps counted/6 minutes/colony

The weekly mean population of predatory wasps on different timings during April to November 2020 was calculated by dividing the study duration in Standard Meteorological Weeks (SMW) of year 2020, starting from 14^{th} SMW to 48^{th} SMW. Weekly mean population at different timings was calculated from daily mean data and hence cumulative mean population for the different weeks was calculated.

Predatory wasps hovering in front of *Apis mellifera* colony entrances

RESULTS AND DISCUSSION

The data presented in Table 1 and Fig. 1 reveals that the highest mean population of 16.356 predatory wasps, was recorded during 38th Standard Meteorological Week, followed by 15.792, during 39th Standard Meteorological Week. Both the means are significantly different. The lowest population of 0.714, was recorded during 14th Standard Meteorological Week. The highest weekly population at morning, midday and evening was 8.667, 27.394 and 13.052 during 38th SMW and the lowest weekly population at morning, midday and evening was 0.366, 1.116 and 0.660 during, 14th SMW.

Table 1: Weekly mean population of *Vespa velutina* at different timings during April to Nov., 2020

SMW	Timing			Mean
	Morning	Midday	Evening	
W14	0.366	1.116	0.660	0.714
W15	0.470	1.129	0.727	0.775
W16	0.627	1.187	0.896	0.903
W17	0.599	1.229	0.908	0.912
W18	0.410	1.295	0.709	0.805
W19	0.523	1.410	0.853	0.928
W20	0.610	1.840	1.253	1.234
W21	0.896	2.682	1.869	1.816
W22	1.096	2.967	2.139	2.067
W23	1.167	3.610	2.338	2.372
W24	1.167	4.382	2.681	2.743
W25	2.096	5.226	3.296	3.539
W26	2.310	6.025	3.522	4.270
W27	2.890	6.023	3.898	4.567
W28	2.801	6.816	4.084	3.952
W29	4.092	7.039	4.790	5.309
W30	5.171	11.583	7.298	8.017
W31	5.101	11.296	7.667	8.021
W32	5.409	11.296	7.667	8.124
W33	5.424	11.411	7.651	8.162
W34	4.782	13.538	6.838	8.386
W35	5.382	16.023	7.267	9.557
W36	6.667	19.868	10.996	12.510
W37	7.283	24.397	12.095	14.591
W38	8.667	27.394	13.052	16.356
W39	8.624	25.739	12.970	15.792
W40	6.838	20.440	10.597	12.625
W41	5.439	18.110	7.849	10.466
W42	5.324	17.896	7.539	10.253
W43	4.482	13.938	5.955	8.1249
W44	3.212	9.681	4.009	5.634
W45	2.825	7.066	3.481	4.457
W46	2.310	5.367	2.855	3.510
W47	1.637	3.324	2.367	2.442
W48	1.225	2.111	1.481	1.605
	3.369	9.270	4.979	

C.D ($p \leq 0.05$) each no. in the figures represents the mean of ten replications

