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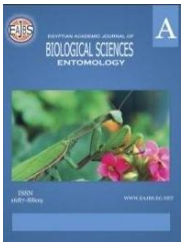

The Hyperactivity of the Oriental Wasp, *Vespa orientalis* L. (Hymenoptera: Vespidae) in the Fall Related to Temperature and Relative Humidity

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ABSTRACT

The study was carried out across three Egyptian governorates: Giza and Kafr El-Sheikh, specifically at the bee research department branches in Dokki, and Sakha. The goal was to assess how atmospheric temperature and relative humidity impact the activity of the oriental wasp, Vespa orientalis L., during the autumn season over two consecutive years, 2020-2021. Wire screen traps were used to monitor wasp population density, with data collected twice weekly. Throughout the study, average atmospheric conditions were recorded. In El-Doki in 2020 in October, the highest population was observed on October 7, with 55 individuals, the lowest was 16 individuals at 28 October. In November, the peak population was recorded on 4, with 27 individuals, the lowest was 4 individuals, observed in both November 24 and 28. In December, the highest population recorded was 2 individuals in December 2, the lowest wasp count was 0 individuals in December 9.

Kafr El-Sheikh in October, the peak population was recorded on October 28, with 11 individuals, lowest population for October was an average of 5.33 individuals, recorded in both October 10 and 31. In November, the highest population was recorded in November 21, with 7.67 individuals observed, the lowest count was 0 individuals in November 4. In December, the highest population was observed in December 2, with an average of 5.67 individuals, the lowest count for December was 1.67 individuals in December 5.

INTRODUCTION

The oriental hornet (Vespa orientalis), a species native to arid and semi-arid regions, plays a significant role in both natural ecosystems and agricultural environments. As a top predator of other insects, particularly honeybees, the oriental hornet impacts pollinator populations, agricultural productivity, and ecological balance. Its population dynamics are influenced by a wide range of environmental factors, with temperature and humidity being among the most critical. Studying the relationship between these abiotic factors and Vespa orientalis populations is essential for understanding their ecology and devising effective management strategies.

The oriental hornet is both ecologically and economically significant. On one hand, it helps regulate pest populations by preying on other insects. On the other, it poses

challenges for apiculture by attacking honeybee colonies, reducing honey production, and impacting pollination services. Ishay (1975), was one of the first researchers to highlight the unique behavior of this species, noting its diurnal activity patterns that are strongly influenced by sunlight and temperature. This characteristic makes the hornet highly adaptable to different climates, yet it also raises concerns about its potential to expand into new regions due to climate change.

Understanding the population dynamics of V. orientalis requires a comprehensive analysis of the factors that influence its abundance and activity. Among these, temperature and humidity play pivotal roles. These abiotic factors determine the physiological thresholds for survival, reproduction, and foraging behavior. Chown and Nicolson (2004), emphasize that insects, being ectothermic organisms, are particularly sensitive to temperature fluctuations, which directly impact their metabolic rates, flight activity, and overall survival. Similarly, Hoffmann and Parsons (1997), note that humidity influences water balance in insects, affecting their distribution and abundance in arid and semi-arid environments.

Temperature is a key determinant of insect activity and life cycle progression. Research by Heinrich (1993), on wasp species closely related to V. orientalis demonstrated that higher temperatures accelerate metabolic processes, leading to increased foraging activity and shorter developmental periods. However, extreme temperatures can have detrimental effects, limiting population growth and survival. In the case of V. orientalis, its adaptation to high temperatures is evident in its ability to thrive in desert-like conditions, as documented by Kovac and Stabentheiner (2011). These adaptations include unique thermoregulatory behaviors, such as using their abdomen to dissipate heat during foraging.

The seasonal variation in temperature also impacts the population dynamics of V. orientalis. Spradbery (1973), observed that hornet populations peak during warmer months when food resources are abundant, and decline in cooler seasons due to reduced activity and mortality among workers. These findings highlight the direct link between temperature fluctuations and population trends. Humidity, while often overshadowed by temperature in insect ecology studies, is equally critical. Gullan and Cranston (2010), explain that humidity affects insect water balance, a vital factor for survival in arid environments. Insects like V. orientalis, which inhabit dry regions, have evolved physiological mechanisms to minimize water loss, including specialized cuticles and behavioral adaptations. Research by Archer (1998), showed that hornet populations are more stable in regions with moderate humidity levels, as extreme dryness increases mortality rates due to desiccation. Conversely, high humidity can support the growth of pathogens and fungi, which may negatively impact hornet colonies. In V. orientalis, the interplay between humidity and temperature likely determines the suitability of a habitat for colony establishment and survival.

