Abiotic Factors Influence Patterns of Hymenopteran Diversity in Leafy Vegetable Field of Kumhari, Durg

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ABSTRACT
In the leafy vegetable field of Kumhari villages Durg, Kumhari, an assessment was conducted in the field to determine the seasonal abundance of the main insect groups of leafy vegetables from January 2022 to December 2022. In winter, the number of hymenopteran species is high because the temperature, humidity, and light intensity are ideal for the growth and blooming stages of green crops. Conversely, a moderate number of hymenopteran families survive the summer months since the high temperatures and low humidity are detrimental to their foraging habits. The season after harvest resulted in a decrease in food availability for hymenopterans. In contrast, the pre-growing and seeding phases of green vegetables are at their peak during the wet season. In this season, no. of family of hymenopteran less found because maximum family member of hymenopteran after matting winter season became the form of larval and egg stages so it's not play the foraging and nutrition taking and The variety, foraging behaviour, nutrition-taking activities, and mating of the Hymenopteran family were also impacted by the light intensity. Light intensity is ideal for foraging behaviour, mating activity, and nourishment during the winter, resulting in the highest number of hymenopteran activity. Comparatively speaking, a moderate number of hymenopteran species can withstand high light levels during the summer. It indicates that high light levels are unsuitable for the maximal hymenopteran family's foraging behavior and nutritional viability. In comparison to the winter and summer seasons, the rainy season has intermediate light intensity but low hymenopteran diversity and activity. Seasonally, the Pearson correlation shows a slight negative association between temperature and the number of family members ($r = -0.161$, $p = .636$).There is a non-significant medium-sized negative association between the number of family members and humidity (%) ($r = .343$, $p = .332$), and a non-significant very tiny negative correlation between the number of family members and light intensity (Lux) ($r = .0667$, $p = .855$).

Keywords: hymenopteran, seasonal incidence, abiotic factors, kumhari.

1. INTRODUCTION

As a vital part of terrestrial ecosystems, insects are highly adaptive and contribute significantly to the transformation of energy and the transport of nutrients. [1]. with a wide variety of behaviour's, insects are a diversified group that contribute significantly to the ecological balance of various habitats. They also significantly affect the service functions and ecosystem processes of environments [2,3].The heightened sensitivity of insects to changes in temperature, light, humidity, and other environmental factors makes them essential indicator organisms as well [4].

An important topic in the study of insect ecology is the investigation of the distribution patterns and maintenance strategies of insect species [5]. Several studies have demonstrated that complex biotic and abiotic variables, namely temperature, humidity, and light intensity, influence the distribution and diversity of insect species. [6,7,8,9,10,11,12]. The species composition of insect community structures may be drastically altered by abiotic variables like temperature and relative humidity & light, which are important determinants of insect diversity and species dispersion, according to several studies. [13]. A wide number of studies have demonstrated that global climate change may drastically alter insect community structures, and that rising temperatures will impair insect activity and survival. [14, 15, 16]. When the soil nutrient content is higher in a terrestrial ecosystem, it may promote the growth of plants to a certain extent [12, 17], which in turn increases the species and number of insect populations [18, 19, 20]. However, due to the differences in environmental variables, such as climate, topography, soil, and vegetation types, it is difficult to reach a consensus on the impact of environmental variables on insect communities in different regions. Hence, the maintenance mechanisms that influence insect community structure, distribution patterns, and diversity in different ecosystems should be explored further.

A large number of variations in environmental factors into a small geographical space, which provides useful natural experimental conditions for studying biodiversity distribution [21, 22, 23, 24]. As ectotherms, insects are very sensitive to changes in environmental temperature; therefore, slight changes in the temperature can directly affect their development, reproduction, and survival [6]. Therefore, the elevation gradient is an important factor affecting insect species composition, community construction, and the spatial pattern of diversity [23, 25]. Studies on altitudinal patterns of insect community species diversity in forest ecosystems are helpful in revealing the status of global biodiversity and its maintenance and change mechanisms [26]. Additionally, many studies have shown that elevation has the same effect on vegetation and soil properties as latitude does [27, 28, 29, 30].