C.V: 5.30; Timing (T): 0.081; Weeks (W): 0.280; TxW: 0.485

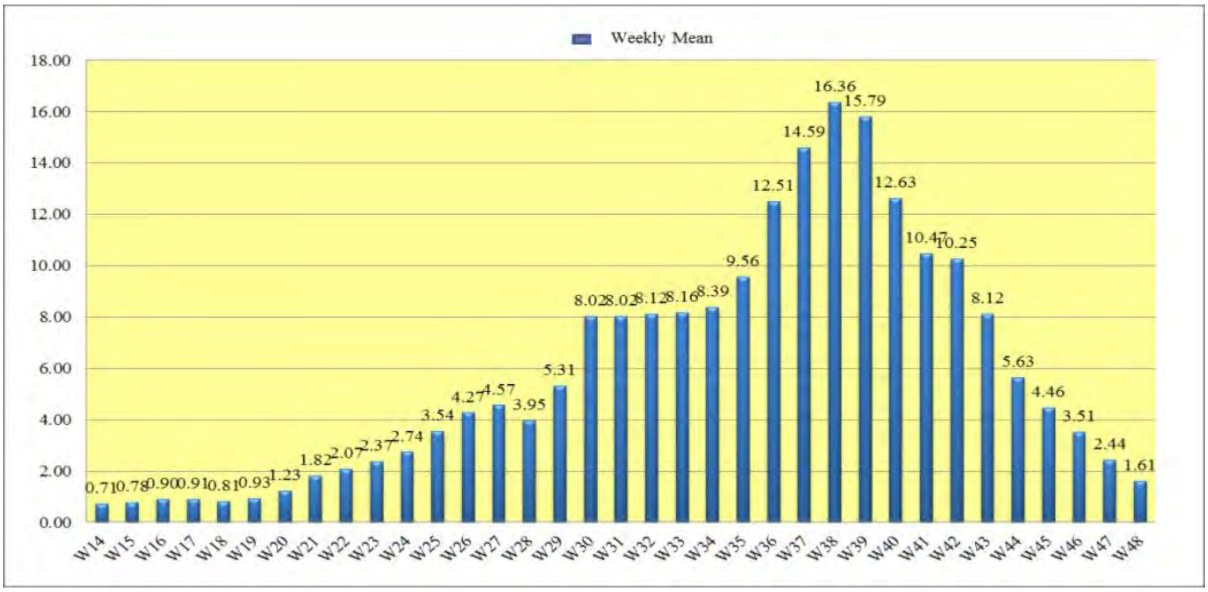

Fig. 1: Weekly mean population of predatory wasps attacking *A. mellifera* colonie

It also depicted that the weekly mean population of predatory wasps was highest at midday (9.270), followed by evening (4.979) and lowest in the morning (3.369), for all the 35 number of Standard Meteorological Weeks. Present findings draw their support from Chhuneja *et al.* (2008) who revealed that highest weekly mean population of *V. orientalis,* was recorded on second week of September. Ibrahim (2009), reported lowest rate of hornet attack was recorded for the second week of August. The present findings were also in harmony with Islam *et al.* (2015) who concluded that low populations of *Vespa velutina* and *V. orientalis* were observed in June while the population of *V. tropica* started to appear in the first week of July and then increased gradually from the second week of August up to the fourth week of October. The highest number of hornets was observed in October followed by September and August. The population of different hornet's species showed a decreased trend at the fourth week of November.

Pearson's correlation (r) between weekly mean population of *Vespa velutina* attacking *Apis mellifera* colonies and different weather parameters: The perusal of data in Table 2, Fig. 2a and Fig. 2b reveals that the weekly mean population of predatory wasps is positively correlated with the maximum temperature (r= 0.421) at 5% level of significance. It also depicts that the weekly mean population of predatory wasps is negatively correlated with the minimum relative humidity (r=-0.612), at 1% level of significance. The correlation of weekly mean population with minimum temperature, wind velocity, maximum relative humidity is positive and with that of precipitation is negative, non-significant with the correlation coefficient r= 0.158, 0.330, 0.072 and -0.121, respectively.

Similar correlation effect was established between incidence of *V. velutina* with temperature at Solan, Himachal Pradesh, India (Brar *et al*., 2018). Sharma and Mattu (2014) also found positive correlation between number of *V. velutina* and *V. mandariana* wasps with temperature and relative humidity, but both reported negative correlation with minimum relative humidity, which could be due to different agro-climatic zones. Similarly, Bista *et al*. (2020) reported that the hornet population was found negatively correlated at forest area and positive at rural area, in the mid-hill areas of Lalitpur, Nepal. The hornet incidence around the honeybee apiary at both locations were negatively correlated with rainfall but were positively correlated with maximum and minimum temperature. These investigations also got support from the findings of earlier workers (Kumar *et al*. 1998 and Rana *et al*. 2000). They have reported maximum incidence of *V. auraria* during July to November, showing positive correlation with temperature and relative humidity. The present investigations are also in line with the studies conducted by Sharma *et al*. (1979) and Kumar *et al*. (1998) at Solan, who also noticed low incidence of *V. auraria* during June and peak in September and also the weather parameters; formerly mentioned established positive correlation with the incidence of the *V. auraria* . Similar studies were conducted by Nagaraja and Rajagopal (2003), who also reported that the maximum infestation was observed during October to November in southern regions of Indian subcontinent, besides the results were positively correlated with the maximum temperature and relative humidity and negatively correlated with the minimum temperature. Brar *et al*. (2018) conducted a similar study and the results were also in harmony with the present one and reported that the incidence of *V. auraria* showed significant positive correlation with temperature (r= 0.759) and relative humidity (r= 0.665) on *A. mellifera* colonies at Nauni, Solan district, Himachal Pradesh.