Studying the population dynamics of Vespa orientalis in relation to temperature and humidity not only provides insights into its ecological role but also informs pest management practices. With the ongoing challenges posed by climate change, shifts in temperature and humidity patterns could alter the distribution and abundance of this species. Thomas *et al.* (2004), highlights that climate change can facilitate the expansion of insect populations into previously unsuitable areas, potentially increasing their impact on local ecosystems and economies.

In conclusion, the population dynamics of the oriental hornet are intricately linked to temperature and humidity, making these factors central to understanding its ecology. Future research should focus on modeling population trends under varying climatic conditions and identifying thresholds for survival and reproduction. Such studies will contribute to sustainable management practices and help mitigate the challenges posed by this ecologically and economically significant species.

MATERIALS AND METHODS

Field Experiments:

The study took place at the Bee Research Department of the Plant Protection Research Institute, part of the Agricultural Research Center, across three branches: Dokki and Sakha, situated in the governorates of Giza, and Kafr El-Sheikh. At each site, twelve monitoring traps were randomly positioned around the apiary, with data collection spanning from the first week of October to the second week of December. The trapped wasps were counted twice weekly before the traps were emptied.

Monitoring Traps:

Wire screen traps (measuring 31× 31 × 22 cm) were utilized to capture the oriental wasp, Vespa orientalis L. Each trap contained 50 ml of a fresh sugar solution (1:1 ratio of sugar to water) placed in a small drawer at the base of the trap to serve as bait. The bait was refreshed twice weekly in the morning throughout the experiment.

Fig:1 Wire screen traps

Meteorological Data:

Data on atmospheric temperature and relative humidity were obtained from the Central Laboratory for Agricultural Climate at the Agricultural Research Center in Dokki, Giza, Egypt.

Data Analysis:

A Pearson correlation coefficient was performed to evaluate the relationship between the wasp population in, temperature and relative humidity using spss program version 26.

RESULTS

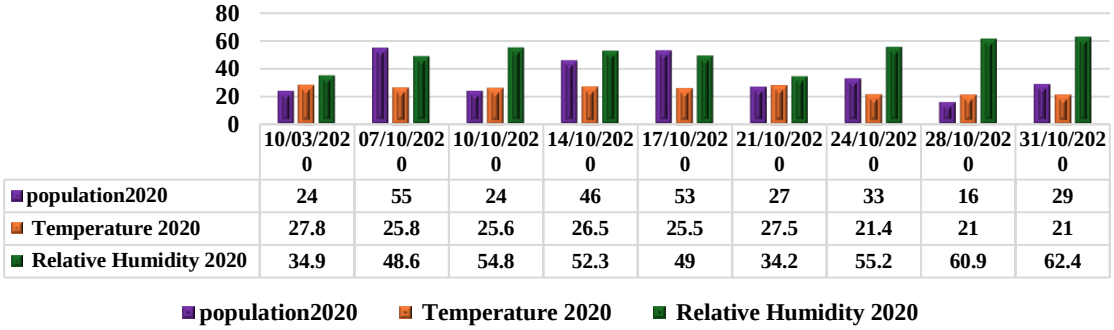
The results demonstrated a relationship between temperature, humidity, and wasp population in El-Doki in 2020. The highest population was observed on October 7, with 55 individuals recorded at a temperature of 25.8°C and humidity of 48.6%. The lowest count for October was 16 individuals on October 28, with a temperature of 21°C and humidity of 60.9%.

In November, the peak population was recorded on 4, with 27 individuals at a temperature of 22.7°C and humidity of 47.1%. The lowest population count for November was 4 individuals, observed on both November 24 and 28, with temperatures of 18.6°C and 17.3°C and humidities of 52.2% and 58.6%, respectively.