The vegetable field of kumhari is located in the middle range of the durg district in the chhattishgarh, with a latitude variation ranging from21^0 15N to 81^0.31E/21,25N to 81.52^{0}E. The vegetation types in kumhari show obvious vertical zonation along the altitude gradient, and the leafy vegetation types in this area are relatively complete in northern chhatishgarh. At present, studies on the changes in insect community distribution pattern, and diversity with abiotic factor such as temperature light intensity and relative humidity. Hence, it is necessary to study the impact of environmental factors on the insect population structure and diversity patterns in this area.

In this study, we selected three typical vegetation community ecosystems at different field of kumhari area of durg: including leafy vegetable field of fallowing village's kapri, Rampur and kumhari, covering all the leafy vegetable ecosystems in the kumhari area. The main objectives of this study were to investigate the distribution patterns and diversity of insect species in leafy vegetable of the kumahri area. Specifically, this study aimed to address the following which environmental variables influence the spatial distribution and diversity of insect communities

2. MATERIALS AND METHODS

2.1. Study site

The vegetable field of kumhari is located in the middle range of the durg district in the chhattishgarh, with a latitude variation ranging from210 15N to 810.31E/21,25N to 81.520E. The vegetation types in kumhari show obvious vertical zonation along the altitude gradient, and the leafy vegetation types in this area are relatively complete in north-mid Chhattisgarh.

2.2. Collecting method

Pitfall trapping was performed in the leafy vegetable field of kumhari area, between 19.01.2022–19.12.2022 at three locations: (i) leafy vegetable field of khapri village and (ii) Rampur leafy vegetable field (iii) patelpara leafy vegetable field of kumhari. Samples were taken with five pitfall traps per site, with four traps in the corners of a square of 5 m side length, and one trap in the middle of the square. The traps were filled with 70% ethylene glycol solution and were emptied fortnightly.

2.3. Preservation and identification of insect sample

The samples were stored in 70% ethanol before sorting their material under compound microscope. For more details on the sampling see (Van Noort, S., 1995) [31].

2.4. Determine correlation of the Insect Diversity with Abiotic Factors

Standard procedures monitored the relevant abiotic parameters such as temperature, humidity level and light intensity of each study site. An instant read thermometer probe recorded the temperature of each study site. The thermometer's hang on leafy vegetable field (10-15cm height) to possibly monitor the accurate reading of the temperature of each study sites. The atmospheric temperature was observed at each habitat patch during the study period using a mercury-filled thermometer. We also monitored the relative humidity level in each study location. Relative humidity of each site observed using a digital metrological instrument known as a hygrometer. In this study, to check light intensity of each site, by photometer instruments. And determined the correlation through Pearson's correlation, method:-

$$\frac{\sum (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum (x_i - \overline{x})^2}\sqrt{\sum (y_i - \overline{y})^2}}$$

where is

Formula for Pearson's correlation. \frac{\sum (x_i - \overline{x}) (y_i - \overline{y})}{\sqrt{\sum{(x_i - \overline{x})^2}}{\sqrt{\sum{(y_i - \overline{y})^2}}}.

Pearson correlation coefficient takes values between -1 and 1, where 1, 0, and -1 indicate a perfect match, no correlation, and perfect negative correlation, respectively. (Alptekin Temiz *et al*., 2011) [32]

3. RESULTS AND DISCUSSION

This study investigates the environmental conditions in Kumhari, Durg District, focusing on temperature, humidity, and light intensity recorded from January 2022 to December 2022. These climatic factors are crucial for understanding the biodiversity of Hymenoptera insects within leafy vegetable fields, as they significantly influence insect behaviour, activity levels, and population dynamics. The temperature data indicates a clear seasonal pattern, with maximum temperatures peaking in June at 43°C, followed by a decrease in July due to the onset of the monsoon season. The moderate conditions during the cooler months may lead to fluctuations in Hymenoptera diversity, as some species may become dormant or migrate. The humidity levels reflect a similar trend, with high maximum values in January (98.6%) and significant drops during the drier months of March and April, suggesting that moisture availability play a vital role in shaping the ecological dynamics within the fields. The onset of the monsoon in June raises average humidity levels, likely enhancing food resources and fostering increased insect activity and diversity. Light intensity, measured in lux, follows a corresponding trend, with maximum levels recorded in May (87,040 lux), which aligns with the peak flowering period of various plants, thus providing sample resources for Hymenoptera.