Table 2: Pearsons correlation (r) between weekly weather parameters and mean population of *Vespa velutina* attacking *Apis mellifera* colonies

Parameter	Weekly Mean Population	Maximum Temperature	Minimum Temperature	Wind Velocity	Precipitation	Relative Humidity Maximum	Relative Humidity Minimum
Weekly Mean Population	1	0.421*	0.158	0.330	-0.121	0.072	-0.612**
Maximum Temperature	0.421*	1	0.816**	0.662**	-0.216	-0.630**	-0.649**
Minimum Temperature	0.158	0.816**	1	0.787**	0.203	-0.387*	-0.183
Wind Velocity	0.330	0.662**	0.787**	1	0.095	-0.296	-0.278
Precipitation	-0.121	-0.216	0.203	0.095	1	0.474**	0.553**
Relative Humidity Maximum	0.072	-0.630**	-0.387*	-0.296	0.474**	1	0.533**
Relative Humidity Minimum	-0.612**	-0.649**	-0.183	-0.278	0.553**	0.533**	1

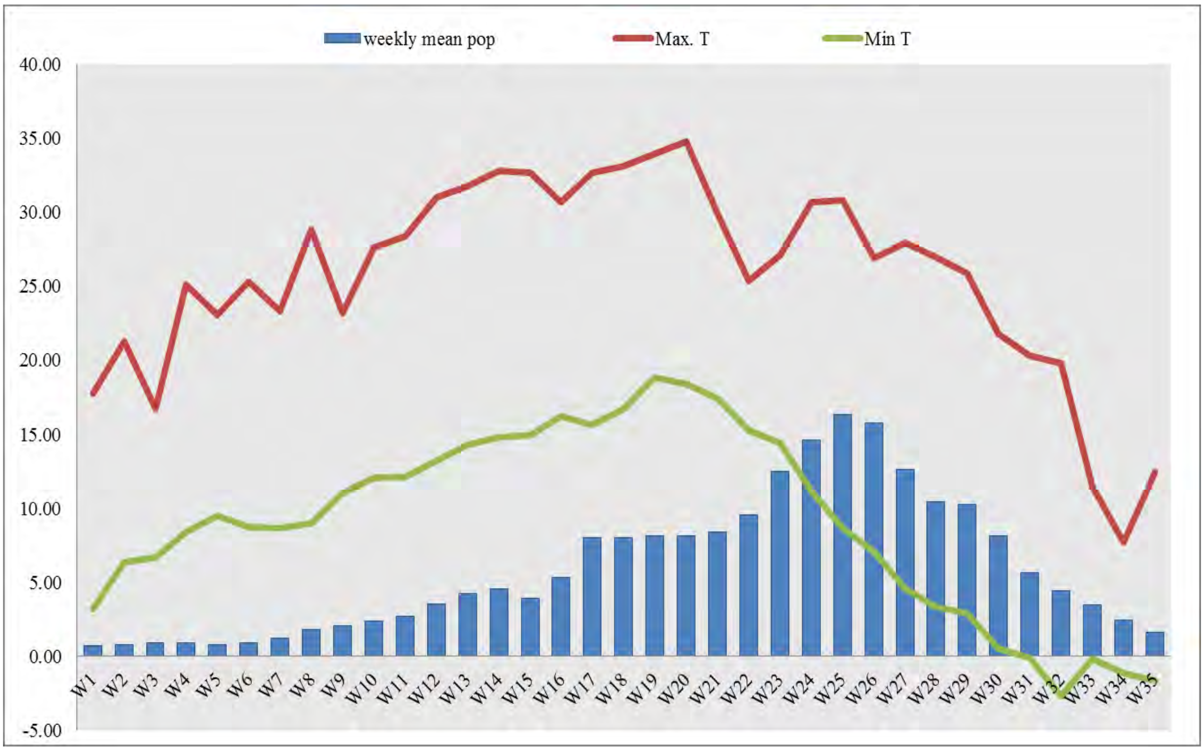

Fig. 2a: Pearsons correlation of weekly mean population of wasps with Temperature