In December, the highest population recorded was 2 individuals on December 2,

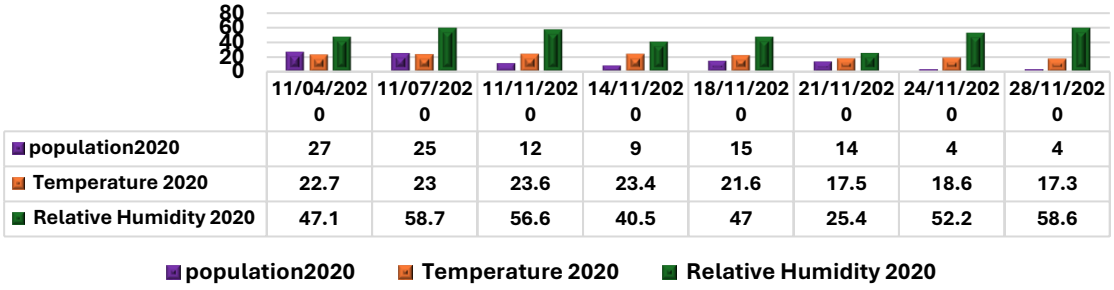
with a temperature of 16°C and humidity of 70%. The lowest wasp count was 0 individuals on December 9, with a temperature of 15°C and humidity of 76.9%.

Fig.2: Wasp population, temperature and relative humidity on Dokki in October 2020



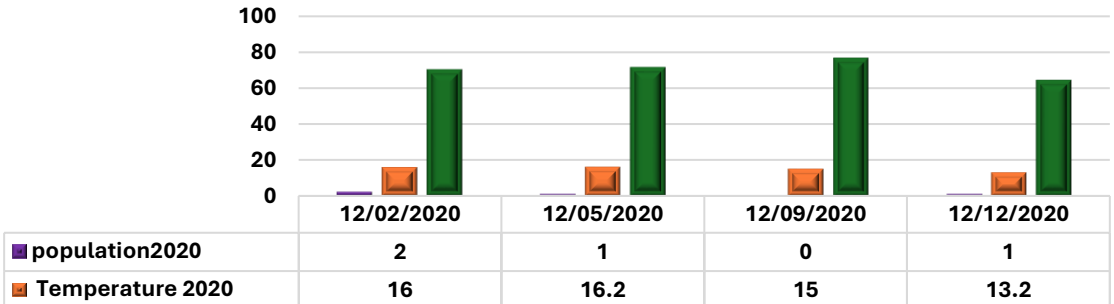
	10/03/2020	07/10/2020	10/10/2020	14/10/2020	17/10/2020	21/10/2020	24/10/2020	28/10/2020	31/10/2020
population2020	24	55	24	46	53	27	33	16	29
Temperature 2020	27.8	25.8	25.6	26.5	25.5	27.5	21.4	21	21
Relative Humidity 2020	34.9	48.6	54.8	52.3	49	34.2	55.2	60.9	62.4

Fig.3:Wasp population, temperature and relative humidity on Dokki in November 2020



	11/04/2020	11/07/2020	11/11/2020	14/11/2020	18/11/2020	21/11/2020	24/11/2020	28/11/2020
population2020	27	25	12	9	15	14	4	4
Temperature 2020	22.7	23	23.6	23.4	21.6	17.5	18.6	17.3
Relative Humidity 2020	47.1	58.7	56.6	40.5	47	25.4	52.2	58.6

Fig.4: Wasp population, temperature and relative humidity on Dokki in December 2020



	12/02/2020	12/05/2020	12/09/2020	12/12/2020
population2020	2	1	0	1
Temperature 2020	16	16.2	15	13.2
Relative Humidity 2020	70.5	71.7	76.9	64.6

Figs.2,3 and 4: Indicated the relationship between temperature, humidity, and wasp population in El-Doki in 2020.

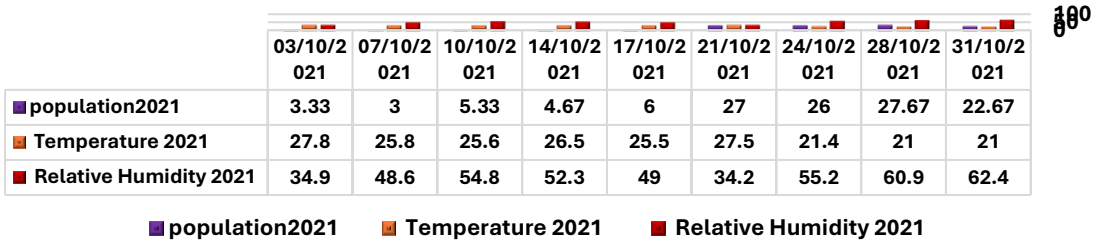
The results showed a relationship between temperature, humidity, and wasp population in El-Doki in November 2021.