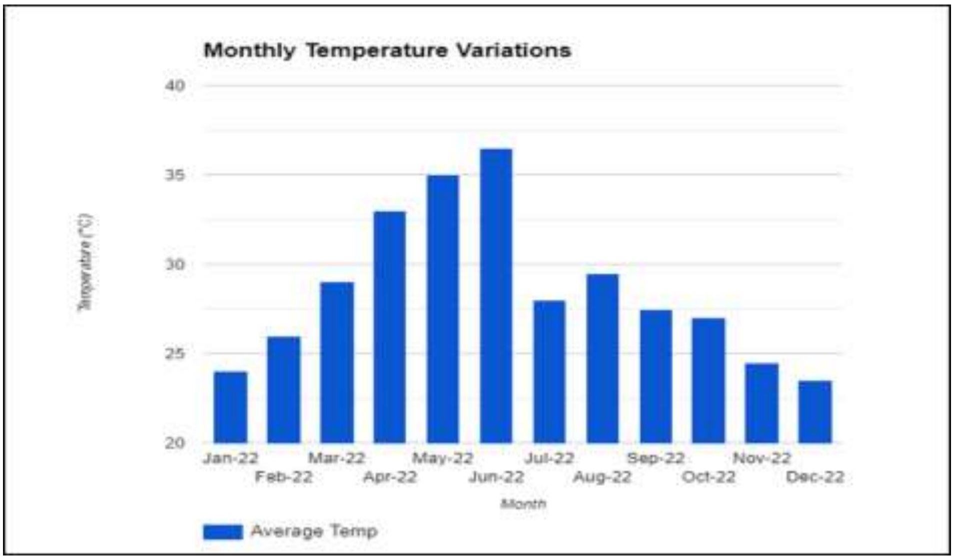
However, light intensity diminishes in the following months, especially during the winter season, potentially impacting insect abundance and activity. The interplay of temperature, humidity, and light intensity throughout the year creates a complex environment that influences the lifecycle, habitat selection, and interactions of Hymenoptera with their ecosystems. Understanding these environmental factors is essential for predicting changes in Hymenoptera diversity and their ecological roles in agricultural systems, particularly in the context of sustainable agricultural practices in Kumhari.

Table 1: Temperature (°C) recorded from the study area during January 2022 – December 2022

S. No.	Month	Temperature		
		Max	Min	Average
1	Jan-22	32	16	24
2	Feb-22	34	18	26
3	March-22	36	22	29
4	April-22	40	26	33
5	May-22	42	28	35
6	Jun-22	43	30	36.5
7	July-22	31	25	28
8	Agust-22	33	26	29.5
9	Sep-22	31	24	27.5
10	Oct-22	32	22	27
11	Nov-22	31	18	24.5
12	Dec.-22	28	19	23.5

The table presents temperature data recorded from January 2022 to December 2022 in the study area of Kumhari, Durg District, providing insights into environmental conditions that could impact the diversity of Hymenoptera insects within leafy vegetable fields. This data details maximum, minimum, and average temperatures for each month, reflecting seasonal trends that are crucial for understanding insect behavior and population dynamics.

In January 2022, the recorded maximum temperature was 32°C, with a minimum of 16°C, resulting in an average of 24°C. This moderate temperature may create a conducive environment for Hymenoptera, which often thrive in warmer climates. As the months progressed, temperatures generally increased, peaking in June 2022 with a maximum of 43°C and an average of 36.5°C. The high temperatures during the summer months could influence the activity levels, reproduction, and foraging behaviors of Hymenoptera, potentially increasing their diversity as they seek out resources in leafy vegetable fields. The significant drop in temperature observed in July, with a maximum of 31°C and an average of 28°C, corresponds to the onset of the monsoon season. This cooler and wetter environment could enhance the availability of flowering plants and increase moisture in the soil, creating favourable conditions for various Hymenoptera species. The average temperatures in August and September, which stabilize at 29.5°C and 27.5°C, respectively, may support a diverse array of insect life, as many species of Hymenoptera are active during these transitional months. As the year progresses into the cooler months of November and December, with average temperatures of 24.5°C and 23.5°C, the biodiversity of Hymenoptera may fluctuate due to decreased activity and foraging opportunities, as some species may become dormant or migrate. Understanding these temperature patterns is essential for anticipating changes in Hymenoptera diversity, as fluctuations can directly affect their life cycles, habitat selection, and interactions with crops in leafy vegetable fields.