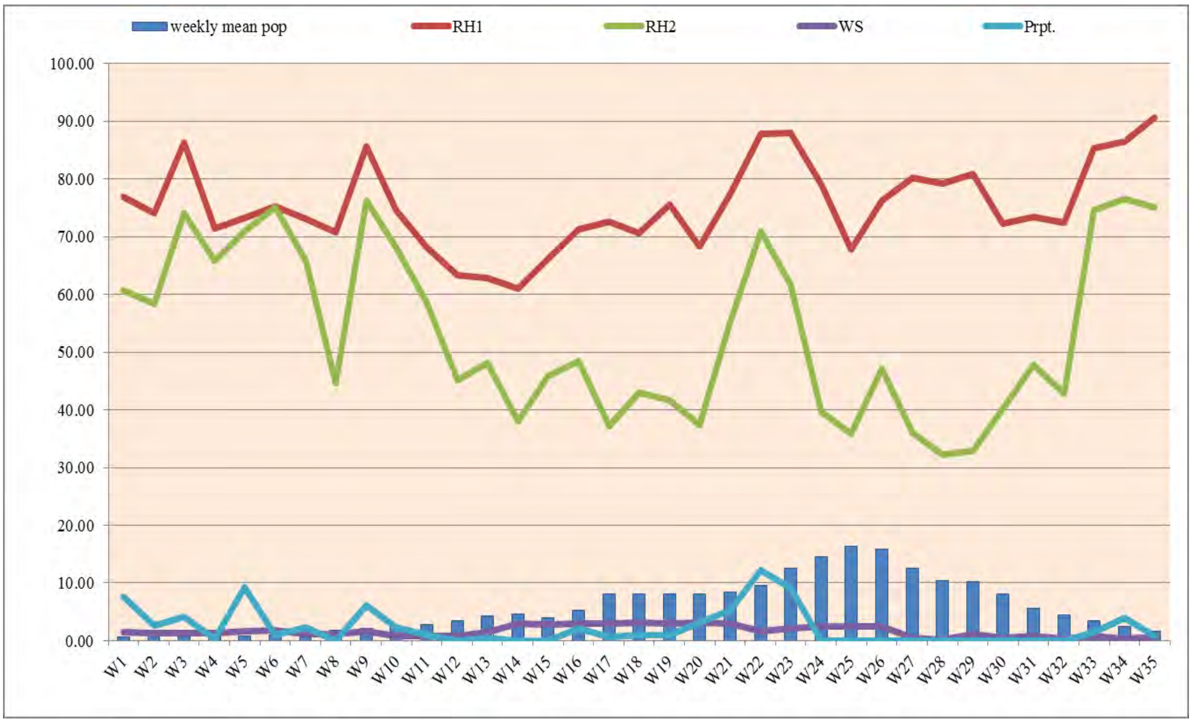

Fig. 2b Pearsons correlation of weekly mean population with weather parameters; relative humidity, wind velocity and precipitation

CONCLUSION

As its foraging activity starts in April, the overwintered queen hornet/wasp starts visiting the apiaries to collect food for its brood. In the beginning of the Summer season the colony expansion takes place giving rise to a large number of foraging hornet/wasp workers i.e. the maximum incidences of predatory wasps occurred during August to October with the highest peaks on 38th SMW followed by 39th SMW, which coincides with the floral dearth period for the honeybees. The incidence of wasps/hornets is governed by the various prevailing weather parameters. The daily average population of predatory wasps exhibited positive correlation with the maximum temperature and minimum daily temperature, but negative correlation with the minimum relative humidity. Weekly mean population of predatory wasps exhibited positive correlated with the maximum temperature and negative correlation with the minimum relative humidity. A constant hornet/wasp attack during this period weakens the colonies while a serious attack results in absconding or devastation of honeybee colonies. Monitoring the population variations, population buildup and predation along with weather parameters would help in decision making to develop sustainable management plans against predatory wasps.

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