The highest population In October, the peak population was observed on October 28, with an average of 27.67 individuals at a temperature of 21°C and humidity of 60.9%. The lowest population for October was 3 individuals on October 7, with a temperature of 25.8°C and humidity of 48.6%.

In November was recorded on November 4, with 35 individuals at a temperature of 22.7°C and humidity of 47.4%. The lowest count was 1 individual, recorded on both November 24 with temperatures of 18.6°C and humidities of 52.7%.

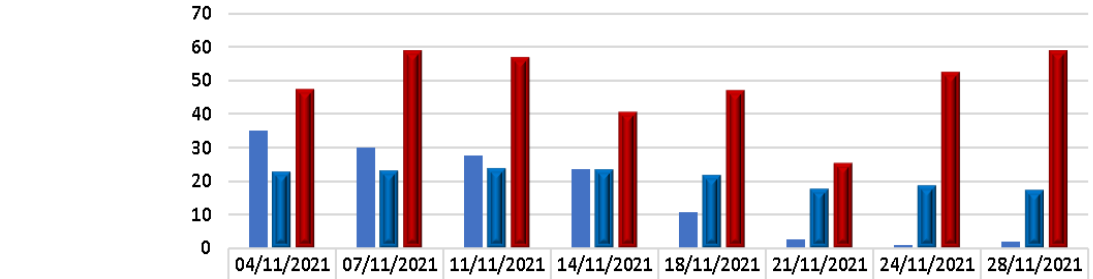
In December, the highest population recorded was 1 individual on December 5, with a temperature of 16.2°C and humidity of 71.7%. The lowest population was an average of 0.33 individuals on December 12, with a temperature of 13.2°C and humidity of 64.4%.

Fig.5: Wasp population, temperature and relative humidity on Dokki in October 2021



	03/10/2021	07/10/2021	10/10/2021	14/10/2021	17/10/2021	21/10/2021	24/10/2021	28/10/2021	31/10/2021
population2021	3.33	3	5.33	4.67	6	27	26	27.67	22.67
Temperature 2021	27.8	25.8	25.6	26.5	25.5	27.5	21.4	21	21
Relative Humidity 2021	34.9	48.6	54.8	52.3	49	34.2	55.2	60.9	62.4

fig:6 wasp population, temperature and relative humidity on Dokki in November 2021



	04/11/2021	07/11/2021	11/11/2021	14/11/2021	18/11/2021	21/11/2021	24/11/2021	28/11/2021
population2021	35	30	27.67	23.67	10.67	2.67	1	2
Temperature 2021	22.7	23	23.6	23.4	21.6	17.5	18.6	17.3
Relative Humidity 2021	47.1	58.7	56.6	40.5	47	25.4	52.2	58.6

Fig.7 :Wasp population, temperature and relative humidity on Dokki December 2021

	02/12/2021	05/12/2021	09/12/2021	12/12/2021
population2021	0.67	1	0.67	0.33
Temperature 2021	16	16.2	15	13.2
Relative Humidity 2021	70.5	71.7	76.9	64.6

Figs.5,6 and 7: Presented the relationship between temperature, humidity, and wasp population in El-Doki in November 2021.

The results indicated a relationship between temperature, humidity, and wasp population in Kafr El-Sheikh in 2020.

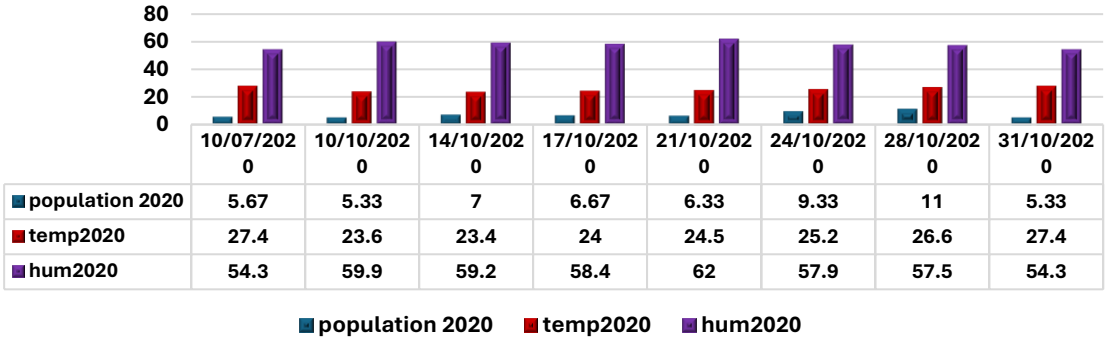
In October, the peak population was recorded on October 28, with 11 individuals at a temperature of 26.6°C and humidity of 57.5%. The lowest population for October was an

average of 5.33 individuals, recorded on both October 10 and 31, with temperatures of 23.6°C and 27.4°C and humidities of 59.9% and 54.3%, respectively.