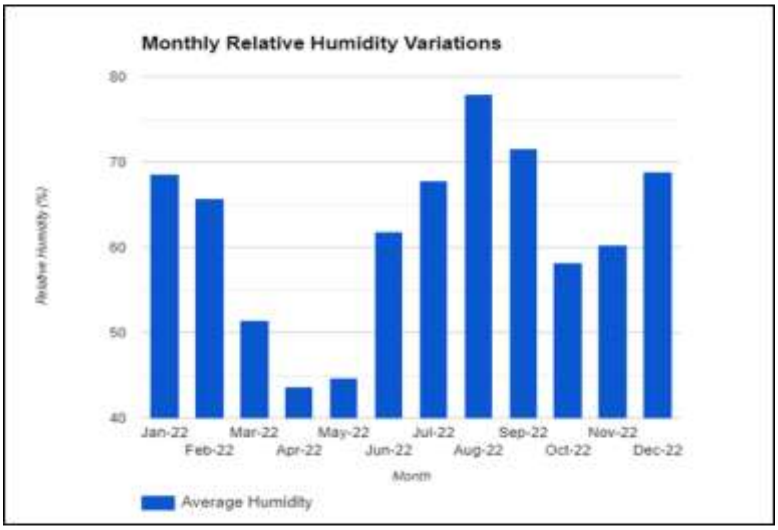


Graph 1: shows the monthly average temperature variation in year 2022.

Table 2: Humidity recorded from the study area during January 2022 – Dec.-2022

S. No.	Months	Relative Humidity %		
		Max %	Min%	Average
1	Jan-22	98.6	38.6	68.6
2	Feb-22	97.1	34.4	65.75
3	March-22	83.2	19.7	51.45
4	April-22	75.9	11.5	43.7
5	May-22	69.9	18.7	44.7
6	Jun-22	95.2	28.5	61.85
7	July-22	96.4	39.2	67.8
8	Agust-22	97.2	58.6	77.9
9	Sep-22	97.7	45.4	71.55
10	Oct-22	86.2	30.1	58.15
11	Nov-22	93.4	27.2	60.3
12	Dec.-22	94.9	42.8	68.85

The table presents the relative humidity data recorded from January to December 2022 in the study area, providing insights into the moisture levels that could significantly impact the diversity and behavior of Hymenoptera insects in leafy vegetable fields in Kumhari, Durg District. This data includes maximum, minimum, and average humidity percentages for each month, reflecting seasonal trends and environmental conditions that can influence insect activity and ecological dynamics. In January 2022, the recorded maximum humidity was 98.6%, with a minimum of 38.6%, leading to an average of 68.6%. The high humidity levels during this month could foster an environment conducive to the presence of various Hymenoptera species, as many insects thrive in moist conditions. As the year progresses, February also exhibits elevated humidity, with an average of 65.75%, though a notable decline in both maximum and minimum values indicates a gradual decrease in moisture levels as spring approaches. The months of March and April show a significant drop in average humidity to 51.45% and 43.7%, respectively. This reduction can create a less favourable habitat for certain Hymenoptera species, potentially leading to decreased activity and foraging behaviours. By May, the average humidity stabilizes at 44.7%, suggesting continued dryness that may further limit insect diversity and abundance in the area.



Graph 2: show that monthly variation of average humidity with in year 2022.

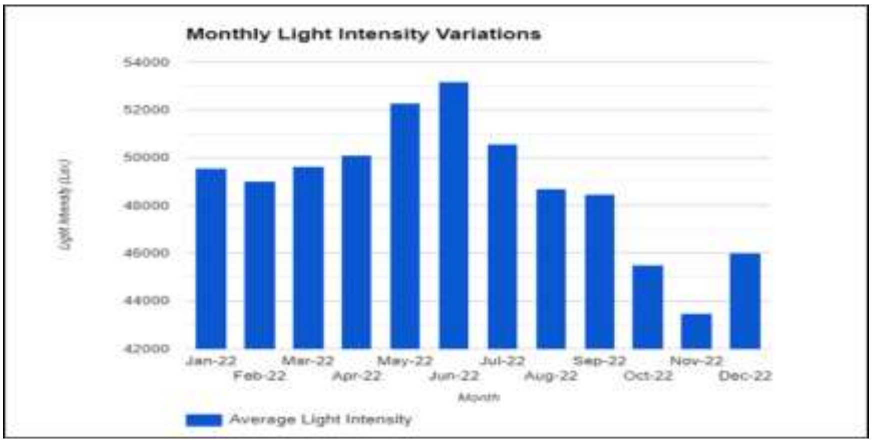
Table 3: Light Intensity recorded from the study area during January 2022 –December 2022

S. No.	Month	Light Intensity in Lux		
		Max	Min	Average
1	Jan-22	81145	18000	49575
2	Feb-22	82015	16000	49007
3	March-22	83034	16240	49637
4	April-22	83224	17000	50112
5	May-22	87040	17500	52,270
6	Jun-22	88032	18321	53176
7	July-22	83050	18111	50580

8	Agust-22	80532	17800	48716
9	Sep-22	80035	16900	48467
10	Oct-22	77021	14000	45510
11	Nov-22	75000	12000	43,500
12	Dec.-22	79000	13000	46000

The table presents the light intensity data recorded from January to December 2022 in the study area, measured in lux. This information is critical for understanding the environmental conditions that influence the diversity and behavior of Hymenoptera insects in leafy vegetable fields in Kumhari, Durg District. The data includes maximum, minimum, and average light intensity values for each month, reflecting seasonal variations that may affect insect activity and plant growth. In January 2022, the maximum light intensity recorded was 81,145 lux, with a minimum of 18,000 lux, leading to an average of 49,575 lux. These values suggest that the early part of the year experiences relatively high light conditions, which can be favorable for plant growth and insect activity. As February approaches, the light intensity remains similar, with a maximum of 82,015 lux and a slightly lower minimum of 16,000 lux, resulting in an average of 49,007 lux. This consistency in light conditions may help support the existing insect populations. In March, light intensity increases marginally, with maximum values reaching 83,034 lux and a minimum of 16,240 lux, yielding an average of 49,637 lux. The slight increase in light intensity may enhance photosynthetic activity in plants, thereby providing more resources for Hymenoptera. April sees a continued increase in light levels, with an average of 50,112 lux, indicating a strengthening sunlight as the growing season progresses.

May exhibits the highest maximum light intensity recorded in the year at 87,040 lux, with a minimum of 17,500 lux, leading to an average of 52,270 lux. This peak in light intensity during late spring is crucial as it likely correlates with the peak availability of flowering plants, providing abundant food sources for Hymenoptera species. The following month, June, maintains elevated light conditions, with an average of 53,176 lux, further supporting the growth of both flora and the insects that depend on them. However, light intensity begins to decrease in July, averaging 50,580 lux, which could suggest a slight decline in environmental conditions as the region transitions into the monsoon season. August and September see average light intensities of 48,716 lux and 48,467 lux, respectively, indicating continued reduction in light levels. This drop may influence the behavior and abundance of Hymenoptera, as lower light intensity can affect plant health and the availability of resources. In October, the average light intensity further decreases to 45,510 lux, followed by a significant drop in November, averaging 43,500 lux. These reductions can be attributed to the onset of the winter season, which may adversely impact insect activity and diversity due to reduced food availability. By December, while there is a slight increase to 46,000 lux, the overall lower light intensity in the colder months may limit the ecological interactions between Hymenoptera and their surrounding environment.

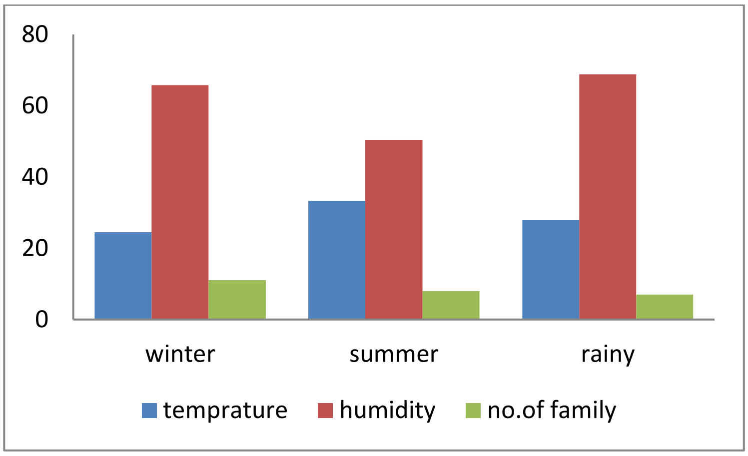


Graph 3: shows that monthly average Light intensity variation within year 2022.