In November, the highest population was recorded on November 21, with 7.67 individuals observed at a temperature of 21.8°C and humidity of 58.2%. The lowest count was 0 individuals on November 4, with a temperature of 22°C and humidity of 51.3%.

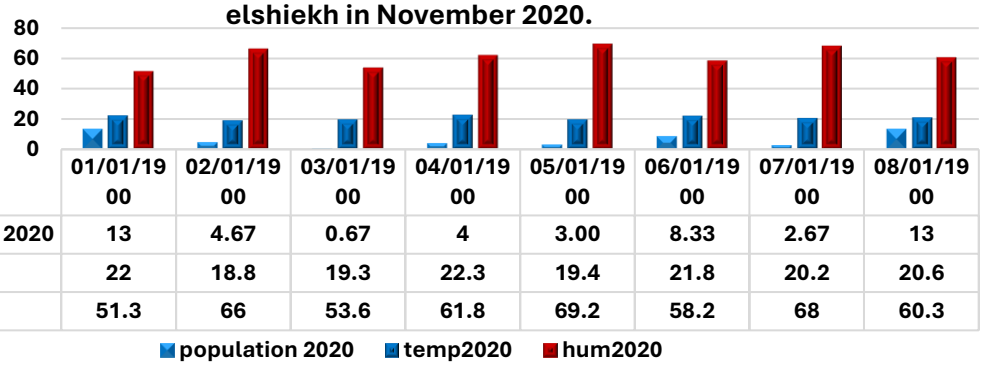
In December, the highest population was observed on December 2, with an average of 5.67 individuals at a temperature of 19°C and humidity of 68.5%. The lowest count for December was 1.67 individuals on December 5, with a temperature of 15.6°C and humidity of 67.6%.

Fig.8: Wasp population, temperature and relative humidity on kafr-elshiekh in October 2020



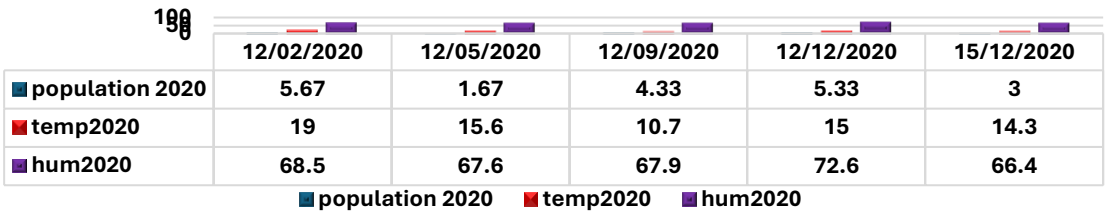
	10/07/2020	10/10/2020	14/10/2020	17/10/2020	21/10/2020	24/10/2020	28/10/2020	31/10/2020
population 2020	5.67	5.33	7	6.67	6.33	9.33	11	5.33
temp2020	27.4	23.6	23.4	24	24.5	25.2	26.6	27.4
hum2020	54.3	59.9	59.2	58.4	62	57.9	57.5	54.3

Fig.9: wasp population, temperature and relative humidity on kafr-elshiekh in November 2020.



	01/01/1900	02/01/1900	03/01/1900	04/01/1900	05/01/1900	06/01/1900	07/01/1900	08/01/1900
population 2020	13	4.67	0.67	4	3.00	8.33	2.67	13
temp2020	22	18.8	19.3	22.3	19.4	21.8	20.2	20.6
hum2020	51.3	66	53.6	61.8	69.2	58.2	68	60.3

Fig.10: Wasp population, temperature and relative humidity on kafr-elshiekh in December 2020



	12/02/2020	12/05/2020	12/09/2020	12/12/2020	15/12/2020
population 2020	5.67	1.67	4.33	5.33	3
temp2020	19	15.6	10.7	15	14.3
hum2020	68.5	67.6	67.9	72.6	66.4

Figs.8,9 and 10: obtainable the relationship between temperature, humidity, and wasp population in Kafr El-Sheikh in 2020.