Table 4: Diversity of hymenopteran family season wise of kumhari on leafy vegetable field

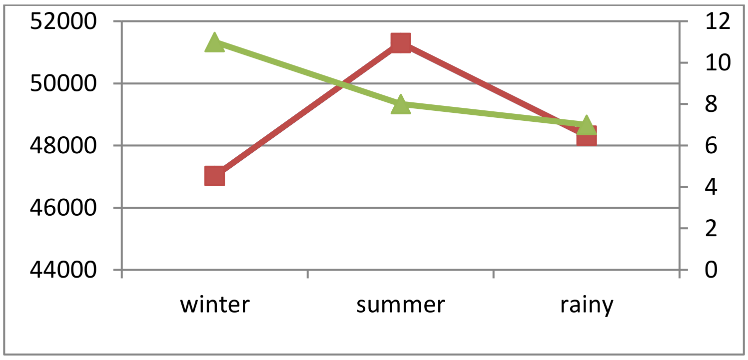
S. No.	Location	Order of Hymenopteran Family	Seasons	Abiotic factor of leafy vegetable fields		
				Temperature (c0)	**Light intensity (Lux)**	**Humidity (%)**
1.		Apidae, Crabronidae Cycipidae, Cynipoidea Eulophidae Formicidae Scelionidae	Winter	16 min.- 34max.	43,500 min.- 49575max	27.2 min.- 98.6 max

		Sphecidae Telenominae Vespidae Xyelidae				
2.	Kumhari, Durg	Apidae Bethylidae Chrysididae Formicidae Halictidae Ichneumonidae Thynnidae Vespidae	summer	22 min.-43 max.	49637 min.-53176 max.	11.5 min.-95.2 max
3.		Apidae Formicidae Platygastridae Scelionidae Systasidae Tenthredinidae Vespidae	rainy	22 min.-33max.	45510 min.-45510 max	30.1min.-97.7 max.



Graph 4: show the diversity pattern of hymenopteran family influence byTemperature and humidity

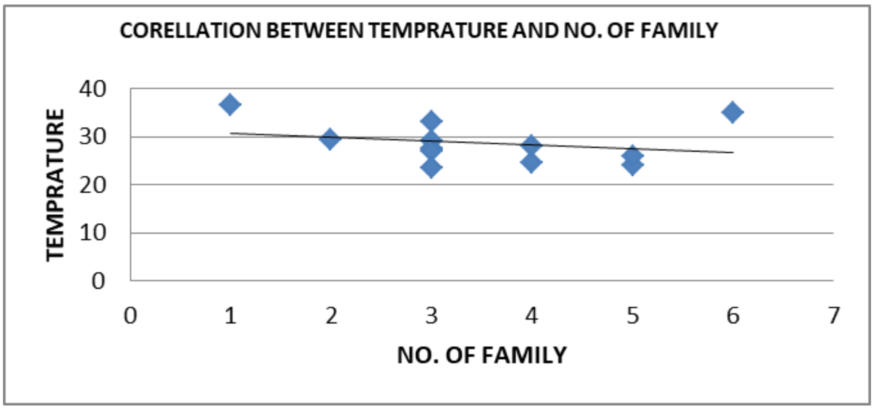
Diversity pattern of number of family of hymenopteran influence by temperature and humidity according to the graph 3.4 show that in winter no of family of hymenopteran abundance because temperature and humidity suitable for hymenopteran behaviour and nutrition purpose. But in case of summer some hymenopteran family member survives in low humidity and high temperature because their nutrition viability less and foraging behaviour not do well. In rainy season no of family of hymenopteran less found because maximum family member of hymenopteran in the form of larva and egg stages so it’s not seen in the foraging activity and matting activity and getting nutrition.