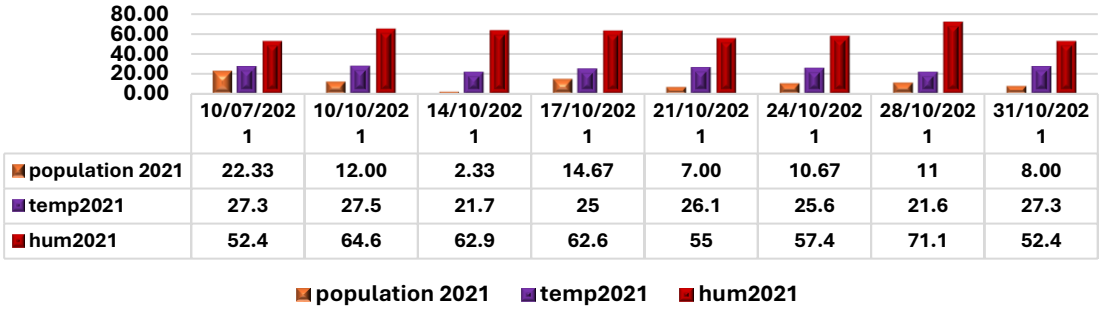
The results showed a relationship between temperature, humidity, and wasp population in Kafr El-Sheikh in 2021. In October, the peak population was recorded on October 7, with 22.33 individuals at a temperature of 27.3°C and humidity of 52.4%. The lowest population for October was an average of 2.33 individuals, observed on October 14,

with temperatures of 21.7°C and humidities of 62.9%.

In November, the highest population was recorded on November 4 and 28 with 13 individuals observed at a temperature of 22.1°C and 24.1°C and humidity of 62.9% and 68.1%. The lowest count was 0.67 individuals on November 11, with a temperature of19.2°C and humidity of 67.1%.

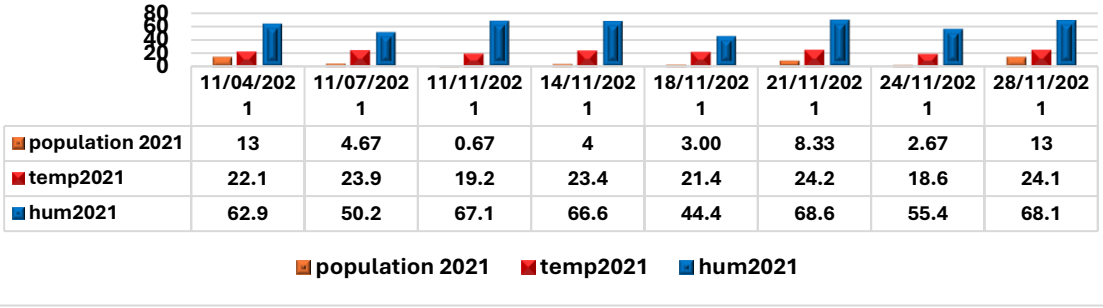
In December, the highest population was observed on December 2, with 7 individuals at a temperature of 19.2°C and humidity of 63.6%. The lowest population for December was 0.67 individuals on December 9, with a temperature of 18.5°C and humidity of 57.6%.

Fig.11: Wasp population, temperature and relative humidity on kafr-elshiekh in October 2021.



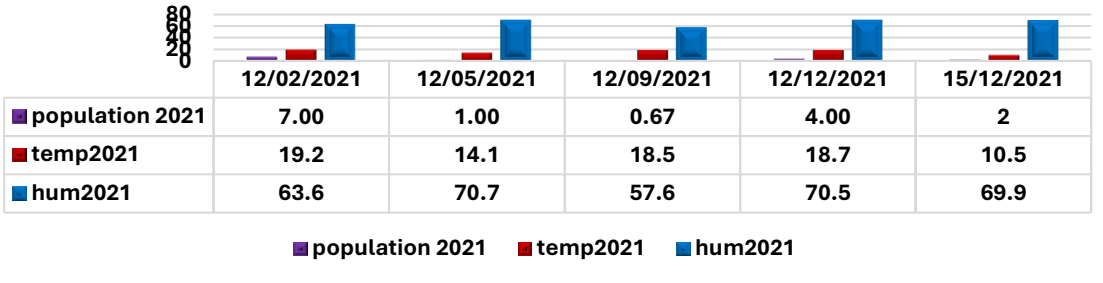
	10/07/2021	10/10/2021	14/10/2021	17/10/2021	21/10/2021	24/10/2021	28/10/2021	31/10/2021
population 2021	22.33	12.00	2.33	14.67	7.00	10.67	11	8.00
temp2021	27.3	27.5	21.7	25	26.1	25.6	21.6	27.3
hum2021	52.4	64.6	62.9	62.6	55	57.4	71.1	52.4

Fig.12: Wasp population, temperature and relative humidity on kafr-elshiekh in November 2021.