Graph 5: light intensity influence the diversity of hymenopteran family season wise

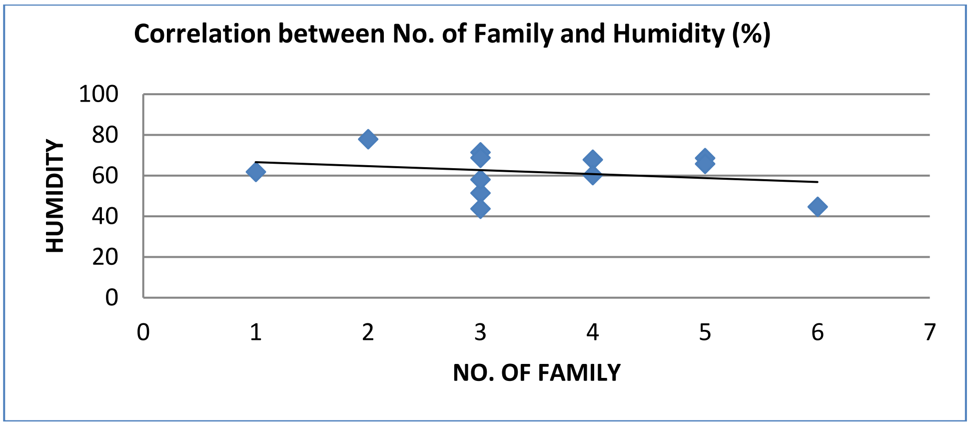
diversity pattern of family of hymenopteran members stimulus by light intensity according to the graph 5 show that in winter light intensity (±47020.5 Lux) no of family of hymenopteran abundance and its foraging behaviour and nutrition purpose activity maximum means in winter light intensity suitable for maximum no. of hymenopteran family . But in summer moderate no. of family of hymenopteran survives in high light intensity (±51298.7Lux).its means high

light intensity shown that it's not suitable for nutrition viability and foraging behaviour of all hymenopteran family. In rainy season no. of family of hymenopteran less diversity as compare then winter and summer season whereas light intensity(±48318.2) moderate level as compare to winter and summer light intensity because maximum family member of hymenopteran in the form of larva and egg stages so it's not seen in doing foraging activity and matting activity and getting nutrition.
Season wise the Pearson correlation graph indicated that there is a non-significant small negative relationship between No.of family, and temperature, (r =-0 .161, p = .636).



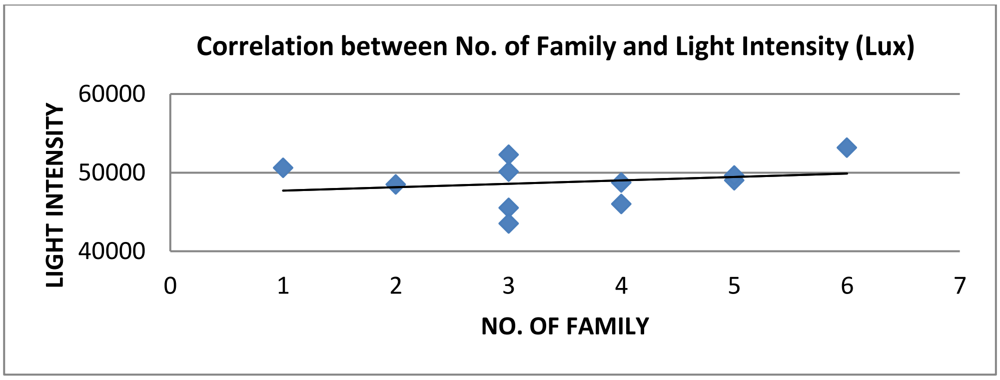
Graph 6: Correlation between Temperature and No. of Family

The Pearson correlation graph indicated that there is a non-significant medium negative relationship between No.of family and Humidity (%), (r = .343, p = .332).



Graph 7: Correlation between No. of Family and Humidity (%)

The pearson correlation graph indicated that there is a non-significant very small negative relationship between No. of family and Light intensity (Lux), (r = .0667, p = .855).



Graph 8: Correlation between No. of Family and Light Intensity (Lux)

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