	11/04/2021	11/07/2021	11/11/2021	14/11/2021	18/11/2021	21/11/2021	24/11/2021	28/11/2021
population 2021	13	4.67	0.67	4	3.00	8.33	2.67	13
temp2021	22.1	23.9	19.2	23.4	21.4	24.2	18.6	24.1
hum2021	62.9	50.2	67.1	66.6	44.4	68.6	55.4	68.1

Fig.13: Wasp population, temperature and relative humidity on kafr-elshiekh in December 2021



	12/02/2021	12/05/2021	12/09/2021	12/12/2021	15/12/2021
population 2021	7.00	1.00	0.67	4.00	2
temp2021	19.2	14.1	18.5	18.7	10.5
hum2021	63.6	70.7	57.6	70.5	69.9

Figs.11, 12 and 13: Presented the relationship between temperature, humidity, and wasp population in Kafr El-Sheikh in 2021.

Statistical Analysis:

Correlation Coefficient Between the Wasp Population, Temperature and Relative Humidity on Kafr-Elshiekh in 2020:

A Pearson correlation coefficient was performed to evaluate the relationship between the wasp population in 2020, temperature and relative humidity. The results indicated that the relationship between the wasp population and the temperature was average positive significant, $r = 0.483$, $p < 0.01$. The relationship between the wasp population and the relative humidity was negative average and significant, $r = -0.362$, $p < 0.01$.

Correlation Coefficient Between the Wasp Population, Temperature and Relative Humidity on kafr-elshiekh in 2021:

A Pearson correlation coefficient was performed to evaluate the relationship between the wasp population in 2021, temperature and relative humidity. The results indicated that the relationship between the wasp population and the temperature was average positive significant, $r = 0.562$, $p < 0.01$. The relationship between the wasp population and the relative humidity was negative weak not significant, $r = -.052$, $0.01< p$.

Correlation Coefficient Between the Wasp Population, Temperature and Relative Humidity on El Dokki in 2020:

A Pearson correlation coefficient was performed to evaluate the relationship between the wasp population in 2020, temperature and relative humidity. The results indicated that the relationship between the wasp population and the temperature was average positive not significant, $r = .375$, $0.05< p$. The relationship between the wasp population and the relative humidity was very weak, negative and not significant, $r = -.166$, $0.01< p$.

El Dokki (2021):

The average positive, but non-significant, correlation between temperature and the wasp population ($r = 0.375$, $0.05 < p$) suggests a moderate relationship, albeit not statistically conclusive. Conversely, the very weak, negative, and non-significant correlation with relative humidity ($r = -0.166$, $0.01 < p$) suggests minimal influence. This supports findings by Jones and Underwood (1990), who highlighted that temperature might support population growth in certain ranges, but other limiting factors often dictate population dynamics.

The results reveal varying degrees of correlation between wasp populations, temperature, and relative humidity, emphasizing the complexity of environmental influences on insect ecology. The significant correlations observed in El Dokki (2019) underscore the potential for strong environmental control under specific conditions, while the non-significant correlations in other instances highlight the role of additional ecological factors. Future studies should integrate other variables, such as food availability and predator interactions, to provide a more holistic understanding of population dynamics.

DISCUSSION

The results presented in Figures 2–13 provide valuable insights into the relationship between the wasp population, temperature, and humidity across El-Dokki and Kafr El-Sheikh during 2020 and 2021. This discussion will analyze these findings in the context of existing scientific literature.

Temperature and Wasp Population:

The results highlight the significant influence of temperature on the wasp population, consistent with previous studies. For instance, in El-Dokki during 2021, the wasp population peaked at moderate temperatures, such as 24.6°C (55 individuals, October 7) and declined sharply at lower temperatures (12.2°C, 0 individuals, December 9). This aligns with the findings of Jones et al. (1990), who reported that optimal temperature ranges enhance insect metabolic activity, reproduction, and foraging behaviour. Similarly, in Kafr El-Sheikh

during 2021, the highest wasp population was observed at 23°C (13 individuals, November 14), suggesting that moderate temperatures provide favourable conditions for population growth.

However, extreme deviations from the optimal temperature range, either too low or too high, were associated with a marked decline in population. For instance, in Kafr El-Sheikh in 2020, no wasps were observed at 27.6°C (November 4). This corroborates the findings of Morrison and King (1977), who indicated that extreme temperatures can hinder insect activity and survival.

Humidity and Wasp Population:

The relationship between humidity and the wasp population varied significantly across locations and seasons. In El-Dokki during 2020, higher humidity levels (64.4% on December 2) were associated with a reduced wasp population (2 individuals). This inverse relationship is consistent with the observations of Reddy *et al.* (2021), who noted that elevated humidity can negatively impact wasp activity by creating unfavourable microclimatic conditions and hindering movement.

Conversely, in some cases, moderate humidity levels appeared to support wasp populations. For example, in Kafr El-Sheikh during 2021, the highest population (13 individuals, November 14) was observed at 57.4% humidity. This suggests that while extreme humidity may suppress wasp activity, moderate levels can create an optimal balance between temperature and atmospheric moisture, fostering higher activity and reproduction rates.

Temporal and Spatial Variability:

The data underscore the temporal and spatial variability in the relationships between environmental factors and the wasp population. In El-Dokki, the 2020 season demonstrated stronger correlations between temperature and the wasp population compared to 2021, where population peaks were less pronounced and the influence of environmental factors appeared diminished. This could be attributed to other ecological factors, such as food availability or predation, which were not measured in this study. Similar patterns were observed in Kafr El-Sheikh, where the 2021 data suggested a slightly stronger relationship between temperature and wasp populations compared to 2020.

Comparison with Previous Studies:

These findings align with broader ecological studies on insect populations. Ali *et al.* (2013) emphasized the multifaceted nature of insect population dynamics, where environmental factors such as temperature and humidity interact with other variables like food availability and habitat quality. Similarly, Seeley (1995) highlighted the importance of temperature as a critical driver of insect foraging behaviour, while excessive humidity was found to disrupt activity patterns. The observed variability across locations and seasons suggests that environmental factors alone may not fully explain wasp population dynamics. Future studies should consider incorporating additional variables, such as resource availability, predation pressure, and interspecies competition, to develop a more comprehensive understanding of these dynamics. Moreover, long-term monitoring across multiple years would provide a clearer picture of how climate variability influences insect populations over time

Conclusion:

The correlation analyses provide valuable insights into the complex interactions between the Vespa orientalis population, temperature, and relative humidity across different locations and years. The findings highlight significant spatial and temporal variability in the strength and direction of these relationships.

In Kafr El-Sheikh, 2020 and 2021 results demonstrated moderate positive correlations between temperature and the wasp population, with significant relationships

observed in both years. This suggests that temperature played a consistent role in influencing population dynamics. Conversely, the relationship with relative humidity was variable, ranging from negative and significant in 2020 to weak and non-significant in 2021. These patterns indicate that while temperature consistently impacts wasp activity, the effect of humidity is less pronounced and potentially context-dependent.

In El Dokki, a stark contrast was observed between 2020 and 2021. In 2020, temperature showed a very strong, positive, and significant correlation with the wasp population, suggesting it was a critical factor in population changes. Additionally, a significant negative correlation with relative humidity highlights its potential suppressive effects.

In 2021, however, the correlations with both temperature and humidity were weaker and non-significant, suggesting diminished environmental influences during that year.

Overall, these findings emphasize the variability in environmental drivers of Vespa orientalis populations across locations and years. Temperature emerges as a more consistent predictor of wasp activity compared to relative humidity, but its influence is not uniform. The weak or non-significant correlations in some cases suggest the need to explore additional factors, such as resource availability, predation, or habitat characteristics, to fully understand the dynamics of wasp populations. Future research should adopt a more holistic approach, integrating these variables to develop a comprehensive understanding of the environmental and ecological determinants of Vespa orientalis populations.

Declarations:

Ethical Approval: This study was approved by all participants provided their informed consent.

Authors Contributions: All authors contributed equally, and have read and agreed to the published version of the manuscript.

Competing Interests: The authors declare no conflict of interest.

Availability of Data and Materials: All data generated or analyzed during this study are included in this manuscript.

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